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The deliverable presents an overview of various innovative approaches and solutions for promoting climate resilience in cities and communities, which in sum represent the Final Climate Resilience Solution for Communities developed within the Mission CE Climate.

The Climate Resilience Solution for Communities is an integrated package that supports communities in moving from fragmented, sectoral climate actions toward coordinated climate resilience governance led by local and regional authorities and implemented together with MISSION CE CLIMATE stakeholders and citizens. The Climate Resilience Solution for Communities encompasses the following components:

- An online tool CLIMATEHUB.SI
- Practical solutions for mitigating climate change in urban environments
- A digital solution for monitoring climate change and supporting local decision-making

A. AN ONLINE TOOL CLIMATEHUB.SI

A central delivery channel of the Climate Resilience Solution for Communities is the online knowledge base hosted on climatehub.si, which provides access to citizen-oriented resources and supports long-term dissemination.

Within this environment, the project's Climate Resilience Tool for Citizens structures guidance and good practices around three citizen-relevant themes:

- Adapting homes for climate resilience.
- Adopting sustainable consumption practices.
- Building a resilient community.

In addition, the online knowledge base includes a section on innovative funding schemes for climate resilience activities on the local level.

The citizen tool combines a printable guide/leaflet approach with web-based content (guidelines and tips, good practices, and motivational tutorials), enabling awareness raising and practical action by citizens and households.

A climate resilience guide for citizens

In this guide, practical steps for citizens to foster climate resilience are displayed. From energy-efficient upgrades and water conservation practices to emergency preparedness and nurturing climate-resilient gardens, it covers a range of strategies to make homes more resilient. The guide also addresses sustainable consumption practices and how to build resilient communities.

A manual on igniting community-led climate initiatives

Igniting Community-Led Climate Initiatives is a practical guide designed to support citizens, communities NGOs and civil associations in their climate mitigation efforts. It is aimed to showcase how together with their local governments, business and other organizations, citizen initiatives launching and scaling climate action from the ground up is not only feasible, but oftentimes able to yield results faster and more effectively than separate top-down approaches.

Community-led climate initiatives are locally rooted efforts driven by citizens, municipalities, and stakeholders to adapt to and mitigate the effects of climate change through inclusive, participatory, and place-based solutions. These actions are essential for building long-term resilience and enabling sustainable and just green transition that responds to real local needs.

This manual presents a collection of experiences, actions, and insights drawn from the Interreg Central Europe project MISSION CE CLIMATE. Over the course of the project, co-creation processes were carried out across six Central European countries (Slovenia, Slovakia, Austria, Germany, Croatia and Italy), fostering collaboration between local governments, sectoral agencies, citizens, academia, businesses, non-governmental institutions and experts. This manual reflects the practical outcomes of these efforts—from targeted trainings and awareness-raising campaigns to the co-development and co-implementation of pilot projects—highlighting diverse pathways for increasing climate resilience at both local and regional levels, adapted to local context.

Each section combines lessons learned from the practical implementation of pilot projects within the established living labs in the cities of Maribor (Slovenia), Košice (Slovakia), Dornbirn (Austria), Pforzheim (Germany), Brač (Croatia) and Lignano Sabbiadoro (Italy). It can be found at https://www.climatehub.si/en/climate-resilience/citizen-science-approach/

The online tool encompasses the following deliverables:

- D.2.5.1 Igniting community-led climate initiatives manual
- D.3.3.1 Citizen tool
- D.3.2.1 Capacity building of key stakeholders report (learning materials)

B. PRACTICAL SOLUTIONS FOR MITIGATING CLIMATE CHANGE IN URBAN ENVIRONMENTS

Urban Climate Change Solutions - Five Innovative Approaches to Building Climate Resilience in Cities

These five solutions demonstrate how cities can effectively address climate change through innovative combinations of technology, governance, and community engagement. Each approach has been validated through real-world implementation and offers replicable models for other municipalities facing similar climate challenges. Each solution has been tested through pilot projects and demonstrates practical approaches that combine digital technologies, citizen engagement, and nature-based solutions.

Topic: Citizen science and participation

CITIZEN TOOLKIT FOR ENVIRONMENTAL MONITORING

Innovativeness: The solution highly integrates digital technologies by combining open data principles, participatory and data-driven education, and a functional link between technical monitoring and community engagement.

Objective: The project develops and implements a Citizen Toolkit for environmental monitoring . It empowers citizens to contribute data and insights using IoT sensors, fostering community participation in smart city initiatives and promoting long-term environmental stewardship.

Geographical coverage: The pilot project was implemented in the city of Pforzheim, in southwestern Germany, with future uptakes planned across the broader Northern Black Forest region.

Topic: Combating urban heat islands

NATURE-BASED COOLING OF URBAN BUS STOPS SUPPORTED BY IOT MONITORING AND CITIZEN ENGAGEMENT

Innovativeness: This integrated, micro-scale approach combines nature-based solutions—such as green roofs and planters at bus shelters—with digital IoT monitoring and open data transparency. It successfully incorporates citizen feedback to deliver tangible climate adaptation benefits while overcoming the spatial and regulatory constraints typical of dense city centers.

Objective: The solution reduces heat stress and improves thermal comfort at highly exposed urban micro-locations by upgrading public transport stops. It enhances the well-being of vulnerable users while generating measurable climate data to support evidence-based urban planning and future replication.

Geographical coverage: The project was implemented in the city of Maribor, Slovenia, specifically targeting selected bus stops and shelters located within the city center, which are notable heat islands with highly dense traffic and citizen movement.

Topic: Combating water scarcity in coastal areas

UPGRADING THE EFFICIENCY OF THE WATER DISTRIBUTION SYSTEM AND DECREASING WATER LOSSES TO ADAPT TO POSSIBLE DROUGHTS CAUSED BY CLIMATE CHANGE

Innovativeness: The pilot demonstrates a high level of integration between digital technologies and human resource management. It modernizes the network by combining advanced water consumption measurement and leak detection equipment with a newly established, specialized team dedicated to finding water losses.

Objective: The project upgrades the water supply network on the island of Brač to significantly reduce water losses. By introducing advanced monitoring and management, it enables timely interventions to secure the water supply and improve the overall quality of life during summer droughts.

Geographical coverage: The pilot project focuses specifically on the environmental systems and the water supply network of the island of Brač, Croatia.

Topic: Climate data management

DIGITAL SOLUTION FOR LOCAL CLIMATE MONITORING IN OUTDOOR AREAS TO SUPPORT DECISION-MAKING, AWARENESS, AND CLIMATE RESILIENCE

Innovativeness: This digital solution combines open data principles and participatory education while establishing a functional link between technical monitoring and community engagement. It uniquely introduces a multifactorial comparison of the individual and combined cooling effects of different urban surfaces and shading.

Objective: The project improves data governance for municipal climate adaptation through the systematic collection, processing, and visualization of local climate data. It aims to evaluate the potential of nature-based solutions, enable informed decision-making, and educate the public on urban microclimates.

Geographical coverage: The solution covers the outdoor school areas within the city of Košice, Slovakia, as well as park areas in the city of Dornbirn, Austria.

Topic: Governance of climate change

INTEGRATED PARTICIPATORY CLIMATE GOVERNANCE MODEL FOR LOCAL CLIMATE-RESILIENT PLANNING

Innovativeness: The framework takes a systemic, governance-oriented approach that integrates participatory processes directly into formal decision-making and planning cycles. It links community engagement with binding instruments like masterplans and offers a modular combination of tools adaptable to various local contexts.

Objective: The pilot provides local and regional authorities with a structured, transferable framework to strengthen climate governance through coordinated, cross-sectoral processes. It helps municipalities translate climate risks into shared planning priorities and long-term civic engagement, ultimately building institutional capacity and public ownership.

Geographical coverage: The governance model is broadly applicable at local and urban levels across Central Europe, with the specific pilot actions designed and tested in the municipality of Lignano Sabbiadoro, Italy.

Those five solutions are more specifically described in the following deliverables:

- D.2.2.1 Five climate resilience pilot projects implemented
- D.2.4.1 Validation of demonstrated results
- O2.2 - Climate resilience solutions for CE communities – 5 factsheets

C. A DIGITAL SOLUTION FOR MONITORING CLIMATE CHANGE AND SUPPORTING LOCAL DECISION-MAKING

A TESTED DIGITAL SOLUTION CONCEPT FOR MONITORING CLIMATE CHANGE AND SUPPORTING LOCAL DECISION-MAKING

Innovativeness: This concept stands out through a unique "dual-dashboard" approach that translates complex climate data into accessible, engaging tools for citizens while simultaneously providing advanced analytical features for municipal experts. It innovatively combines satellite Earth Observation data (like Copernicus), local smart sensor networks, and active citizen science contributions within a co-creation framework to ensure the technology is user-friendly and truly meets local needs.

Objective: The goal is to provide a structured, user-centered framework for designing customized digital dashboards that enable rapid, data-driven responses to climate events. Rather than creating a single software tool, it offers a modular methodology to help municipalities build sustainable, scalable climate information services that empower both local authorities and the public to build climate resilience.

Geographical coverage: The framework is designed for application across Central Europe, with its methodologies and best practices drawn from and applied to municipal examples in Pforzheim (Germany), Košice (Slovakia), and Dornbirn (Austria).

This solution is more specifically described in the deliverables:

- D.3.4.1 Design of a digital solution for monitoring of climate change in communities
- D.3.4.2 Pilot testing of digital solution for monitoring of climate change in communities

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- D.2.2.1 Five climate resilience pilot projects implemented
- D.2.4.1 Validation of demonstrated results
- D.2.5.1 Igniting community-led climate initiatives manual
- O2.2 - Climate resilience solutions for CE communities – 5 factsheets
- D.3.2.1 Capacity building of key stakeholders report (learning materials)
- D.3.3.1 Citizen tool
- D.3.4.1 Design of a digital solution for monitoring of climate change in communities
- D.3.4.2 Pilot testing of digital solution for monitoring of climate change in communities

D.2.2.1 Five climate resilience pilot projects implemented

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D2.2.1.: Five climate resilience pilot projects implemented

Pilot Project Completion Report

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1. Introduction

This document represents the Deliverable 2.2.1: and provide the evidence and description of implemented pilot projects in geographic areas of Commune Lignano Sabbiadoro (IT), City of Dornbirn (AT), City of Košice (SK), City of Pforzheim (DE), City of Maribor (SI), Splitsko-Dalmatinska County (HR) with thematic focus on:

Pilot project thematic focus	Pilot project geographic area
Governance of climate change in community through cross-sectoral, coordinated and participatory approach	Commune Lignano Sabbiadoro (IT)
Data acquisition, monitoring, analysis and interpretation using digital solutions	City of Dornbirn (AT)
Data acquisition, monitoring, analysis and interpretation using digital solutions	City of Košice (SK)
Citizen science and participation for monitoring and adapting to climate change	City of Pforzheim (DE)
Combating urban heat islands using innovative methods	City of Maribor (SI)
Combating water scarcity in coastal areas	Splitsko-Dalmatinska County (HR)

2. Contribution to climate resilience

All pilot projects contributed to enhancement of climate resilience of communities in specific thematic fields:

Thematic field 1: Data acquisition, monitoring, analysis and interpretation using digital solutions

The Dornbirn pilot advances climate adaptation by proving a practical, city-ready pipeline for data acquisition, monitoring, analysis, and interpretation of urban heat. Using the heat index to compute perceived temperature, it translates raw sensor data into human-centric risk signals for planners and the public. These insights are then shared via the CityMonitor dashboard, which turns technical readings into clear visuals that support awareness, policymaking, and replication across new sites. In sum, the pilot operationalizes an end-to-end digital method—from robust sensing to meaningful public interpretation—that municipalities can reuse to target, validate, and prioritize nature-based cooling measures.

The Košice school-based climate resilience pilot provides a controlled, real-world testbed for the full digital data lifecycle—from sensor readings to public interpretation. Multi-parameter sensors installed on school grounds capture local air and weather conditions and transmit them to the city's Open Data platform. On top of this pipeline, a public "Climate data monitoring" dashboard transform raw streams into intelligible insights, linking values to health and environmental impacts and recommended behaviors. Thanks to cooperation with school teachers, human-centered interpretation of data was ensured and the solution was incorporated into the curriculum through prepared lesson plans and student projects, thereby promoting its lasting acceptance.

Both pilots share a common architecture and purpose: they operationalize an end-to-end digital pipeline—from on-the-ground sensing through monitoring, analysis, and public interpretation—to turn climate data into decisions. Each deploys physical sensors to capture local microclimate conditions and then translates raw readings into human-centric signals that non-experts can understand (e.g., perceived heat, health relevance, recommended behaviors). Results are published via public dashboards that convert technical measurements into clear visuals, strengthening awareness and enabling evidence-based policymaking. The solutions are aligned with municipal, designed for replication across new sites, and explicitly support planners in targeting and prioritizing adaptation measures. Hereby, both initiatives demonstrate how robust data acquisition and analytics, combined with accessible communication, can drive practical, scalable climate resilience.

Thematic field 2: Governance of climate change in community through cross-sectoral, coordinated and participatory approach

The Lignano Sabbiadoro pilot contributes to climate-challenge solutions in community climate governance by proving a cross-sectoral, coordinated, and participatory model that turns strategy into accepted action. It mobilized the municipality and wide range of other stakeholder groups to co-design interventions and produced a City-Council-approved masterplan for a flood-vulnerable area, building social license for implementation. It advanced citywide rules via a Green Management Plan and launched a participatory path to its regulatory framework so responsibilities and standards are co-defined with citizens, aligning daily practice with resilience goals. To mainstream awareness and coordination across disciplines, the Lignano 180° festival connecting technical planning, nature-based approaches, mobility, and public-space quality with civic dialogue—positioning governance as both technical and cultural work.

Thematic field 3: Citizen science and participation for monitoring and adapting to climate change

The pilot in Pfozheim contributes a practical, scalable pathway for tackling climate challenges by turning citizen participation into continuous environmental intelligence and actionable local decisions. It delivers a low-cost LoRaWAN sensing network, using The Things Network and an enerchart dashboard, that citizens and students help install and operate, shifting monitoring from occasional expert surveys to always-on, community data streams. The project couples technology with a DIY Citizen Toolkit and campaigns that grow digital literacy and ownership. By blending open IoT, user-centric dashboards, and structured citizen science, the pilot accelerates how communities monitor and adapt to climate change while building the social capital needed for long-term resilience.

Thematic field 4: Combating urban heat islands using innovative methods

The Maribor pilot contributes to combating urban heat islands by pairing nature-based solutions at bus stops—living roofs and added planters—with continuous IoT monitoring and open data. Focusing on transit shelters tackles heat where people actually spend time, delivering immediate shade, evapotranspiration cooling, and small biodiversity gains that make waiting more comfortable. Sensors at treated and reference stops will stream temperature, humidity, particulates, key gases, rainfall, solar radiation, and wind into the municipal platform, turning each micro-intervention into evidence for before/after evaluation and transparent replication. The pilot offers a practical, policy-aligned, and data-validated pathway cities can reuse to cool hot spots quickly and scale what works.

Thematic field 5: Combating water scarcity in coastal areas

The Brač pilot contributes a practical, scalable solution set for combating water scarcity in coastal areas by turning non-revenue water into a resilience resource. It replaces aging meters with magnetic-inductive units and expands telemetry and leak-detection capability to continuously find and fix losses, cutting distribution losses and stabilizing supply during droughts and peak tourist seasons. The project couples technology with governance—creating a dedicated Water Loss Unit, integrating data into simple operator dashboards, and validating savings over a full seasonal cycle—so utilities can act on evidence, not estimates. Night-time works and staged procurement show how to modernize coastal networks with minimal service disruption and within tight budgets, while citizen guidance materials reduce household demand. The result is a replicable "coastal playbook": instrument priority reservoirs and trunk lines, isolate sectors to pinpoint leaks, align interventions with tourism cycles, and use split-financing to de-risk delivery. Beyond securing potable water, the approach lowers pumping energy and emissions, strengthens drought preparedness, and offers a ready-to-adopt toolkit and operating model for other island and shoreline utilities facing climate-driven water stress.

3. Pilot Project profiles

This section describes realization of all 6 pilot projects within the WP2: Catalysing Climate Resilience of Communities through Pilot Projects in 5 thematic fields: governance od climate change in community, climate data management, citizen science and participation at adaptation, combating urban heat islands and water scarcity in coastal areas.

3.1. Pilot Project in Košice

Main pilot goal

Improve data governance for decision-making and increase the availability of local climate data for the public—especially for education and awareness—by monitoring climate indicators at up to 10 outdoor school sites and visualizing them via an open digital dashboard.

Pilot overview

The pilot's overarching goal is simple and city-pragmatic: improve data governance for decision-making while making local climate data openly available for education and public awareness. It does this through three pillars: (1) monitoring climate indicators at up to 10 outdoor school sites, (2) creating an education program that uses the data in regular lessons, and (3) publishing a friendly public dashboard integrated with Košice's Open Data platform.
This "measure-learn-act" loop aligns directly with the city's Adaptation Plan and supports the Climate City Contract under the EU Mission for Climate-Neutral and Smart Cities—so the work in schoolyards also scaffolds city-level action.
Based on the city's risk and vulnerability analysis, the project team selected school locations in hotter, more exposed parts of Košice. Indicators monitored include particulate matter (PM10), nitrogen dioxide (NO_2), carbon monoxide (CO), air temperature idicators and wind idicators.

TUKE and Košice city stood up an Azure-based pipeline (IoT Central/Hub) that streams readings into the municipal Open Data environment, enabling daily exports and simple widgets for school websites and internal screens. This technical stack underpins the public dashboard where anyone can explore values, impacts on people and the environment, and recommended behaviours.
Cooperation launched with seven elementary schools, each treated as its own community. The Košice city and TUKE convened a co-creation workshops to define how schools want to use data—pedagogically, strategically, for community engagement, and for spatial micro-interventions like shading and greening.

TUKE and teachers co-developed an education program for the 2025/26 school year. Ready-to-use worksheets show how to bring live climate data into Physics, Biology, Chemistry, and Civic Education, building students' digital and analytical skills while keeping lessons tied to real places.

The "Climate data monitoring" dashboard doesn't just plot lines; it explains what the indicators mean, why they matter for health and the environment, and what residents can do. It draws directly from datasets published on Open Data Košice, closing the loop between sensors, city systems, and citizen understanding.

Pilot achievements & highlights

Košice climate pilot ties sensors to lessons, dashboards to open data, and open data to community micro-actions. It's a digitally heavy solution by design (no direct nature-based installations in the pilot), but it deliberately points toward nature-based responses—shade, trees, permeable surfaces—guided by measured conditions at each school.

A city-university-schools system for local climate monitoring and education was moved from concept to operation: seven school-based stations were installed (Jan 2025), data flows into the City's Open Data platform via Azure IoT, a public "Climate data monitoring" dashboard was developed and tested, and a curriculum-linked education program was co-created with teachers for the 2025/26 school year. Customized school dashboards for on-premise displays and a replication toolkit (co-creation agenda, commissioning checklist, communication guidance) were planned to support scale-up and igniting citizens ownership.

Pilot KPI review

Evaluation dimension	Specific KPI	KPI Target value	Reached KPI value	Comments
Usability of solution				
Relevance	Pilot solution design is accepted by regional stakeholders.	4 stakeholders accepted the Pilot design	4	Reference to strategic documents in the pilot status report 01.
Coherence	Pilot solution is aligned with implementation of climate adaptation strategies or policies on local/regional level.	2 strategies	2	Reference to strategic documents in the pilot status report 01.
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	1 solution maintenance document	1	Reference to strategic documents in the pilot status report 03.
Up-scaling of solution				
Integration	Cross-Platform Compatibility - Pilot digital solution is compatible with at least 1 digital platform	1 digital platform compatible with the solution	1	Reference to strategic documents in the pilot status report 03.
Community Awareness building				
Trainings & Dissemination events	Education programme for capacity building of target groups is created	1 education programme	1	Reference to strategic documents in the pilot status report 03.

Lessons learned

Bringing school leaders and teachers in from day one turns the pilot from a “city project at schools” into a “school project for the city.” Early, genuine involvement builds ownership and motivation, improves data use in lessons and school life, and makes the approach easier to transfer to other schools. That ownership translates into motivation—teachers bring data into class discussions, principals champion the project to parents, and students start asking sharper questions. It also improves transferability: once the approach is co-designed, it’s easier to replicate at other schools because the model already reflects real classroom needs and routines.

Air quality and weather stations are only as trustworthy as their placement. Avoiding mutual interference requires thoughtful mounting (clear airflow, distance from walls/vents, stable power/connectivity). Plan for a commissioning check and, if needed, timely replacement of faulty units.

Publishing school-level climate data can unintentionally stigmatize specific schools or neighbourhoods. Emphasize learning and action—what this means for student health today, which simple steps help (e.g., timing outdoor activities, opening windows, planting shade), and how microclimates differ even across short distances.

Dashboards and open data gain real value when embedded in teaching. Education is the sustainability lever that keeps the project alive after the pilot window closes. Lesson plans and student projects build skills and awareness and create a feedback loop where communities understand the data and act on it—an approach that can be replicated elsewhere.

3.2. Pilot Project in Maribor

Main pilot goal

Deploy and test NBS at bus stops to reduce heat-stress exposure, improve micro-climate and citizen well-being, generate open climate datasets, and create a replicable model for other city locations.

Pilot overview

Maribor is testing a simple but powerful idea: make bus stops greener and smarter to cool the city and make everyday life more comfortable. Under the MISSION CE CLIMATE initiative, the municipality and its partners are turning heat-exposed transit shelters into small nature-based solutions (NBS), pairing living roofs and planters with sensors that track micro-climate and air quality. The goal is twofold—ease heat stress for people who spend time at stops and generate open data the city can use to replicate what works.

The pilot's focal point is the Vetrinjska Street bus stop, one of the busiest in the city. Here, the team prepared a conceptual design and costs, secured cultural-heritage consent, aligned with concessionaires, and drew up tender specifications for both the green infrastructure and a suite of IoT sensors. To keep momentum while formal approvals and procurement ran their course, the city also greened several other central shelters. This "learn by doing" step yielded practical lessons, kept the public engaged, and helped de-risk installation at the flagship site.

Bus stops were chosen because they gather many people—kids, commuters, and older adults—often with little shade during peak heat. Green roofs and planters can lower surface and ambient temperatures, add a touch of biodiversity, and make the wait noticeably more pleasant. But the pilot isn't just about aesthetics; it's about evidence. Sensors will measure air temperature and humidity, particulates (PM2.5/PM10), gases such as ozone, carbon monoxide and nitrogen dioxide, rainfall, solar radiation, and wind. By comparing treated and untreated locations, the city will build a clear picture of how much cooling and comfort the interventions deliver under real conditions.

Despite the inevitable administrative choreography, tangible progress is visible. Urban equipment for the pilot site has been delivered, greening at several central shelters is already in place, and installation of the Vetrinjska site's NBS and sensor package is prepared. A pre-installation on-site survey captured the experiences and needs of 200 citizens; a follow-up survey will gauge how perceptions change once the green roofs, planters, and monitoring are operating. The city will publish the resulting datasets openly through its platform, turning a single pilot into a reusable knowledge asset.

Pilot achievements & highlights

Maribor's pilot directly targets heat-exposed micro-sites—bus stops—by combining nature-based solutions (NBS) with digital monitoring, an approach that is both place-specific and scalable. Green roofs and added vegetation at shelters provide shading, evapotranspiration, and biodiversity gains that cool the immediate micro-climate and improve comfort for frequent users, including vulnerable groups.

What makes the method innovative is the tight integration of NBS and IoT. Sensors at treated and untreated stops will stream 11 climate and air-quality datasets (e.g., temperature, humidity, PM2.5/PM10, O_3, CO, NO_2, rainfall, solar radiation, wind) as open data into the city platform. This turns a physical intervention into evidence-driven adaptation, enabling before/after analysis, public transparency, and data-guided replication across additional sites.

The pilot is also systems-aware: it aligns with Maribor's climate strategies, secures heritage and traffic approvals, and coordinates with concessionaires—showing how to deliver NBS in complex urban settings. Where administrative steps caused delays, the team greened alternative shelters to maintain learning and citizen visibility, demonstrating an agile model for incremental roll-out.

In short, the pilot exemplifies the thematic topic by mitigating urban heat islands through innovative, data-validated NBS, embedded in local policy, co-created with stakeholders, and designed for replication city-wide.

Pilot KPI review

Evaluation dimension	Specific KPI	KPI Target value	Reached KPI value	Comments
Usability of solution				
Relevance	• No. of strategic documents identifying the local needs.	3	3	Reference to strategic documents in the pilot status report 01.
Effectiveness	• No. of interventions with NBS solutions. • No. of climate datasets coming from sensors.	2 3	2 11	Reference to No. of interventions with NBS solutions in the Pilot status report 03 (description of Activity 10). Reference to No. of climate datasets coming from sensors in the Pilot status report 03 (description of Activity 12).
Efficiency	• No. of exploited assets (assets already used in another project such as open data portals).	1	1	Reference to No. of exploited assets (assets already used in another project such as open data portals) in the Pilot status report 03 (description of Activity 12).
Impact	• More green infrastructure in public spaces. • Improved well-being of citizens. • Pilot case possible to replicate in other locations in the city with the continued collection of data. • Improved micro-climate on the pilot site (better air quality and lower temperature).	1 (yes) 1 (yes) 1 1 (yes)	1 1 1 1	Reference to KPIs in the Pilot status report 03 (description of Activity 12).
Up-scaling of solution				
Adaptability	• No. of different NBSs to choose from in the process of the pilot definition (*several different greening suggestions make it easier to adapt the solution*).	3	3	Reference to different NBS in the pilot status report 01.
Community Awareness building				
Community Engagement	• No. of people participated in a survey (no. of citizens involved). • No. of stakeholders involved in the planning of the pilot action (solution).	100 10	200 15	No. of people participated in a survey: Reference to No. of people participated in a survey in the pilot status report 03. No. of stakeholders involved in the planning of the pilot action (solution): Reference to No. of stakeholders in the pilot status report 01, 02 and 03.

Lessons learned

The implementation of the Maribor pilot project faced several challenges typical for innovative urban initiatives. Establishing collaboration among diverse stakeholders and acquiring new external knowledge required significant time, making project processes longer than initially planned. The pilot was highly dependent on external experts due to the specific technical and environmental expertise needed, while limited project funding restricted the scope of implementation. Spatial interventions were further constrained by strict regulations and the need for approval from heritage, urban planning, and architectural authorities, which also limited opportunities for citizen involvement in site and design decisions. Integrated urban solutions demanded additional resources and coordination across multiple services. Although transferring good practices from elsewhere was helpful, they were not always suitable for the local context.

Administrative and approval procedures on public sites often caused timeline shifts, emphasizing the need for flexibility in planning. Interim actions, such as greening alternative bus shelters, were valuable for maintaining visibility and stakeholder engagement during delays. Complex and lengthy public procurement processes also affected the overall schedule. Despite these challenges, early partial implementations and continuous communication with stakeholders and the public helped sustain momentum, gather useful feedback, and adapt subsequent project phases effectively.

The work is a true multi-actor effort. The Municipality of Maribor leads, with the Regional Development Agency for Podravje – Maribor as a key partner. Urban planners, utilities and maintenance services, bus stop and street-furniture concessionaires, universities, and specialized suppliers are all part of the mix. That breadth brings strength—and complexity. Coordinating timelines, navigating heritage and traffic rules, and aligning multiple procurement processes have stretched schedules and forced design iterations. Those challenges shaped a core lesson of the pilot: plan for extra time, be ready to adapt, and use interim actions to keep learning and stakeholder buy-in alive.

3.3. Pilot Project in Dornbirn

Main pilot goal

Quantify and clearly demonstrate how nature-based solutions—especially tree shade and unsealed surfaces—reduce urban heat stress in Dornbirn, and turn those measurements into actionable, public-facing insights (via CityMonitor) that guide municipal planning and raise citizen awareness.

Pilot overview

The Dornbirn pilot (Vorarlberg, AT) is a city-level demonstration that uses a LoRaWAN sensor network to quantify how nature-based solutions—especially tree shade and unsealed surfaces—cool urban spaces and reduce heat stress. Installed in and around Kulturhauspark (including a heat-island reference at the basketball court), the sensors record air temperature, relative humidity, and infrared surface temperature, from which perceived temperature (heat index) is calculated.

Early measurements show meaningful cooling effects (roughly ~5 °C lower perceived temperature and up to ~27 °C lower surface temperature in shaded/vegetated spots versus sealed areas in sun), illustrating the value of existing trees as a fast, measurable intervention. The project was co-created with the City of Dornbirn and FHV: after scoping and procurement through P1–P4, sensors were installed in April 2025 and data collection is ongoing.

Results are visualized for policymakers and citizens through the CityMonitor dashboard, informing spatial planning and awareness-raising. The solution is modular and scalable; additional use cases with the city's resilience team (e.g., fire brigade) and enhanced visualizations (incl. a 3D model and sealed vs. unsealed comparisons) are in development. Outreach has included media coverage and conference showcases, with a public event planned for early 2026, while risks around site suitability, data quality, and procurement have been managed through close coordination and staged implementation.

Pilot achievements & highlights

The Dornbirn pilot has moved from concept to execution and public impact: sensors were procured (order confirmed 13 Mar 2025), installed in April, and are now continuously collecting air temperature, humidity, and surface temperature data in Kulturhauspark and the adjacent heat-island basketball court, with results visualized on the CityMonitor platform for citizens and decision-makers.

Early readings clearly quantify cooling from trees and unsealed surfaces (≈4.78 °C lower perceived temperature; up to 27.2 °C lower surface temperature; ≈6.9 °C lower air temperature on a representative hot day), underscoring the value of shade and permeable surfaces and the heat retention of sealed areas at night. The pilot has been showcased widely—poster session at FHV's UDay (25 Jun 2025), coverage by ORF and Die Presse, and an accepted presentation at Naturgefahrentagung (6–8 Oct 2025) featuring a 3D model comparison—building local awareness and policy relevance, with a public event planned at inatura Dornbirn (www.inatura.at) in early 2026.

Operationally, the team completed site selection, overcame procurement delays, and established a maintainable measurement regime with regular site visits; methodologically, they aligned indicators with municipal systems and documented lessons on data compatibility and sensor-quality vs. density trade-offs.

Strategically, KPIs for usability and effectiveness are met (digital solution live; UI/UX defined with City + provider), replicability and scalability are underway (modular dashboard, expanding sensor network), and new use-cases with the city's resilience team (incl. fire brigade) are being implemented—positioning the pilot as a template for city-scale rollouts.

Pilot up-scale scope

Through the risk workshop and the pilot study, the team for disaster control in Dornbirn expressed the interest in an improved access to data and especially, in data visualization to enable better-informed decision-making in emergencies. As part of the measures described, selected climate resilience and disaster control-related content was integrated into and processed by the existing data and visualization platform of the city of Dornbirn (Citymonitor). The aim was to structure existing data sources, integrate additional relevant data points, and present them in such a way that they can be used in both operational and strategic contexts.

The implementation was carried out with consistent consideration of the existing technical, organizational, and specialist framework conditions of the city of Dornbirn. The project built on existing sensor technology, existing data flows, and established processes. Vorarlberg has always been exposed to natural hazards, such as flooding and thus, Vorarlberg already has a high level of protection against floods. Nonetheless, climate change intensifies the severity and the frequency of heavy rainfalls. This makes the implementation of robust monitoring and early warning systems not just important, but urgent, which is exactly the focus of this scale-up initiative.

The integration of content into Citymonitor serves to consolidate and supplement existing data sets for the city of Dornbirn and make them consistently usable for different applications. The structured processing of data creates a common overview of the situation, which supports both disaster control and other municipal departments in their decision-making processes.
The integrated content contributes in particular to:

- making climate and disaster control-related information centrally available facilitating the use of data in daily workflows
- making findings from existing measurement and monitoring activities visible – also to citizens
- creating a basis for the further use of data in future projects and use cases

Citymonitor acts as a central platform for consolidating, visualizing, and interpreting relevant data without replacing existing systems.

Two use cases were developed in iterative formats with the innovation management team of the city of Dornbirn and the city's emergency services:
Use Case A – Water levels and flood monitoring
Use Case B – Local weather data and microclimate
Both use cases are described in more detail in Pilot Project Supplementary report

Pilot KPI review

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution:			
Relevance	• Raises awareness of importance and effectiveness of nature-based solutions	1	Achieved - within the municipality, but also regarding the wider public
Coherence			
Effectiveness	• Implementation of digtial solutions, supporting nature-based approaches	1	Achieved - pilot study has been implemented; UI/UX guidelines were defined as cooperation between FHV/Dornbirn City & implemented with solution provider weavs/CityMonitor
Impact	• Assessment of micro-climate at the pilot study site, affected by nature-based solutions • Possibiltiy to replicate	1	Assessment of data is still ongoing Microclimate is not relevant for the upscale of the pilot study (different thematic focus). However, the possibility to replicate is given, since the integrated content is designed in such a way that future use cases can build on the same data structures. It should be emphasized that the entire solution is transferable and was not implemented as a stand-alone solution. The packages can be used by surrounding

			municipalities/cities, for example, thus supporting inter-municipal data exchange and cooperation.)
Up-scaling of solution			
Scalability & Replicability	• The scalability of the pilot study is given	1	Achieved – Modularity was implemented a key concept in the requirements assessment; the relevant data can be extended as modules across the CityMonitor platform and embedded in other solutions, including solutions targeted at Citizen awareness raising / citizen science. Through the upscale of the pilot, the scalability is achieved.
Community Awareness building			
Community Engagement	• An event will be organized to disseminate the results	1	Achieved – the pilot study was disseminated through 2 conducted workshops and site visits with relevant city officials, one workshop with the firebrigade, and a poster session at the Uday on the 25th of June. Further, the results will be presented at the Naturgefahrentagung in Dornbirn from the 6th until the 8th of October. Addtionally, another dissemination event is planned for the beginning of 2026 at the Inatura in Dornbirn. Moreover, the pilot study was disseminated through local media outlets. (achieved 5)

Lessons learned

Nature-based solutions (NBS) measurably cool cities, but surface type matters as much as shade—sealed areas retain heat (even overnight), while unsealed/vegetated areas enable cooling via infiltration and evapotranspiration. Methodologically, comparability is everything: place sensors in one park under similar macro-weather to isolate effects; plan for data compatibility with existing systems; and balance sensor quality vs. density given budget.

Operationally, schedule regular site visits for uptime and data integrity, and be mindful that wording shapes understanding — position this as a *digital solution supporting NBS* to avoid confusion. For delivery, public-sector procurement rules (≥3 quotes) can shift timelines; factor this into critical paths. For impact, visualization is as critical as measurement—clear dashboards translate technical readings into decisions and build awareness; the modular setup also supports scaling and replication across the CityMonitor platform and beyond.

The up-scale was initially not planned, thus the scale-up is a deviation of the original paln. However, heat and changes in the water cycle were identified as two of the main climate risks for the region and thus, it is extremely useful that through the Mission CE Climate project both climate risks were addressed and that the scalabiltiy of the pilot study was already demonstrated within the project`s lifetime.

3.4. Pilot Project in Pforzheim

Main pilot goal

Develop and implement a Citizen Toolkit focused on environmental monitoring and engagement within the Pforzheim area. This toolkit aims to empower citizens to contribute data and insights using IoT sensors, thereby fostering community participation in smart city initiatives and promoting environmental stewardship.

Pilot overview

The Pforzheim/Northern Black Forest pilot designs, tests, and scales a Citizen Toolkit for environmental monitoring that lets residents, students, and public bodies gather and use local climate/urban data via low-power IoT sensors and a shared enerchart dashboard over LoRaWAN (TTN/ChirpStack). Prototyped use cases include water-level (flood) monitoring, indoor/outdoor air quality, noise, soil humidity (with custom housings and payload decoders), indoor ambience/urban microclimate (with shielding tests), and traffic radar/people counting; each was deployed and integrated into dashboards.

The quintuple-helix team spans Hochschule Pforzheim, krumedia, WFG Nordschwarzwald, the City/municipalities, and citizens. After feasibility and prototyping in early–mid 2024 (including a v1 DIY toolkit), pilot operations and data collection continued through 2025 with a student campaign and a large public presentation on 6 May 2025 (~250 attendees), which triggered demand for a follow-up. Progress shows a robust, scalable architecture and strong stakeholder acceptance; main issue was theft of early water-level devices, with replacements/anti-theft hardening planned.

Interim KPIs indicate positive relevance, effectiveness, and impact—especially engagement—while formal efficiency and satisfaction metrics will be quantified next. Next steps are to complete the citizen-science rollout across the region, secure/replace water sensors, iterate the toolkit and dashboards based on 2025 learnings (e.g., shielding, decoders, alerting), measure KPIs rigorously (including surveys and telemetry), and host a Q4 results session to map a 2026 replication roadmap.

Pilot achievements & highlights

The pilot delivered a working end-to-end civic-sensing stack—LoRaWAN devices feeding an enerchart dashboard—validated in real conditions across five use cases (water level, air quality, noise, soil humidity, and indoor/urban microclimate). Most sensors have been running continuously; only early water-level units were lost to theft, prompting plans for secured replacements.

A “v1 Citizen Toolkit” with step-by-step guides was produced, with updates queued from subsequent field learnings. The approach for a wider citizen-science rollout was set with local partners, and a public presentation on 6 May 2025 drew roughly 250 attendees, surpassing awareness goals and generating demand for a follow-up. Data is already informing practical decisions—such as road-salt silo logistics, flood preparedness, green-space care, urban climate tracking, and mobility flows.

Key lessons include the robustness and scalability of LoRaWAN and the need for stronger device security. Interim KPIs indicate strong relevance and smooth technical operation, with user satisfaction to be quantified as the rollout expands. Overall, the pilot progressed from feasibility to stable, real-world sensing with a documented, citizen-ready toolkit and clear momentum for regional scaling.

Pilot KPI review

Evaluation dimension	Specific KPI	KPI Target value	Interim reached KPI value	Comments
Usability of solution				
Relevance	Pilot solution design is accepted by regional stakeholders.	2	Qualitatively achieved	Strong qualitative feedback: All regional stakeholders expressed satisfaction and acceptance during interviews and events. No negative feedback registered so far.
Coherence	Number of local/regional/national/EU strategies the pilot is aligned with.	2	Qualitatively achieved	Stakeholder and public feedback highlight the high relevance of the solution for local challenges; citizen science highly valued.
Effectiveness	Error Rate Percentage	2	Qualitatively achieved	Qualitative discussions and strategy mapping confirm alignment; final mapping to be completed as the project matures.
Efficiency	Task Completion Time	To be defined	Technically achieved	All technical components functioned without significant errors throughout pilot phase; stakeholders reported smooth operation during live demonstrations and daily use.
Impact	User satisfaction score	To be defined	Technically achieved	Processes from sensor setup to data handling run smoothly and quickly; both experts and citizen users report the system is efficient and easy to use.
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	> 85%	Qualitatively achieved	All user responses during demo and events have been strongly positive; formal survey to be conducted after broader deployment.
Up-scaling of solution				
Scalability & Replicability	Replication Success Rate Definition: The percentage of attempts to replicate the pilot project's solutions or interventions in other contexts or locations that have been successful, indicating the replicability and transferability of the project.	To be defined	n.a.	Too early for KPI values; initial conversations with other cities and institutions show strong interest; groundwork for upscaling is positive.
Community Awareness building				
Community Engagement	Increase in Public Awareness Definition: The percentage increase in public awareness and understanding of the pilot project's objectives, activities, and benefits over a specified period	100 participants	Qualitatively achieved	Over 250 participants at main event; public enthusiasm and high engagement, especially regarding the citizen science component.
Educational & guidance materials	Citizen DIY toolkit	1	Qualitatively achieved	Toolkit well received; positive feedback from citizens, requests for more comprehensive guides noted, and further materials planned.

Lessons learned

Key lessons from the Pforzheim/Northern Black Forest pilot are that LoRaWAN is technically robust and cost-efficient for civic sensing, with The Things Network accelerating setup, security, and community scaling; this combination reliably supported real-time monitoring across use cases and is well suited for broader replication. Equally important, technology only creates impact when paired with citizen participation: engaging students and residents as sensor installers and informed users turned data into timely actions (e.g., salt-silo logistics, flood readiness, soil care, mobility insights) and built digital literacy and ownership.

The project also learned that user-centric dashboards are essential—they convert raw streams (air quality, soil moisture, traffic, occupancy) into understandable trends and alerts that inform municipal and everyday decisions. Operationally, clear roles, steady communication, and contingency plans matter; the theft of early water-level sensors highlighted the need for hardened deployments and rapid replacement strategies.

Finally, the pilot underscored the value of iterative improvement and early KPI discipline—documenting usability, coherence with local strategies, and satisfaction while more quantitative metrics (error rates, task times, replication success) mature during scale-up.

3.5. Pilot Project in Lignano Sabbiadoro

Main pilot goal

Institutionalize an inclusive, participatory climate-governance model in Lignano Sabbiadoro that turns co-created plans (beginning with Porto Casoni regeneration and the Urban Green Management Plan) into implementable actions, strengthening flood/heat resilience while building broad citizen awareness and acceptance.

Pilot overview

The Lignano Sabbiadoro pilot embeds participatory climate governance into everyday municipal practice by coupling strategic planning with hands-on co-creation and public communication. Centered on three strands:

1. Co-design of regeneration solutions for the flood-prone Porto Casoni area,
2. Drafting and adoption of a citywide Green Management Plan with an accompanying regulatory framework,
3. Public sustainability festival "Lignano 180°" Sustainability Festival that translates technical work into civic engagement

The pilot mobilizes municipal leaders, APE FVG, and a broad set of local stakeholders. It has delivered an approved masterplan for Porto Casoni, advanced the Green Plan from concept to implementation, and proven that well-curated public events can boost awareness and acceptance. Key lessons are the value of early, structured participation, pairing strategies with operational rules, and using culture and communication to sustain momentum. Next steps focus on finalizing and socializing the Green Plan's regulations, securing implementation funding for Porto Casoni, and institutionalizing the festival as an annual platform for climate action.

Pilot achievements & highlights

The Lignano Sabbiadoro pilot has delivered three standout results:

- Fully co-designed regeneration pathway for the flood-prone Porto Casoni area, culminating in a Masterplan approved by the City Council in October 2024 after an intensive participatory process that mapped 16 key stakeholder groups across ~20 meetings—building rare consensus and social licence for implementation while the municipality pursues funding.
- Citywide Green Management Plan developed by an external expert team and approved on 17/04/2025, with work now advancing on a participatory regulatory framework and targeted dissemination so the plan's rules, standards, and responsibilities can be operationalized.
- The launch of Lignano 180°, a two-day sustainability festival (13-14/06/2025) that drew around 800 participants and showcased both the Green Plan and Porto Casoni process—turning technical climate work into a civic conversation and positioning the city to make the festival annual. Together, these actions prove the pilot's core value: institutionalizing inclusive climate governance that couples strategic planning with public engagement to strengthen resilience and community buy-in.

Pilot KPI review

Evaluation dimension	Specific KPI	KPI Target value	KPI value reached	Comments
Usability of solution				
Relevance	Number of climate risk hotspots identified within the SECAP and the Risk & Vulnerability Assessment performed under Mission CE Climate addressed by the pilot demo actions	2	5 (fires, heat waves, flooding from rainfall/overflowing/storm surges)	Reference in planning documents for demo action (i) and (ii)
Effectiveness	Implementation of executive project for Porto Casoni Adoption of Green Management Plan	1 1	1 0	Approved in City Council (Giunta Comunale) Approved by the City Council on 17.04.2025
Impact	Reduced number of flood events Enhanced quality of ecosystem services provided by urban green spaces Promotion of information campaigns and awareness events	0 Climate parameters to be identified +20% usability by citizens and tourists 2 events / year	TBD TBD TBD 2 events in 2024 (1 information campaign + 1 awareness events)	Flood monitoring system Long-term assessment of ecosystem services Attendance sheet and pictures
Up-scaling of solution				
Integration	Number of measures which integrates technological, social, economic, environmental systems. All foreseen demo actions embrace a multidisciplinary perspective.	3	2 (Porto Casoni Masterplan and Urban Green Plan)	Planning documents for demo action (i) and (ii); programme for demo action (iii)
Community Awareness building				
Community Engagement	Number of people participating in the participatory processes for demo action (i) and (ii) Number of people participating in demo action (iii)	> 50 >100	60-70 >150	Attendance sheet and pictures Pictures

Lessons learned

The pilot showed that early, structured participation is decisive for trust, legitimacy, and durable buy-in—Porto Casoni's co-design proved that engaging 16+ stakeholder groups upfront turns a contested site into a shared project. Strategy must be paired with operations and outreach: the Green Management Plan only becomes real when backed by a clear regulatory framework and proactive communication that brings citizens into the rules they'll live with.

Integration multiplies impact: the Lignano 180° festival connected planning, place-based participation, and public narrative, making climate governance as much cultural as technical. Visible political ownership (mayor/councillor presence) sustained credibility and attendance, and cross-actor coordination (municipality, consultants, APE FVG, regional bodies) proved essential. Pilot actions are catalysts, not endpoints: approval triggers the harder work (funding builds, regulation, and continued engagement) while timelines must anticipate external procedures (e.g., added Strategic Environmental Assessment requirements).

Together, these lessons define a replicable model: plan with people, codify the "how," communicate relentlessly, and treat pilots as stepping stones to long-term, adaptive governance.

3.6. Pilot Project in Island of Brač

Main pilot goal

Reduce non-revenue water/distribution losses on Brač's public water network by **at least 10%**—using modern metering, telemetry, and systematic leak detection—to boost drought resilience, service reliability, and energy efficiency.

Pilot overview

The MISSION CE CLIMATE pilot on Croatia's island of Brač strengthens climate-resilient water management by cutting distribution losses in the public network. Led by Split-Dalmatia County with EIHP and Vodovod Brač, the project replaced aging turbine meters with magnetic-inductive meters, added a portable ultrasonic meter, and expanded a telemetry-enabled logger fleet, forming a dedicated Water Loss Unit to run a leak-detection workflow (sector isolation, loggers/vibrophones, geophone pinpointing).

Equipment was jointly financed and installed across 15 key reservoirs representing most of the island's storage, with night-time works minimizing service disruption. Procurement concluded in late 2024; installations and on-site training ran through early 2025, followed by validation and a public pilot presentation in September 2025. Despite budget pressure, a split-financing approach and flexible procurement mitigated delays. Early results show losses reduced from roughly 26% to about 20%, on track toward ~15%, meeting the ≥10% reduction KPI and aligning with regional climate and energy plans.

The pilot also achieved its communication goals through stakeholder events and citizen guidance materials, and it has produced a standardized, replicable toolkit for other utilities. Next steps focus on completing a 12-month validation dataset, embedding methods in verification tools, and scaling dissemination to at least ten regional water companies.

Pilot achievements & highlights

The Brač pilot delivered a step-change in climate-resilient water management by replacing aging turbine meters with 15 magnetic-inductive meters, adding a portable ultrasonic meter, and expanding a telemetry logger network (with a new Water Loss Unit to run systematic leak detection). All procurements and installations were completed with night-time works to avoid service disruption, staff were trained on site, and split financing between the county and utility safeguarded delivery despite budget pressure. Early operational results show distribution losses cut from roughly 26% to about 20%—surpassing the project's ≥10% reduction KPI and trending toward ~15%—while improving service reliability and energy/operational efficiency.

The team met outreach targets through stakeholder events, citizen guidance, and a public pilot presentation in September 2025. With a validated workflow and toolkit now in place, the pilot is positioned for replication across regional utilities as the 12-month performance validation and broader dissemination continue.

Pilot KPI review

Evaluation dimension	Specific KPI	KPI Target value	Interim reached KPI value	Comments
Usability of solution				
Relevance	SECAP of the island of Brač and Annual report on the condition of the water supply system of the Brač water supply system	Annual report, implementation of SECAP	0	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. To be implemented by the end of 2025-SDŽ
Coherence	A number of local/regional/national/ European strategies the pilot is aligned with?	2 strategies	Done	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. SECAP and Split-Dalmatia County Climate Change Mitigation and Adaptation Program
Effectiveness	Recorded losses in the water supply system in the pilot area	Reduction of losses by 10%	Done	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. See verification.
Evaluation dimension	Specific KPI	KPI Target value	Interim reached KPI value	Comments
Up-scaling of solution				
Integration	Integration of pilot project results (verification of adaptation measures report) into the new tools for verifying adaptation measures.	1	0	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. To be implemented by Vodovod Brač the end of 2025-SDŽ
Scalability & Replicability	Number of water supply companies in the region that are familiar with the results of the project	10	0	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. To be reached by the end of 2025.webinar organized by SDC
Community Awareness building				
Community Engagement	People familiar with pilot project implementation and results on adaptation to climate change.	30	Done (50)	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. The two promotional events organized on the 25-26.9 Brač (see KPI below)
Trainings & Dissemination events	Number of organized dissemination events	2	Done (2)	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. Prvi 1.10.2024. 25-26.9 Brač Attendance list. Mission CE Climate presentation to local stakeholder. Participation on the local festival FLAG Supetar. news, video, photo
Educational & guidance materials	A number of dissemination materials (articles, news, reports...)	5	Done (more than 5)	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. Online pilot project presentation on the web, LinkedIn, promotion material-A guide for households, providing island and county residents with practical advice on reducing energy and water consumption.

Lessons learned

Key lessons from the Brač pilot center on planning, data, and people. Upfront split-financing and staged procurement de-risked budget erosion and supply-chain delays, while pre-installation electrical/metal works and night-time interventions minimized service disruption.

Magnetic-inductive meters proved far more reliable than aged turbine meters—especially at low flows—when paired with a denser logger network and a clear leak-detection workflow (isolation → logging → vibrophone/geophone pinpointing). Data quality is pivotal: establish a clean baseline, instrument priority nodes first, and allow a full seasonal cycle for validation before declaring savings.

Creating a dedicated Water Loss Unit accelerated response times and ensured that new tools (including the portable ultrasonic meter) were used. Integration with existing SCADA/telemetry should be planned early, with simple dashboards for operators. On an island system, logistics and timing matter—schedule heavy works outside the tourist peak and keep spare parts and alternative specs/vendors ready.

Stakeholder engagement (utility staff training, municipal briefings, citizen guidance) increases acceptance and sustains results. For replication, start small with the highest-leverage reservoirs, standardize documentation and KPIs, and treat the pilot as a living testbed that continuously feeds operational playbooks for other utilities.

4. Pilots`implementation evidence

Annex 1: Detailed evidence of implementation of pilot in Košice
Annex 2: Detailed evidence of implementation of pilot in Maribor
Annex 3: Detailed evidence of implementation of pilot in Dornbirn
Annex 4: Detailed evidence of implementation of pilot in Pforzheim
Annex 5: Detailed evidence of implementation of pilot in Lignano Sabbiadoro
Annex 6: Detailed evidence of implementation of pilot in Island of Brač
Annex 7: Pilot Project Supplementary report of pilot in Dornbirn

D.2.4.1 Validation of demonstrated results

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MISSION CE CLIMATE

Pilot Assessment Report
Validation of demonstrated solutions
D.2.4.1.

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1. Introduction

This document represents the outputs of the joint assessment of pilots by Advisory Board of MISSION CE CLIMATE project. It forms the baseline for elaboration of deliverable D.2.4.1: Validation of demonstrated solutions.

2. Members of Advisory Board

The Advisory Board (AB) of the Mission CE Climate project functions as a strategic and scientific sounding board, ensuring the relevance, quality, coherence with EU climate and energy policies, and the practical impact of the project's activities and outputs. The Board supports the project consortium by providing independent expert advice, policy-oriented insights, and constructive feedback on methodological approaches, implementation progress, and the overall strategic direction of the project.

The Advisory Board has been established at the project level and is composed of representatives from key technical project partners, including EIHP, E-zavod, TUKE, FHV, APE-FVG, and Krumedia. Through its work, the Board contributes to strengthening the project's credibility, external visibility, and long-term sustainability by integrating perspectives from EU policymaking, climate science, public authorities, industry, finance, and regional development.

Table: Members of the Advisory Board present at the final meeting in Lignano Sabbiadoro

Partner (Country)	Advisory Board Member
Krumedia (DE)	Luc Schmerber
E-zavod (SI)	Katerina Ivanovska
E-zavod (SI)	Matjaž Gerl
TUKE (SK)	František Janke
TUKE (SK)	Marek Kolarčik
APE-FVG (IT)	Martina Arteni
APE-FVG (IT)	Chiara Tringali
EIHP (HR)	Ilja Drmač
EIHP (HR)	Ivona Prar

The Advisory Board convened during project reporting periods 3, 4, and 5. Its activities commenced at the project meeting held in Split on 1 October 2024. During this meeting, project partner TUKE, acting as the Work Package 2 leader, introduced the MIRO-based presentation and peer-review tool. This online tool was used to support structured peer review of pilot projects, including the provision of comments and recommendations related to pilot implementation, verification processes, definition of relevant KPIs, and identification of lessons learned.

Subsequent Advisory Board meetings and peer-review sessions were held in person during project meetings in Split (1–2 October 2024), Pforzheim (26–27 February 2025), and were concluded in Lignano Sabbiadoro (1–2 October 2025). The peer assessment process was successfully completed, with the final exchange workshop organised in Lignano Sabbiadoro. All feedback, recommendations, and conclusions were consolidated and documented within the MIRO board of the Mission CE Climate project.

3. Island of Brač

3.1. KPIs evidence

Evaluation dimension	Specific KPI	KPI Target value	Interim reached KPI value	Comments
Usability of solution				
Relevance	SECAP of the island of Brač and Annual report on the condition of the water supply system of the Brač water supply system	Annual report, implementation of SECAP	0	The target value for KPIs is exp to be reached in Period 5 afte full implementation of the project. To be imnplemente the end of 2025-SDŽ
Coherence	A number of local/regional/national/ European strategies the pilot is aligned with?	2 strategies	Done	The target value for KPIs is exp to be reached in Period 5 afte full implementation of the project. SECAP and Split-Dal County Climate Change Miti and Adaptation Program
Effectiveness	Recorded losses in the water supply system in the pilot area	Reduction of losses by 10%	Done	The target value for KPIs is exp to be reached in Period 5 afte full implementation of the project. See verification.

Evaluation dimension	Specific KPI	KPI Target value	Interim reached KPI value	Comments
Up-scaling of solution				
Integration	Integration of pilot project results (verification of adaptation measures report) into the new tools for verifying adaptation measures.	1	0	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. To be implemented by Vodovod Brač the end of 2025-SDŽ
Scalability & Replicability	Number of water supply companies in the region that are familiar with the results of the project	10	0	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. To be reached by the end of 2025.webinar organized by SDC
Community Awareness building				
Community Engagement	People familiar with pilot project implementation and results on adaptation to climate change.	30	Done (50)	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. The two promotional events organized on the 25-26.9 Brač (see KPI below)
Trainings & Dissemination events	Number of organized dissemination events	2	Done (2)	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. Prvi 1.10.2024. 25-26.9 Brač Attendce list. Mission CE Climate presentation to local stakeholder. Participation on the local festival FLAG Supetar. Objave, video, fotke...
Educational & guidance materials	A number of dissemination materials (articles, news, reports...)	5	Done (more than 5)	The target value for KPIs is expected to be reached in Period 5 after the full implementation of the pilot project. Online pilot project presentation on the web, linkin, Web, linked, promotion material-A guide for households, providing island and county residents with practical advice on reducing energy and water consumption.

3.2. Lessons learned

Vodovod Brač took a proactive role in organizing a dedicated department for water loss detection and adapting the setup of meters to account for seasonal tourist fluctuations. Despite unexpected price variations in equipment procurement, the company contributed financially to ensure the project's success, initially planned to be fully funded by the Mission CE Climate project. The equipment is now actively used to detect leaks, reducing water losses and energy consumption in the supply system.

Two key challenges emerged during the project implementation: fluctuations in equipment prices and the poor condition of existing infrastructure. Price variations during the research and procurement phase resulted in fewer devices being purchased through the Mission CE Climate project than initially planned. However, Vodovod Brač recognized the project's importance and stepped in to co-finance the missing equipment, demonstrating its commitment to improving water loss detection. Additionally, the company organized a dedicated team of three professionals to focus on this initiative, highlighting the project's positive impact on the water supply company.

The second challenge arose during the installation of metering equipment when it became evident that the existing pipes and infrastructure were in poor condition. To ensure the effectiveness of the new meters, Vodovod Brač opted to replace the outdated components, creating a fully upgraded system better suited for accurate water loss detection.

The results of this project not only highlight immediate water and energy savings but also serve as a model for other water supply companies, showcasing the benefits of small-scale investments. Plans for dissemination include presentations and events to share findings with other companies and the local community. Additionally, the project aligns with broader regional and national climate strategies, such as the SECAP and the Split Dalmatia County Climate Change Mitigation Program. A longer project duration would have allowed for more extensive data collection and leak repairs, leading to even greater benefits. The financial feasibility of such projects, with a quick return on investment, suggests that future initiatives could be supported through regional, national, or European funding programs.

4. City of Lignano Sabbiadoro

4.1. KPIs evidence

PILOT TITLE:	[insert Pilot title]	
Specific KPI	**KPI delivery status**	**Advisory Board comments & recommendations**
Number of climate risk hotspots identified within the SECAP and the Risk & Vulnerability Assessment performed under Mission CE Climate addressed by the pilot demo actions.	5 (fires, heat waves, flooding from rainfall/overflowing/storm surges)	NA

Implementation of executive project for Porto Casoni	1	NA
Adoption of Green Management Plan	1	Strengthen Public Engagement in Green Regulation - While the Green Regulation is being developed, more citizen participation should be integrated, ensuring the community understands and supports new sustainability rules
Reduced number of flood events	NA	This KPI was selected as a parameter to assess the impact of the Masterplan for Porto Casoni in the long term and in view of introducing a flood monitoring system
Enhanced quality of ecosystem services provided by urban green spaces	NA	This KPI was selected as a parameter to assess the impact of the Green Managament Plan in the long term
Promotion of information campaigns and awareness events	2 events in 2024 (1 information campaign + 1 awareness raising event); 2 events in 2025 achieved (1 information campaign + 1 knowledge sharing/awareness raising event) + 2 planned	NA
Number of measures which integrates technological, social, economic, environmental systems. All foreseen demo actions embrace a multidisciplinary perspective.	3 (Porto Casoni Masterplan, Urban Green Plan and Lignano180 Festival)	NA
Number of people participating in the participatory processes for demo action (i) and (ii) **Number of people participating in demo action (iii)**	60-70 for demo action (i) About 800	

4.2. Lessons learned

The implementation of the three demo actions under the Mission CE Climate pilot project in Lignano Sabbiadoro — the participatory regeneration of Porto Casoni, the development of the Green Management Plan, and the launch of the Lignano 180° Festival — has provided valuable insights into how local climate governance can be made more inclusive, adaptive, and future-oriented. Each action brought forward practical and strategic lessons that will inform not only the next phases of the project, but also future initiatives by the Municipality and other partners.

1. Civic participation and dialogue build ownership and trust

Across all three demo actions, especially in the Porto Casoni participatory process, it became clear that early and meaningful stakeholder involvement is key to building trust, transparency, and collective ownership. By engaging over 16 stakeholder groups through one-to-one meetings, interviews, and public events, the Municipality succeeded in creating a sense of shared responsibility around the regeneration of a vulnerable and high-value area.

The process demonstrated that civic engagement can lead to better, more accepted outcomes, even when interests differ. Moreover, participants expressed appreciation for being treated not merely as recipients of decisions, but as active contributors to shaping their territory — a milestone for the local administration, which adopted such an inclusive approach for the first time.

Moreover, without civic participation, the results of the actions would not have been as successful, in particular in the case of Porto Casoni. By successful, we mean that the proposed regeneration plan gained legitimacy, public support, and social relevance — essential ingredients for its long-term viability. The participatory approach ensured that the outcomes reflected the needs, values, and aspirations of the local community. Without this shared ownership, the plan would likely have faced resistance, limited recognition, and a lack of local buy-in, ultimately compromising both its implementation and impact.

2. Strategic planning needs operational tools and public awareness

The experience of developing the Green Management Plan highlighted that while strategic documents are essential to guide climate adaptation and the sustainable use of green infrastructure, they must be accompanied by clear regulatory frameworks and communication strategies to ensure real impact. A plan's success depends not only on its content, but also on how well it is understood, shared, and implemented over time.

A key lesson from this action is that technical planning and public engagement must go hand-in-hand. The lack of dissemination immediately following the Plan's approval delayed broader citizen involvement. This gap is now being addressed through the upcoming launch of a participatory process, aiming to connect planning with people's lived experiences and expectations.

3. Integrated approaches amplify impact

The Lignano 180° Festival served as a powerful integrator of all three demo actions. By bringing together experts, citizens, institutions, and designers in a shared space for learning and dialogue, the festival helped connect the dots between high-level strategies (like the Green Management Plan), concrete participatory actions (like Porto Casoni), and wider public debate.

The Festival illustrated that climate governance is not only a technical challenge, but also a cultural and communicative one. Turning sustainability into a shared civic narrative — supported by technical content,

site visits, and cultural moments — helped raise awareness and position the city as a forward-looking, inclusive, and resilient coastal community.

4. Institutional commitment is key to success

In all three demo actions, the active involvement of the Municipality of Lignano Sabbiadoro, including direct participation of political representatives (the responsible Councillor in the first place), proved critical. Their visible and consistent support reinforced the credibility of the processes and encouraged stakeholder participation.

Institutional leadership also enabled cross-sectoral collaboration — for instance, between municipal departments, external consultants, APE FVG, and regional authorities — demonstrating that climate governance requires cooperation across levels and disciplines.

5. Pilot actions are catalysts, not endpoints

Finally, the pilot demonstrated that demo actions should be seen as catalysts for broader transformation, not as standalone projects. The Porto Casoni Masterplan, now approved, still requires funding and further support for implementation. The Green Management Plan needs a robust regulatory base and continued civic engagement. And the Lignano 180° Festival, while highly successful in its first edition, is now envisioned as a recurring annual event to keep the momentum alive.

A core lesson is that resilience-building is a continuous process, where long-term vision, institutional continuity, and adaptive governance mechanisms must evolve together.

5. City of Dornbirn

5.1. KPIs evidence

Evaluation dimension	Specific KPI	KPI Target value	
Usability of solution			
Relevance	Raises awareness of importance and effectiveness of nature-based solutions	1	Achieved - within the municipality, but also regarding the wider public
Effectiveness	Implementation of digital solution supporting nature-based solutions in urban areas	1	Achieved - pilot study has been implemented; UI/UX guidelines were defined as cooperation between FHV/Dornbirn City & implemented with solution provider weavs/CityMonitor
Impact	Improved micro-climate at the pilot study site Possibiltiy to replicate	1	Since only the effect of existing trees was measured and no new trees were planted, we did not have an effect on the micro-climate, we only measured

			the effect of nature-based solutions on the micro-climate. The possibility to replicate is given (large-scale project is already ongoing)-

Evaluation dimension	Specific KPI	KPI Target value	
Up-scaling of solution			
Scalability & Replicability	The scalability of the pilot study is given	1	Achieved - Modularity was implemented a key concept in the requirements assessment; the relevant data can be extended as modules across the CityMonitor platform and embedded in other solutions, including solutions targeted at Citizen awareness raising / citizen science. Further, expansion of the sensor network and dashboard is already ongoing.

Evaluation dimension	Specific KPI	KPI delivered	
Community Awareness building			
Community Engagement	An event will be organized to disseminate the results	5	The pilot study was disseminated through 2 conducted workshops and site visits with relevant city officials, one workshop with the firebrigade, and a poster session at the Uday on the 25th of June. Further, the results were presented at the Naturgefahrentagung in Dornbirn from the 6th until the 8th of October. Addtionally, another dissemination event is planned for the beginning of 2026 at the Inatura in Dornbirn. Moreover, the pilot study was disseminated through local media outlets.

5.2. Lessons learned

At the project partner meeting in Split (October 2025), the Dornbirn pilot received targeted feedback aimed at refining its design before full implementation. Partners praised the methodological foundation of the pilot—measuring perceived temperature using multiple indicators—but recommended broadening the spatial scope by adding diverse measurement sites and clearly justifying site selection for better replicability and

communication. Suggestions included integrating the data into open data platforms, cross-referencing with external datasets, and encouraging citizen participation through perception-based inputs. The importance of robust dissemination strategies was emphasized, both for public engagement and policymaker influence. Overall, the pilot is seen as having strong potential to deliver valuable microclimatic insights if diversity, transparency, and replicability are prioritized in final preparations.

During the partner meeting in Pforzheim (February 2025), further recommendations were gathered to fine-tune the Dornbirn pilot's focus and dissemination strategy. It was advised to reframe the pilot description to emphasize digital solutions supporting nature-based interventions, ensuring clarity for broader communication. The results should inform a set of proposed solutions specifically addressing urban heat islands like the pilot's basketball court location, stressing social and health benefits. Dissemination should target both citizens and policymakers, including guidelines for replicating the study, leveraging the Citymonitor platform, and encouraging public input on future study sites. Finally, aligning the pilot with Dornbirn's Smart City initiatives was highlighted to boost visibility and long-term impact, reinforcing the integration of nature-based solutions into broader urban development strategies.

During the partner meeting in Lignano (October 2025), the implemented pilot study was presented and received good feedback. The set-up, the indicators that were measured as well as the way we communicated the results to the public were highlighted as positive feedback. The question was raised, how we had an effect on the micro-climate, which was initially an objective of the pilot. Since we changed the pilot from new trees to measuring the effects of existing trees on surface and air temperature, we did not have an effect on the micro-climate. We only measured the effect of nature-based solutions. Synergies to the pilot with elementary schools were mentioned through the visualisation of the pilot through a 3D model.

6. Municipality of Maribor in cooperation with Regional Development Agency for Podravje - Maribor

6.1. KPIs evidence

PILOT TITLE:	Combating urban heat island at selected micro location - bus stop	
Specific KPI	**KPI delivery status**	**Advisory Board comments & recommendations**
Usability of Solution: **No. of strategic documents identifying the local needs.**	3	During desktop research strategic documents identifying local needs were identified. Strategy and Heat Action Plan for the Municipality of Maribor (Raedy for Heat, Interreg Central Europe, 2024, result of the project) (MEASURE: RAISING AWARENESS AMONG THE POPULATION (M)), MEASURE: EDUCATION AND TRAINING (M) etc.); Local Energy and Climate Concept of Municipality of Maribor (2021) (MEASURE 45: Introduction of bus shelters to provide protection against sun protection at public transport stops (MISSION CE CLIMATE PILOT)); Sustainable urban strategy (2023 – 2035) (PRIORITY 2.1 GREEN PUBLIC OPEN SPACES (measures: increasing green spaces, tree planting and urban forests, integrated management of green spaces and protected areas, green roofs on public buildings, green islands on urban road infrastructure, community gardens, etc.))

		KPI No. of strategic documents identifying the local needs - 3 No. reached in Status report 01: 3 The identification of three strategic documents demonstrates a solid understanding of Maribor's climate and urban needs. The Advisory Board recommends building stronger cross-references between these documents and the pilot's measurable impacts to ensure long-term policy alignment and integration into local planning frameworks. Future updates should emphasize how the pilot contributes to the implementation of the Local Energy and Climate Concept and Sustainable Urban Strategy measures.
Usability of Solution: No. of interventions with NBS solutions.	2	Greening of roofs of bus shelters and additional greenery at the bus stop in planter boxes. No. reached in Status report 03: 2 The pilot successfully implemented two NBS interventions at bus stops, contributing to both thermal comfort and aesthetic improvement. The Advisory Board suggests evaluating long-term maintenance needs and monitoring vegetation performance across seasons to assess durability and scalability. Involving local schools or communities in maintenance could enhance ownership and awareness.
Usability of Solution: No. of climate datasets coming from sensors.	11	Testing of the installed NBS will be implemented on the technical level with continuous measurement of different relevant parameters: Air temperature and Humidity, PM2.5, PM10, O3, CO, NO2, Rainfall, Solar radiation, Wind speed and direction. No. reached in Status report 03: 11 The collection of 11 climate datasets provides a solid data foundation for evaluating NBS effectiveness. The Advisory Board recommends ensuring open access to anonymized datasets via city platforms and promoting data interpretation through citizen-friendly dashboards or workshops. Further calibration and data validation will enhance reliability for replication.
Usability of Solution: No. of exploited assets (assets		After the implementation of the NBS solution and the sensors on the pilot location, together with the IOT solution for data

already used in another project such as open data portals).	1	collection and its integration into the existing city platform to be visible to wider target groups. No. reached in Status report 03: 1 Integration with the existing city IoT platform is an excellent step toward digital continuity. The Advisory Board advises expanding interoperability with regional or national open data platforms to maximize visibility, knowledge exchange, and cross-city comparison.
Usability of Solution: **More green infrastructure in public spaces.**	1	The Impact of the implementation of NBS, measurements and collection of data and survey among citizens will be: more green infrastructure in public spaces; improved well-being of citizens; pilot case possible to replicate in other locations in the city with the continued collection of data; Improved micro-climate on the pilot site (better air quality and lower temperature). Contribution to KPIs in section "Impact". No. reached in Status report 03: 1 The intervention contributes positively to urban greening and climate resilience. The Advisory Board recommends documenting the biodiversity and microclimate benefits quantitatively and including social perception surveys post-implementation to capture public attitudes and perceived comfort improvements.
Usability of Solution: **Improved well-being of citizens.**	1	The Impact of the implementation of NBS, measurements and collection of data and survey among citizens will be: more green infrastructure in public spaces; improved well-being of citizens; pilot case possible to replicate in other locations in the city with the continued collection of data; Improved micro-climate on the pilot site (better air quality and lower temperature). Contribution to KPIs in section "Impact". No. reached in Status report 03: 1 The pilot's focus on comfort at public transport points is highly relevant to climate adaptation. The Advisory Board encourages conducting follow-up surveys to assess whether perceived comfort and satisfaction levels improved after installation. Such data would strengthen evidence on health and social benefits.

Usability of Solution: **Pilot case possible to replicate in other locations in the city with the continued collection of data.**	1	The Impact of the implementation of NBS, measurements and collection of data and survey among citizens will be: more green infrastructure in public spaces; improved well-being of citizens; pilot case possible to replicate in other locations in the city with the continued collection of data; Improved micro-climate on the pilot site (better air quality and lower temperature). Contribution to KPIs in section "Impact". No. reached in Status report 03: 1 The pilot's modular design offers strong replication potential. The Advisory Board suggests developing a brief replication manual and cost-benefit summary to facilitate uptake by other municipalities. Cooperation with local enterprises could support wider rollout under sustainable city programs.
Usability of Solution: **Improved micro-climate on the pilot site (better air quality and lower temperature).**	1	The Impact of the implementation of NBS, measurements and collection of data and survey among citizens will be: more green infrastructure in public spaces; improved well-being of citizens; pilot case possible to replicate in other locations in the city with the continued collection of data; Improved micro-climate on the pilot site (better air quality and lower temperature). Contribution to KPIs in section "Impact". No. reached in Status report 03: 1 The Advisory Board recommends maintaining long-term monitoring to capture seasonal variations and correlating climate data with citizen feedback for a holistic impact evaluation.
Up-scaling of solution:No. of different NBSs to choose from in the process of the pilot definition (*several different greening suggestions make it easier to adapt the solution*).	3	One of the options for NBS was solution of greening the existing bus stop by installing ivy planters and additional greenery. Tthe idea was also of asphalt removing and planting trees or, if this would not be possible, installing additional mobile greening. Different NBS sollutions to choose from: ivy and additional greenery, green roof on bus shelter and additional greenery in planters; green roof on bus shelters and trees planted on a site (asphalt removal) No. reached in Status report 01: 3 Offering three alternative greening solutions (ivy, green roofs, trees/planters) reflects strong design flexibility. The Advisory Board advises testing combinations of these NBSs in diverse micro-locations to refine future interventions and gather comparative performance insights.

Community Awareness building: **No. of people participated in a survey (no. of citizens involved).**	200	As part of the pilot activity, citizens were involved and a survey was conducted at the bus stop (before renovation) in June and July 2025. 200 citizens were involved. They were asked how they felt about the bus stop, given that it is very busy and exposed to high temperatures and what they suggest to improve their well-being and reduce heat load. The analysis of the survey questionnaire was prepared. No. reached in Status report 03: 200 Engaging 200 citizens shows excellent outreach and awareness-building. The Advisory Board recommends summarizing survey findings in accessible visuals and communicating them publicly to enhance transparency and community trust. A second survey after implementation would provide valuable comparative data.
Community Awareness building:No. of stakeholders involved in the planning of the pilot action (solution).	15	KPI No. of stakeholders involved in the planning of the pilot action (solution) – 15 Status report 01: 10 (1 - municipal landscape architect, 2 - representative of Department for Utilities and Traffic, 3- representative of Spatial Planning Sector, 4 – city urbanist, 5 - representative of Association of Youth, 6 - authors of Catalogue of urban equipment of Municipality of Maribor, 7 - representatives of the Faculty of Arts, 8- representatives of the Faculty of Agriculture and Life Sciences, 9 – vice-mayor, 10 – mayor. Status report 02: 3 (1 - representative of concessionaire Europlakat; 2 - representatives of concessionaire Snaga; 3- representative of concessionaire Nigrad) Status report 03: 2 (1- representative of company ATRIVA d.o.o; 1 – representative of company MOGA d.o.o.) The high number and diversity of stakeholders demonstrate effective cooperation. The Advisory Board advises maintaining this engagement network for follow-up monitoring and scaling up the pilot. Future stakeholder mapping could identify underrepresented groups (e.g. transport users, elderly) for inclusion in next phases.

6.2. Lessons learned

The feedback on the Maribor pilot during the exchange workshop in Split in October 2024, focused on greening a key urban bus stop to combat urban heat islands, highlighted both the innovative approach and areas for enhancement. Stakeholders appreciated the awareness-raising efforts and supported further citizen engagement, particularly in capturing perceptions before and after the intervention. Suggestions

included expanding the pilot's scale to more bus stops and even larger public spaces, assessing environmental impacts more systematically, and documenting challenges encountered to support replication. Additional elements such as urban attractors and cooling effect measurements were recommended to strengthen community impact and validate KPIs like biodiversity enhancement and improved thermal comfort. Lessons from administrative and regulatory hurdles could inform policy recommendations, and the pilot was recognized as a strong candidate for interdisciplinary learning and broader replication.

The assessment of the Maribor pilot in Pforzheim in February 2025 emphasized the value of progress made despite challenges, particularly the installation of 10 new bus stops with green-roof potential and active stakeholder engagement. Participants suggested that future impact could be strengthened by formalizing a city-wide "greening bus stops" strategy (Plan B) with broader stakeholder coordination beyond the general public. Emphasis was placed on shifting to a more bottom-up approach to better involve local actors and associations. Stakeholder timing and engagement strategies were highlighted as key lessons, with recommendations to share implementation obstacles transparently and consider well-being surveys as supportive KPIs for future interventions. While regulatory complexity and financial limitations delayed full implementation, the pilot's achievements—such as technical groundwork, interdepartmental collaboration, and integration with ongoing municipal efforts—were acknowledged as a strong foundation for broader replication.

7. Pforzheim

7.1. KPIs evidence

Evaluation dimension	Specific KPI	KPI Target value	Interim reached KPI value	Comments
Usability of solution				
Relevance	Pilot solution design is accepted by regional stakeholders.	2	Qualitatively achieved	Strong qualitative feedback: All regional stakeholders expressed satisfaction and acceptance during interviews and events. No negative feedback registered so far.
Coherence	Number of local/regional/national/EU strategies the pilot is aligned with.	2	Qualitatively achieved	Stakeholder and public feedback highlight the high relevance of the solution for local challenges; citizen science highly valued.
Effectiveness	Error Rate Percentage	2	Qualitatively achieved	Qualitative discussions and strategy mapping

				confirm alignment; final mapping to be completed as the project matures.
Efficiency	Task Completion Time	To be defined	Technically achieved	All technical components functioned without significant errors throughout pilot phase; stakeholders reported smooth operation during live demonstrations and daily use.
Impact	User satisfaction score	To be defined	Technically achieved	Processes from sensor setup to data handling run smoothly and quickly; both experts and citizen users report the system is efficient and easy to use.
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	> 85%	Qualitatively achieved	All user responses during demo and events have been strongly positive; formal survey to be conducted after broader deployment.
Up-scaling of solution				
Integration	N/A	N/A	N/A	Upscaling and integration to be tested as solution matures; positive stakeholder intent for regional replication.
Adaptability	N/A	N/A	N/A	Adaptability across contexts is untested but early discussions with new partners are underway.
Scalability & Replicability	Replication Success Rate Definition: The percentage of attempts to replicate the pilot project's solutions or interventions in other contexts or locations that have	To be defined	n.a.	Too early for KPI values; initial conversations with other cities and institutions show strong interest;

	been successful, indicating the replicability and transferability of the project.			groundwork for upscaling is positive.
Community Awareness building				
Community Engagement	Increase in Public Awareness Definition: The percentage increase in public awareness and understanding of the pilot project's objectives, activities, and benefits over a specified period	100 participants	Qualitatively achieved	Over 250 participants at main event; public enthusiasm and high engagement, especially regarding the citizen science component.
Trainings & Dissemination events		-	Qualitatively achieved	Demand for more public events is high; new events are already being planned for Q4 in light of strong positive public and stakeholder response.
Educational & guidance materials	Citizen DIY toolkit	1	Qualitatively achieved	Toolkit well received; positive feedback from citizens, requests for more comprehensive guides noted, and further materials planned.

7.2. Lessons learned

Over the course of this project, numerous lessons have emerged, encompassing both the technological aspects of IoT deployment and the broader impacts of engaging citizens in data-driven urban and environmental sustainability.

From a technological perspective, the adoption of LORAWAN technology has proven highly advantageous for connecting a diverse array of sensors to a robust, Internet-based dashboard. The long-range, low-power capabilities of LORAWAN enabled the installation of sensors in locations that are traditionally challenging for wired solutions or short-range wireless alternatives. The flexibility and scalability of the network have allowed stakeholders to continuously expand sensor coverage and experiment with new use cases with minimal incremental investment. Notably, LORAWAN's energy efficiency and reliable connectivity have facilitated real-time data collection for applications such as road salt silo management, flood level detection, soil condition monitoring, environmental sensing, and even dynamic crowd and traffic analysis.

Utilizing The Things Network (TTN), an open, global platform, has further accelerated both technology adoption and knowledge sharing. With its suite of accessible tools and strong security features, TTN allowed project teams and citizen collaborators alike to rapidly prototype, test, and scale their IoT applications. The thriving TTN community proved instrumental not only in technical troubleshooting but also in fostering a sense of shared purpose. Local communities across Europe participated in parallel efforts, exchanging

expertise and even integrating data streams, which laid a foundation for future cross-regional collaborations.

Beyond the technical realm, the integration of citizen science emerged as a crucial ingredient for project success and for realizing a deeper dimension of sustainability. Engaging citizens—both as data collectors and informed users—transformed the project from a purely technological exercise into a participatory movement. Citizens actively contributed by installing sensors in their homes, gardens, and workplaces, as well as by responding to emergent insights from the dashboard data. For instance, real-time alerts regarding flood risks or road salt depletion empowered local communities to take preemptive, sustainable actions. The Do It Yourself instructions, which were initially devised during the first campaign, enabled broader public participation and enhanced the project's reach and impact.

The citizen science approach also enriched the educational process, as students and non-experts gained hands-on experience in sensor deployment, data analysis, and digital literacy. This democratization of technology resulted in increased public awareness of sustainability challenges and the value of open data. Participants developed a sense of ownership and agency, recognizing that environmental impact is not solely the domain of experts but something shaped by everyday actions and informed decisions.

On the operational side, several valuable lessons surfaced. The effectiveness of collaboration between krumedia and Hochschule Pforzheim was amplified by clear communication and well-defined roles. Ongoing, routine data collection worked best when both technological and human factors were given equal attention. Challenges—such as the theft of water level sensors—underscored the need for robust security measures and contingency planning. In response, future deployments will emphasize sensor protection and rapid replacement strategies.

Perhaps one of the most significant lessons is the symbiotic relationship between technological advancement and societal involvement. Technology alone cannot drive meaningful or lasting change in urban sustainability. It is the convergence of innovative tools with motivated, informed citizens that has brought about palpable results—from optimized salt logistics and more resilient flood prevention to improved public resource management and greener mobility.

The ongoing analysis and visualization of sensor data through user-centric dashboards proved essential for turning raw numbers into actionable intelligence. For example, continuous records of air quality, soil moisture, traffic density, and public-space occupancy allowed both municipal authorities and everyday citizens to track trends, benchmark progress, and intervene with timely, sustainability-minded actions.

8. Košice city

8.1. KPIs evidence

PILOT TITLE:	[insert Pilot title]	
Specific KPI	**KPI delivery status**	**Advisory Board comments & recommendations**
Pilot solution design is accepted by regional stakeholders.	4 stakeholders accepted the Pilot design	Pilot solution design was accepted by 4 stakeholders of Local Climate Mission in Kosice. The stakeholders confirmed that the solution fulfills the evaluation dimension of Relevance and is in line with the identified development needs and priorities of pilot area. Following stakeholders accepted: City of Kosice

		Technical Universitz of Kosice, Faculty of Economics Klima ta potrebuje, interest group Vychodne pobrezie, civic association
Pilot solution is aligned with implementation of climate adaptation strategies or policies on local/regional level.	2 strategies identified	Pilot solution is aligned with implementation of climate adaptation strategies: Adaptation Plan of the City of Košice for Environmental Change (2022-2030). The adaptation plan is a way in which the city of Košice, under the leadership of the city government, wants to cope with the impacts of climate change and their consequences. Program of economic development and social development of the city of Košice and its functional area 2022-2027. The basic development document of the city of Košice and its districts is drawn up in accordance with Act no. 539/2008 Coll. Regional Development Support Act, as amended. This document considers the goals of sustainable development defined in the 2030 Agenda, it is developed in accordance with the goals and priorities established in the national strategy "Vision and strategy for the development of Slovakia until 2030 long-term strategy for the sustainable development of the Slovak Republic - Slovakia 2030" and considers the goals and priorities established in the development program of the higher territorial unit. The solution of the pilot project is closely related to the development theme - Green development, the priority area Air and noise and to the fulfilment of its goals.
Long-term sustainability of the pilot digital solution is ensured.	1 solution maintenance document created	Individual components of the Mission CE Climate project have been assigned to specific departments and units of the Košice Municipality office. The aim is to ensure clear competencies, effective coordination, and responsibility for the technical, operational, and content-related parts of the solution. Key areas and responsibilities are described in this solution maintenance document.
Cross-Platform Compatibility - Pilot digital solution is compatible with at least 1 digital platform	1 digital platform compatible with the solution created	Cross-platform compatibility is described in the document serving as a comprehensive overview of the solution architecture, key technologies, and implementation plan. The purpose of the document is to describe the technical structure and define the steps necessary for successful implementation—deployment of the technical part of the project.
Education programme for capacity building of target groups is created	1 education programme created	The Technical University of Košice and City of Košice in cooperation with representatives of elementary schools, have prepared an innovative educational program focused on the use of data from climate sensors installed directly in school premises. The aim of the program is to combine modern

		technologies, environmental education, and practical teaching of natural sciences.

8.2. Lessons learned

The climate and air quality pilot implemented in Košice, Slovakia, provided valuable insights into both the technical and organizational aspects of urban environmental monitoring. One of the key lessons learned was the importance of proper sensor placement, as the location of sensors directly affects the accuracy of data collection. In Košice, wind direction and flow proved to be major influencing factors, altering pollution dispersion and measurement results. The pilot also confirmed that long-term monitoring of PM2.5 is necessary for reliable trend analysis, as short-term measurements or focus on PM10 alone may lead to incomplete conclusions. However, expanding high-quality sensor networks remains financially demanding, and cities often lack the resources to do so without external funding. Limited availability and high prices of climate sensors may further constrain the scalability of such initiatives.

Ensuring data reliability and proper validation was another critical takeaway. Errors or inconsistencies in collected data are possible and must be accounted for in analysis. In Slovakia, an additional challenge is that the legislation recognizes only climate data from the official national institution (SHMU), limiting the use of alternative monitoring results. The combination of real-time and uploaded datasets was found to improve accuracy and enhance the understanding of pollution patterns.

The pilot underlined the importance of ongoing communication and collaboration with stakeholders throughout all stages of planning and implementation. Close cooperation with schools, teachers, and local authorities in Košice proved particularly effective. The co-creation process with schools not only engaged young people in environmental education but also emerged as a best practice that can be replicated in other regions. Continuous dialogue helped maintain interest, strengthen community ownership, and ensure more sustainable outcomes.

Another significant finding was the impact of data visualization and presentation. Displaying results through accessible dashboards helped stakeholders understand correlations, such as the link between community behavior and increased local air pollution. These visual insights raised awareness and encouraged behavioral change. Moreover, official documentation and follow-up actions after the pilot were identified as essential for ensuring the sustainability and institutional continuity of the project's achievements.

The experience from Košice also demonstrated the strategic value of environmental data for urban planning and policy development. Integrating monitoring results into broader urban strategies supports better decision-making and fosters greener, healthier urban environments. However, climate data must be communicated carefully to avoid stigmatizing specific schools or neighborhoods, highlighting the need for sensitivity and responsibility in public communication. Regular updates and seasonal comparisons of monitoring results were suggested to enhance understanding of how air quality fluctuates throughout the year.

Finally, the pilot showed that linking long-term sustainability objectives with educational programs is a powerful and replicable model for other regions developing digital climate solutions. The strong collaboration between stakeholders in Košice serves as an excellent example of how data-driven approaches, when combined with community engagement, can foster both environmental awareness and systemic change.

9. Conclusion

The pilot implementations were carried out in 6 different pilot areas across Central Europe: Brač (Croatia), Ligniano (Italy), Dornbirn (Austria), Maribor (Slovenia), Pforzheim (Germany), and Košice (Slovakia). All of them have demonstrated substantial progress toward advancing climate resilience, digital innovation, resource efficiency, and nature-based solutions across diverse geographical, institutional, and climatic contexts. Despite the varying scale, focus areas, and maturity levels of the pilots, the collective results highlight a strong alignment with the project's overarching goals of fostering adaptive capacity, enabling data-driven decision-making, and strengthening cross-sector collaboration in Central Europe.

Overall, the pilots successfully delivered a wide range of activities—from technical monitoring and sensor deployment, to participatory planning, urban greening, microclimate assessments, and large-scale public engagement. These initiatives not only tested innovative solutions but also helped embed new knowledge, capacities, and operational practices within municipal administrations and community networks. Importantly, the majority of pilots demonstrated clear potential for upscaling and replication, either through modular digital tools, transferable interventions, or established stakeholder cooperation structures.

Across all pilots, the delivery of Key Performance Indicators (KPIs) has been generally positive, showing solid achievements in usability, implementation progress, community engagement, and preliminary impact assessment. Many pilots reached or exceeded their KPI targets, particularly in areas related to stakeholder involvement, number of interventions delivered, climate datasets collected, or dissemination activities undertaken. In several cases, the pilots also established important foundations for long-term KPI monitoring—such as the integration of sensor data into municipal platforms, the creation of maintenance documents, and the establishment of educational or participatory programmes. Where KPI targets were not fully measurable within the reporting period (e.g., long-term microclimate improvements, or seasonal vegetation performance), the pilots nonetheless set in place the technical and organisational structures required for continued monitoring beyond the project timeframe. Overall, KPI performance reflects strong commitment, effective coordination, and meaningful progress despite contextual challenges.

A recurring lesson across territories is the role of stakeholder and citizen engagement. Whether through participatory processes, co-creation of educational programmes, workshops with municipal departments, or active involvement in citizen science, each pilot benefited from inclusive approaches that enhanced trust, transparency, and shared ownership. These social components proved critical for ensuring acceptance of proposed solutions, reinforcing behavioural change, and embedding climate considerations into local development cultures.

From a technical and operational standpoint, the pilots revealed both the promise and complexity of deploying digital solutions and nature-based interventions. Several pilots demonstrated strong progress in monitoring climate variables using IoT sensors, leveraging open platforms, or integrating datasets into municipal digital systems. Others highlighted the tangible benefits of small-scale NBS such as green roofs, planters, and tree-based shading, or showed how a small investment in equipment can bring big savings in the water supply network. At the same time, challenges like fluctuating procurement conditions, infrastructure degradation, and the need for clearer regulatory pathways emerged as important factors that must be addressed to ensure long-term impact. These challenges and lessons learned through implementing Mission CE Climate pilots offer valuable insights for improving future implementation strategies, avoiding the mistakes already made, strengthening maintenance plans, and securing political and financial continuity.

Institutional commitment emerged as a critical success factor. Good leadership and interdepartmental cooperation have significantly accelerated progress in multiple pilots, allowing for smoother implementation, better alignment with existing strategies, and early steps toward embedding solutions in long-term urban planning frameworks. The establishment of dedicated teams, integration of new digital

components into existing platforms, and preparation of maintenance and governance structures show promising signs of institutionalization beyond the project duration.

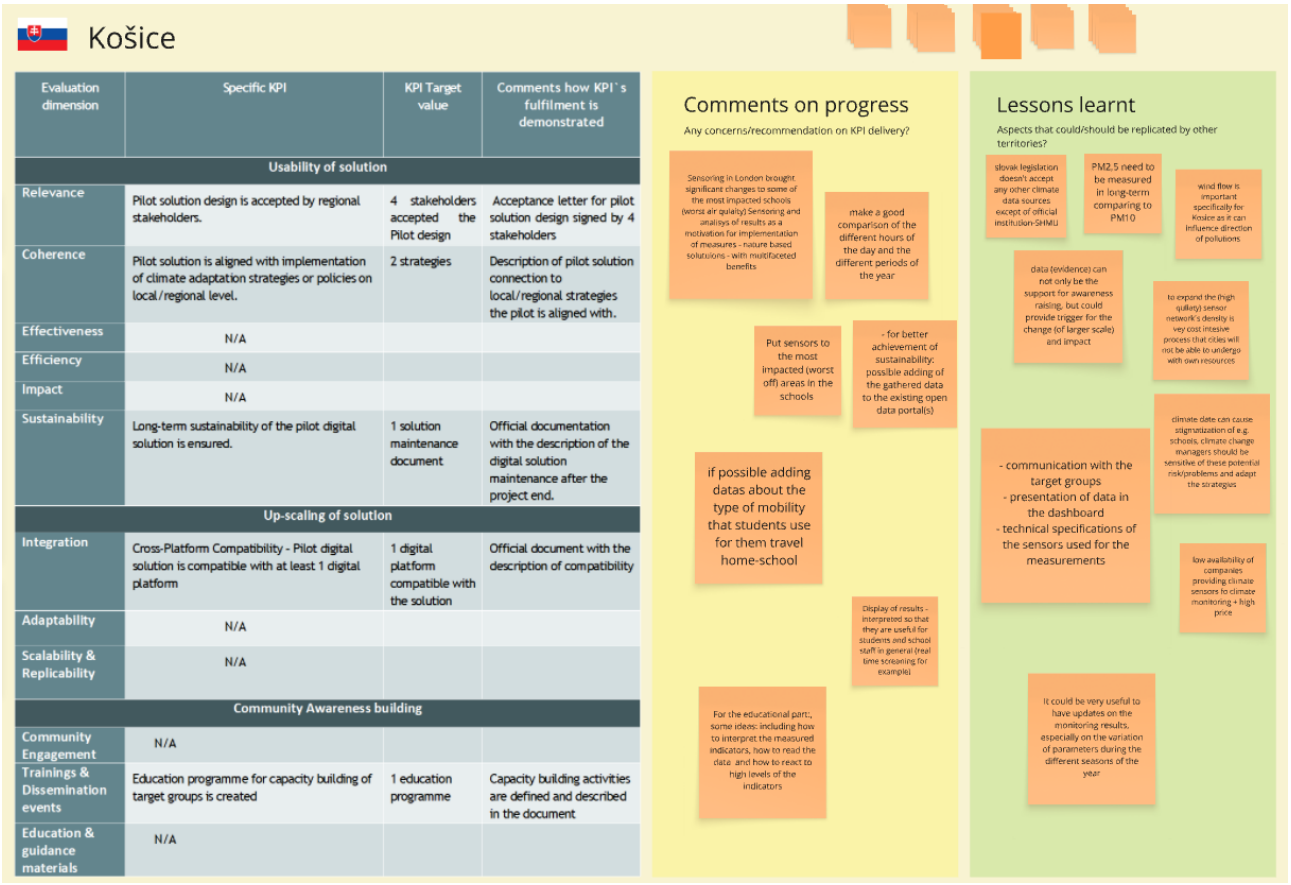
Another important outcome of the pilots is the reinforcement of regional and national policy frameworks. Many pilot actions directly support ongoing climate strategies, Sustainable Energy and Climate Action Plans, adaptation plans, and local development strategies. This alignment ensures both relevance and durability, creating pathways for stronger policy integration, investment planning, and long-term climate governance.

Furthermore, the pilots contributed significantly to capacity building—not only within partner organizations but also among local stakeholders, school communities, and broader publics. Through workshops, surveys, events, site visits, and educational activities, the pilots enhanced environmental awareness and digital literacy, empowered local actors to interpret climate data, and helped establish a culture of shared responsibility. These soft impacts, though less immediately quantifiable, are essential foundations for sustained climate action.

Finally, the cumulative experience of the pilots underscores the catalytic role of Mission CE Climate in stimulating innovation, knowledge exchange, and cross-city learning. The feedback loops generated during partner meetings—in Split, Pforzheim, and Lignano, as well as other exchanges—significantly shaped the refinement of pilot designs and strengthened replicability across regions. This collaborative environment has amplified both the scientific and societal value of the pilots and laid the groundwork for broader replication within and beyond the consortium. They demonstrate that even in the face of financial, technical, or regulatory constraints, targeted investments, active engagement, and adaptive governance can deliver meaningful progress toward climate resilience. The results achieved, the lessons learned, and the strong institutional and community foundations established represent a solid platform for further development, upscaling, and regional dissemination within the Mission CE Climate framework.

10. ANNEXES

10.1. Annex 1: Miro board, Split 2024



Košice

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfilment is demonstrated
Usability of solution			
Relevance	Pilot solution design is accepted by regional stakeholders.	4 stakeholders accepted the Pilot design	Acceptance letter for pilot solution design signed by 4 stakeholders
Coherence	Pilot solution is aligned with implementation of climate adaptation strategies or policies on local/regional level.	2 strategies	Description of pilot solution connection to local/regional strategies the pilot is aligned with.
Effectiveness	N/A		
Efficiency	N/A		
Impact	N/A		
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	1 solution maintenance document	Official documentation with the description of the digital solution maintenance after the project end.
Up-scaling of solution			
Integration	Cross-Platform Compatibility - Pilot digital solution is compatible with at least 1 digital platform	1 digital platform compatible with the solution	Official document with the description of compatibility
Adaptability	N/A		
Scalability & Replicability	N/A		
Community Awareness building			
Community Engagement	N/A		
Trainings & Dissemination events	Education programme for capacity building of target groups is created	1 education programme	Capacity building activities are defined and described in the document
Education & guidance materials	N/A		

Comments on progress

Any concerns/recommendation on KPI delivery?

Sensoring in London brought significant changes to some of the most impacted schools (worst air quality) Sensoring and analisys of results as a motivation for implementation of measures - nature based solutions - with multifaceted benefits

make a good comparison of the different hours of the day and the different periods of the year

Put sensors to the most impacted (worst off) areas in the schools

- for better achievement of sustainability: possible adding of the gathered data to the existing open data portal(s)

if possible adding datas about the type of mobility that students use for them travel home-school

Display of results - interpreted so that they are useful for students and school staff in general (real time streaming for example)

For the educational part:, some ideas: including how to interpret the measured indicators, how to read the date and how to react to high levels of the indicators

Lessons learnt

Aspects that could/should be replicated by other territories?

slovak legislation doesn't accept any other climate data sources except of official institution-SHMU

PM2,5 need to be measured in long-term comparing to PM10

wind flow is important specifically for Kosice as it can influence direction of pollutions

data (evidence) can not only be the support for awareness raising, but could provide trigger for the change (of larger scale) and impact

to expand the (high quality) sensor network's density is vey cost intesive process that cities will not be able to undergo with own resources

climate date can cause stigmatization of e.g. schools, climate change managers should be sensitive of these potential risk/problems and adapt the strategies

- communication with the target groups
- presentation of data in the dashboard
- technical specifications of the sensors used for the measurements

low availability of companies providing climate sensors fo climate monitoring + high price

It could be very useful to have updates on the monitoring results, especially on the variation of parameters during the different seasons of the year

Maribor

Evaluation dimension	Specific KPI	KPI Target value	Comments on how KPI's fulfilment is demonstrated
Usability of solution			
Relevance	• No. of strategic documents identifying the local needs.	3	• In the pilot report - the reference to strategic documents.
Coherence			
Effectiveness	• No. of interventions with NBS solutions. • No. of climate datasets coming from sensors.	2 3	• In the pilot report - the reference to the no. of interventions and the no. of data sets.
Efficiency	• No. of exploited assets (assets already used in another project such as open data portals).		• In the pilot report - the reference to the no. of exploited assets.
Impact	• More green infrastructure in public spaces. • Improved well-being of citizens. • Pilot case possible to replicate in other locations in the city with the continued collection of data. • Improved micro-climate on the pilot site (better air quality and lower temperature).	1 (yes) 1 (yes) 1 1 (yes)	• In the pilot report - the reference to green infrastructure in public spaces. • In the pilot report - the reference to the survey results regarding the change in the well-being of citizens. • In reports connected to Activity 2.3 Transnational pilot replication system. • In the pilot completion report - the reference to the measurements from the pilot site.
Sustainability			
Up-scaling of solution			
Integration			
Adaptability	• No. of different NBSs to choose from in the process of the pilot definition *(several different greening suggestions make it easier to adapt the solution)*.	3	• In the pilot report - the reference to the no. of different NBS solutions
Scalability & Replicability			
Community Awareness building			
Community Engagement	• No. of people participated in a survey (no. of citizens involved). • No. of stakeholders involved in the planning of the pilot action (solution).	100 10	• In the pilot report - the reference to the no. of people participating in a survey and the no. of stakeholders involved.
Training & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

- It would be good to get information on perception of current bus stop from citizens to be able to later comepare the preception of old and ndew
- Scaling up, not only to more bus stations but also to bigger public buildings/areas
- How can a scale-up be achieved (to more bus stops), what are the main roadblocks here
- Recomenadtion for simplyfing the negotiations and enabling better collaboartion could be written up based on lessones learned
- what are the environmental impacts that you've expected / what has been achieved with the current roll-out?
- Maybe the difficulties of implemensing the pilot can be shared to the public
- do a strong marketing campaign to explain why you did it
- maybe could be interesting to put in evidence the gap of the temperature under the bus stop roof from before (now) and after the green intervent
- Comparing the progress of NbS/ bus stops (Maribor - Ljubljana) could be interesting
- could be interesting to add some attractors (ping pong fields, benches, etc.) to evidence that is also a good place to stay and a comunity generator
- awareness raising infoboards at the bus stop
- a list of various NBS solutions for greening bus shelters could be useful for other expereminets in this area
- 180 m2 it is almost small park area, if You add drinking fountain, it could be finally also case study and meinorial of winning of the cross departmental bariers within administration

Lessons learnt

Aspects that could/should be replicated by other territories?

- Share the effect it had on people
- It's a "small" intervent that could be an interesting topic for incerdisciplinary (architecture, botanic, etc.) university workshops

Dornbirn

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	- Raises awareness of importance and effectiveness of nature-based solutions	1	- Achievable temperature reductions will be shown
Coherence			
Effectiveness	- Implementation of digtial and nature-based solution	1	- Implementation of the pilot study
Efficiency			
Impact	- Improved micro-climate at the pilot study site - Possibiltiy to replicate	1	- Achievable temperature reductions shown - Dissemination event
Sustainability			
Up-scaling of solution			
Integration			
Adaptability			
Scalability & Replicability	- The scalability of the pilot study is given	1	- Assessment of whether the pilot study can be replicated an up-scaled
Community Awareness building			
Community Engagement	- An event will be organized to disseminate the results	1	- Dissemination event took place
Trainings & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

- Include also third location for measurement with indicators - parking places with sem vegetative permeable pavers profiles.
- aim to check several different types of surfaces/micro-environments
- Connect it to other benefits (health, biodiversity)
- put in evidence why you choose that place for the datas collection
- - for better achievement of sustainability: possible adding of the gathered data to the existing open data portal(s)
- Are you considering combine this exact data with citizen data and feeling maps?

Lessons learnt

Aspects that could/should be replicated by other territories?

- collect several temperature indicators for assessing perceived temperature, for indicating human well-being on hot days -> air temperature, surface temperature and humidity
- After evaluation of results, a comparison of collected data with open data portal(s) to compare microclimate mapping (match/mismatch?) will be one of the next steps
- Assuming there will be benefits from disseminating the result - show the benefits of dissemination and informing people
- location planning is important: finding a place with many different micro-environments (different surfaces, shaded and non-shaded areas
- design the pilot in a way that it can be replicated on other locations for data evidence of decision making (e.g. promoting nature-based solutions)

Pforzheim

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	Pilot solution design is accepted by regional stakeholders.	2	Pilot implementation reports
Coherence	Number of local/regional/national/EU strategies the pilot is aligned with.	2	Pilot is alinged both with Smart City strategy and climage resilienc eplan of Pforzheim. Extension to the Northern Balck Forest region is aimed for.
Effectiveness	**Error Rate Percentage** Definition: The percentage of user interactions or transactions that result in errors or failures within the pilot project's interface or applications, indicating the reliability and effectiveness of the system.	To be defined	Error rate data will be collected through system logs or error reporting mechanisms, capturing instances of user errors, system glitches, or transaction failures. The error rate percentage will be calculated based on the total number of errors detected relative to the total number of user interactions, and trends will be monitored to identify areas for improvement.
Efficiency	**Task Completion Time** Definition: The average time taken by users to complete specific tasks or transactions within the pilot project's interface or applications, indicating the efficiency of the user experience.	To be defined	Task completion time data will be collected automatically through system logs or user interactions tracking mechanisms integrated into the pilot project's infrastructure. The data will be analyzed to identify trends and improvements in task efficiency over time.
Impact	**User Satisfaction Score** A quantitative measure of users' satisfaction with the usability of the pilot project's interface, services, or applications, obtained through surveys or feedback mechanisms.	> 85%	User satisfaction scores will be collected through post-implementation surveys or feedback forms distributed to pilot project participants. The scores will be aggregated and analyzed to assess overall user satisfaction levels.
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	Description of maintencna of the digital solution	Official document

Comments on progress

Any concerns/recommendation on KPI delivery?

- Technical solution well in place
- Citizen science approach still to be implmented
- Technical solution well in place
- Public awareness will only be achieved later with the roll-out of the citizen science approach

Lessons learnt

Aspects that could/should be replicated by other territories?

- LoRaWAN networks are well distributed across European cities. They work well for colleting data.
- Low-cost (relatively) solutions for sensors do exist
- DIY instructions (IKEA-type of descriptions) work well.
- Scientific support (Pforzheim University in thsi case) is very helpful and supports awarenees raising among studetns
- Opportunities for synergies with Smart city strategies and budgets

Lignano di Sabbiadoro

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI 's fulfillment is demonstrated
Usability of solution			
Relevance	Number of climate risk hotspots identified within the SECAP and the Risk & Vulnerability Assessment performed under Mission CE Climate addressed by the pilot demo actions	2	Reference in planning documents for demo action (i) and (ii)
Coherence			
Effectiveness	• Implementation of executive project for Porto Casoni • Adoption of Green Management Plan	• 1 • 1	• City Council approval • City Council approval
Efficiency			
Impact	• Reduced number of flood events • Enhanced quality of ecosystem services provided by urban green spaces • Promotion of information campaigns and awareness events	• 0 • Climatological parameters to be identified • +20% usability by citizens and tourists • 2 events / year	• Flood monitoring system • Long-term assessment of ecosystem services • Attendance sheet
Sustainability			
Up-scaling of solution			
Integration	Number of mesures which integrates technological, social, economic, environmental systems. All foreseen demo actions embrace a multidisciplinary perspective.	3	Planning documents for demo action (i) and (ii); programme for demo action (iii)
Adaptability			
Scalability & Replicability			
Community Awareness building			
Community Engagement	Number of people participating in the participatory processes for demo action (i) and (ii) Number of people participating in demo action (iii)	> 50 >100	Attendance sheet
Trainings & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

Governance aspect should be central and emhasised though this pilot - highlight your processes (what went well, what were the challanges, cross-sectoral collaboartion)

how the assessment of ecosystem services will be performed? This description should be maybe part of the Impact indicator output

Lessons learnt

Aspects that could/should be replicated by other territories?

Involving the public and local stakeholders is an essential approach to decision making. Where there are multiple interests to consider, participatory approaches should be the norm. Climate resilience issues should always take into account the needs and ideas of stakeholders in order to find a common strategy to address them.

The participatory process carried out in Porto Casoni to regenerate an urban area exposed to sea-level rise is an example of well-managed climate governance: the key stakeholders were identified, met and listened to in order to find the most appropriate way to regenerate the port area in the face of climate risk. Several meetings were held, but in the end they appreciated the municipality's efforts to involve them in the decision-making process and expressed their gratitude for being listened to and involved for the first time.

Splitsko-Dalmatinska County

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	SECAP of the island of Brač and Annual report on the condition of the water supply system of the Brač water supply system	Annual report, implementation of SECAP	Analysis of annual report data
Coherence	A number of local/regional/national/ European strategies the pilot is aligned with?	2 strategies	Pilot action aligns with SECAP of the island of Brač, Split Dalmatia County Climate Change Mitigation Program.
Effectiveness	Recorded losses in the water supply system in the pilot area	Reduction of losses by 10%	Annual report by Vodovod Brač
Efficiency			
Impact			
Sustainability			
Up-scaling of solution			
Integration	Integration of pilot project results (verification of adaptation measures report) into the new tools for verifying adaptation measures.	1	This will be determined by the end of the project. So far, no tools are available.
Adaptability			
Scalability & Replicability	Number of water supply companies in the region that are familiar with the results of the project	10	Presentation of the project results (mail, live events, meetings...)
Community Awareness building			
Community Engagement	People familiar with pilot project implementation and results on adaptation to climate change.	30	Participant list signed, the pictures of events, a letter of support...
Trainings & Dissemination events	Number of organized dissemination events	2	Presentation on the official company site and social media.
Education & guidance materials	A number of dissemination materials (articles, news, reports...)	5	Number of materials

Comments on progress

Any concerns/recommendation on KPI delivery?

- cost of commodity (water) will change
- load capacity of pipelines for the island should be considered (peak season)
- consider the end of the pilot project - it is September 2025, not April 2026 - how this will affect the KPI of Effectiveness?
- someone has to pay the water consumption - swimming pools topic - need for regulation in the future
- tariff for water - suggestion to cover the cost for water looses by subsidies from government

Lessons learnt

Aspects that could/should be replicated by other territories?

10.2. Annex 2: Miro board, Pforzheim 2025

Košice

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfilment is demonstrated
Usability of solution			
Relevance	Pilot solution design is accepted by regional stakeholders.	4 stakeholders accepted the Pilot design	Acceptance letter for pilot solution design signed by 4 stakeholders
Coherence	Pilot solution is aligned with implementation of climate adaptation strategies or policies on local/regional level.	2 strategies	Description of pilot solution connection to local/regional strategies the pilot is aligned with.
Effectiveness	N/A		
Efficiency	N/A		
Impact	N/A		
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	1 solution maintenance document	Official documentation with the description of the digital solution maintenance after the project end.
Up-scaling of solution			
Integration	Cross-Platform Compatibility - Pilot digital solution is compatible with at least 1 digital platform	1 digital platform compatible with the solution	Official document with the description of compatibility
Adaptability	N/A		
Scalability & Replicability	N/A		
Community Awareness building			
Community Engagement	N/A		
Trainings & Dissemination events	Education programme for capacity building of target groups is created	1 education programme	Capacity building activities are defined and described in the document
Education & guidance materials	N/A		

Comments on progress

Any concerns/recommendation on KPI delivery?

consider to make an assessment of the externalities that may have an influence on the air quality (traffic, factories, business, ...) negatively impacting the surrounding of the schools and share these data with the local administration to foster informed decision-making

Integration into national meteorological network

Analisys of PM particles on their origin (traffic, biomass etc.), upraling with sensors for alergens.

Communication about possible solutions to lower air pollution with parents/kids/school staff

discovered higher leverage of awareness and engagement also to defend interest of schools in Kosice

showing correlation between actions/activities influencing air-polution for raising awareness

Lessons learnt

Aspects that could/should be replicated by other territories?

Interesting for communities/ schools in Slovenia

Similar IT solution as in the Slovenian pilot

Good collaboration of all stakeholders

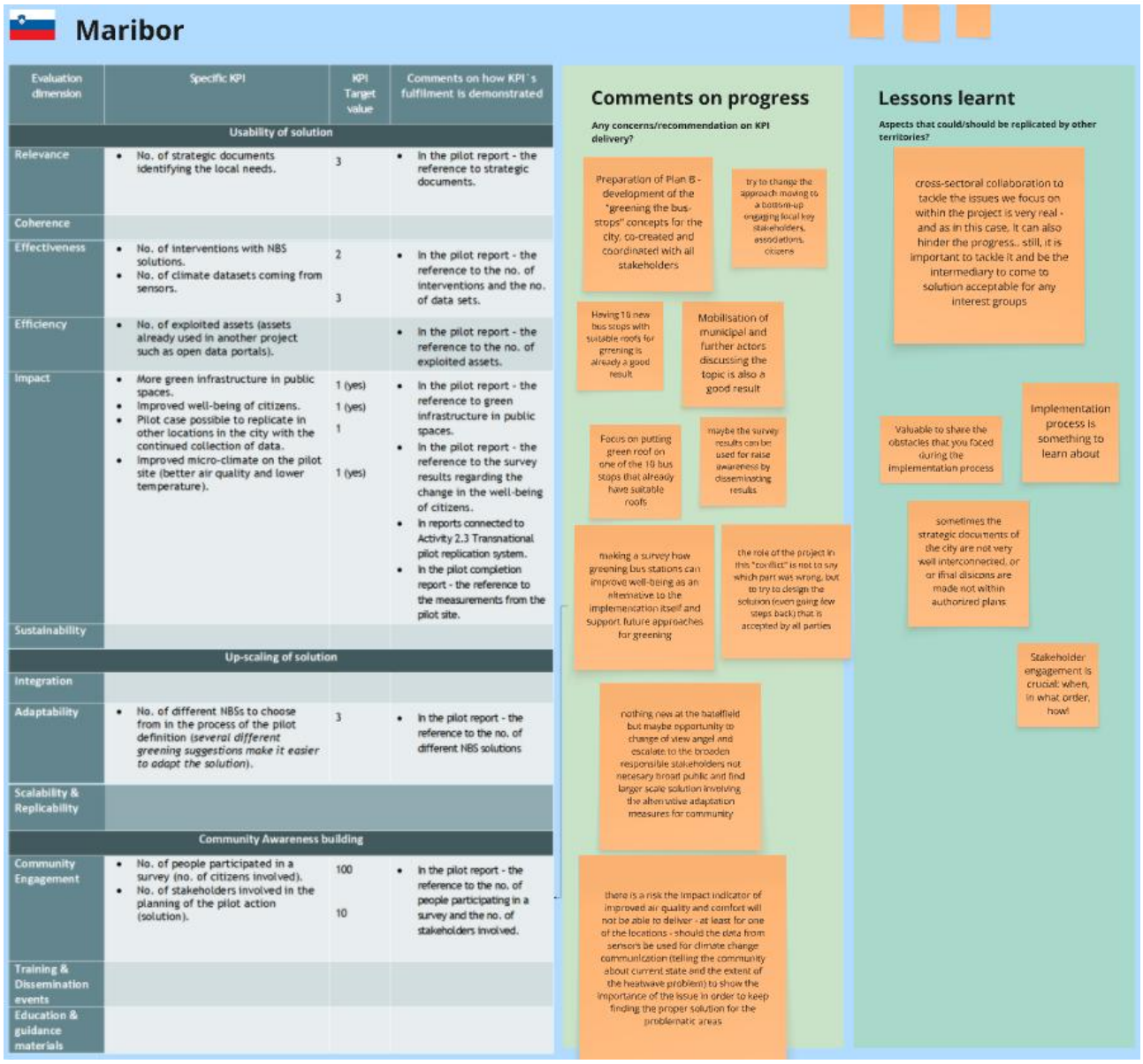
importance of real and uploaded datas to think about possible solution

transferring the model of co-creation process with schools in other pilot activities, as best practice

interconnection between the KPIs "long-term sustainability" and "education programm" is a good approach and has potential for other regions with digital solutions in their pilots

good approach to e.g. show correlation between parents bringing their kids to school by car

in general: showing clear correlations for raising awareness is a good lesson learnt for other digital solution pilots



Maribor

Evaluation dimension	Specific KPI	KPI Target value	Comments on how KPI`s fulfilment is demonstrated
Usability of solution			
Relevance	• No. of strategic documents identifying the local needs.	3	• In the pilot report - the reference to strategic documents.
Coherence			
Effectiveness	• No. of interventions with NBS solutions. • No. of climate datasets coming from sensors.	2 3	• In the pilot report - the reference to the no. of interventions and the no. of data sets.
Efficiency	• No. of exploited assets (assets already used in another project such as open data portals).		• In the pilot report - the reference to the no. of exploited assets.
Impact	• More green infrastructure in public spaces. • Improved well-being of citizens. • Pilot case possible to replicate in other locations in the city with the continued collection of data. • Improved micro-climate on the pilot site (better air quality and lower temperature).	1 (yes) 1 (yes) 1 1 (yes)	• In the pilot report - the reference to green infrastructure in public spaces. • In the pilot report - the reference to the survey results regarding the change in the well-being of citizens. • In reports connected to Activity 2.3 Transnational pilot replication system. • In the pilot completion report - the reference to the measurements from the pilot site.
Sustainability			
Up-scaling of solution			
Integration			
Adaptability	• No. of different NBSs to choose from in the process of the pilot definition (*several different greening suggestions make it easier to adapt the solution*).	3	• In the pilot report - the reference to the no. of different NBS solutions
Scalability & Replicability			
Community Awareness building			
Community Engagement	• No. of people participated in a survey (no. of citizens involved). • No. of stakeholders involved in the planning of the pilot action (solution).	100 10	• In the pilot report - the reference to the no. of people participating in a survey and the no. of stakeholders involved.
Training & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

- Preparation of Plan B - development of the "greening the bus-stops" concepts for the city, co-created and coordinated with all stakeholders
- try to change the approach moving to a bottom-up engaging local key stakeholders, associations, citizens
- Having 16 new bus stops with suitable roofs for greening is already a good result
- Mobilisation of municipal and further actors discussing the topic is also a good result
- Focus on putting green roof on one of the 16 bus stops that already have suitable roofs
- maybe the survey results can be used for raise awareness by disseminating results
- making a survey how greening bus stations can improve well-being as an alternative to the implementation itself and support future approaches for greening
- the role of the project in this "conflict" is not to say which part was wrong, but to try to design the solution (even going few steps back) that is accepted by all parties
- nothing new at the batelfield but maybe opportunity to change of view angel and escalate to the broaden responsible stakeholders not necesary broad public and find larger scale solution involving the alternative adaptation measures for community
- there is a risk the impact indicator of improved air quality and comfort will not be able to deliver - at least for one of the locations - should the data from sensors be used for climate change communication (telling the community about current state and the extent of the heatwave problem) to show the importance of the issue in order to keep finding the proper solution for the problematic areas

Lessons learnt

Aspects that could/should be replicated by other territories?

- cross-sectoral collaboration to tackle the issues we focus on within the project is very real - and as in this case, it can also hinder the progress.. still, it is important to tackle it and be the intermediary to come to solution acceptable for any interest groups
- Implementation process is something to learn about
- Valuable to share the obstacles that you faced during the implementation process
- sometimes the strategic documents of the city are not very well interconnected, or ofr ifnal disicons are made not within authorized plains
- Stakeholder engagement is crucial: when, in what order, how!

Dornbirn

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	- Raises awareness of importance and effectiveness of nature-based solutions	1	- Achievable temperature reductions will be shown
Coherence			
Effectiveness	- Implementation of digtial and nature-based solution	1	- Implementation of the pilot study
Efficiency			
Impact	- Improved micro-climate at the pilot study site - Possibiltiy to replicate	1	- Achievable temperature reductions shown - Dissemination event
Sustainability			
Up-scaling of solution			
Integration			
Adaptability			
Scalability & Replicability	- The scalability of the pilot study is given	1	- Assessment of whether the pilot study can be replicated an up-scaled
Community Awareness building			
Community Engagement	- An event will be organized to disseminate the results	1	- Dissemination event took place
Trainings & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

- Similar pilots with Maribor, maybe some exchange on solutions, findings...
- Modify the pilot roadmap to reflect the ambitions of the pilot - policy impacct to indroduce green infrastructures in new infrastructures
- Perhaps add some suggestions at least on NBS-solutions for implementation on the basketball field if not actual implementation - like a list of proposed solutions
- NBS guide/solutions possible as part of dissemination
- Dissemination of results among citizens and decision makers - not a KPI but it could be valuable
- Rephrase - the narrative of the pilot more like an argument / basis for introducing NBS supported by digital solution
- Maybe focus on the 'smart city' approach rather than NBS (use of data to foster evidence-based decision making)
- digitalization is quite on track but consider maybe to leverage more policy advocacy in relation to the nature based solutionswhich are also also encompased within pilot procet design
- share the activity process and goals with citizens
- Use the platform for involving citizens and gather their suggestions to find other places where to upscale the solution

Lessons learnt

Aspects that could/should be replicated by other territories?

- The approach could be replicated in Maribor to finalize our pilot in the same way (instead of the initially foreseen approach)
- Maribor - same measurements can be performed and a lot of the concept replicated
- Further explore collbaoration with Kosice and Pforzheim (WP3)

Pforzheim

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	Pilot solution design is accepted by regional stakeholders.	2	Pilot implementation reports
Coherence	Number of local/regional/national/EU strategies the pilot is aligned with.	2	Pilot is alinged both with Smart City strategy and climage resilienc eplan of Pforzheim. Extension to the Northern Balck Forest region is aimed for.
Effectiveness	**Error Rate Percentage** Definition: The percentage of user interactions or transactions that result in errors or failures within the pilot project's interface or applications, indicating the reliability and effectiveness of the system.	To be defined	Error rate data will be collected through system logs or error reporting mechanisms, capturing instances of user errors, system glitches, or transaction failures. The error rate percentage will be calculated based on the total number of errors detected relative to the total number of user interactions, and trends will be monitored to identify areas for improvement.
Efficiency	**Task Completion Time** Definition: The average time taken by users to complete specific tasks or transactions within the pilot project's interface or applications, indicating the efficiency of the user experience.	To be defined	Task completion time data will be collected automatically through system logs or user interactions tracking mechanisms integrated into the pilot project's infrastructure. The data will be analyzed to identify trends and improvements in task efficiency over time.
Impact	**User Satisfaction Score** A quantitative measure of users' satisfaction with the usability of the pilot project's interface, services, or applications, obtained through surveys or feedback mechanisms.	> 85%	User satisfaction scores will be collected through post-implementation surveys or feedback forms distributed to pilot project participants. The scores will be aggregated and analyzed to assess overall user satisfaction levels.
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	Description of maintencna of the digital solution	Official document

Comments on progress

Any concerns/recommendation on KPI delivery?

- Could be useful to find a way to know the number of people that are sharing the data from their sensor

Lessons learnt

Aspects that could/should be replicated by other territories?

- data collection can be replicated
- voluntary and authentic motivation of smart infrastructure deployment through citizen data, inspiring how to dampen noise on a busy road in a residential area and achieve speed regulation
- LoRaWAN is very useful for replication and scale-up
- citizens involvement in an effective way
- good connection university/city
- Testing the operation of solution by other cities - connecting sensors through Loraxxx network to Pforzheim dashboard..
- Lorawan possibilities and uses

Lignano di Sabbiadoro

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	Number of climate risk hotspots identified within the SECAP and the Risk & Vulnerability Assessment performed under Mission CE Climate addressed by the pilot demo actions	2	Reference in planning documents for demo action (i) and (ii)
Coherence			
Effectiveness	• Implementation of executive project for Porto Casoni • Adoption of Green Management Plan	• 1 • 1	• City Council approval • City Council approval
Efficiency			
Impact	• Reduced number of flood events • Enhanced quality of ecosystem services provided by urban green spaces • Promotion of information campaigns and awareness events	• 0 • Climatological parameters to be identified • +20% usability by citizens and tourists • 2 events / year	• Flood monitoring system • Long-term assessment of ecosystem services • Attendance sheet
Sustainability			
Up-scaling of solution			
Integration	Number of mesures which integrates technological, social, economic, environmental systems. All foreseen demo actions embrace a multidisciplinary perspective.	3	Planning documents for demo action (i) and (ii); programme for demo action (iii)
Adaptability			
Scalability & Replicability			
Community Awareness building			
Community Engagement	Number of people participating in the participatory processes for demo action (i) and (ii) Number of people participating in demo action (iii)	> 50 >100	Attendance sheet
Trainings & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

Other partners to attend the Sustainability festival and take part in the panel sessions - also a possibility for dissemination of the strategy and other project results

Citizen engagement on point, we should all learn from this experience.

Strengthen Public Engagement in Green Regulation – While the *Green Regulation* is being developed, more citizen participation should be integrated, ensuring the community understands and supports new sustainability rules.

Lessons learnt

Aspects that could/should be replicated by other territories?

How to successfully engage local community

Innovative way to reach to target audiences.

Very strong involvement of citizens! Impressive

creative and non traditional adressing of target groups

Festival is a great approach to reach people that are not yet aware of climate resilience importance

Drive from the municipality is needed

Splitsko-Dalmatinska County

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	SECAP of the island of Brač and Annual report on the condition of the water supply system of the Brač water supply system	Annual report, implementation of SECAP	Analysis of annual report data
Coherence	A number of local/regional/national/ European strategies the pilot is aligned with?	2 strategies	Pilot action aligns with SECAP of the island of Brač, Split Dalmatia County Climate Change Mitigation Program.
Effectiveness	Recorded losses in the water supply system in the pilot area	Reduction of losses by 10%	Annual report by Vodovod Brač
Efficiency			
Impact			
Sustainability			
Up-scaling of solution			
Integration	Integration of pilot project results (verification of adaptation measures report) into the new tools for verifying adaptation measures.	1	This will be determined by the end of the project. So far, no tools are available.
Adaptability			
Scalability & Replicability	Number of water supply companies in the region that are familiar with the results of the project	10	Presentation of the project results (mail, live events, meetings...)
Community Awareness building			
Community Engagement	People familiar with pilot project implementation and results on adaptation to climate change.	30	Participant list signed, the pictures of events, a letter of support...
Trainings & Dissemination events	Number of organized dissemination events	2	Presentation on the official company site and social media.
Education & guidance materials	A number of dissemination materials (articles, news, reports...)	5	Number of materials

Comments on progress

Any concerns/recommendation on KPI delivery?

Great that the involvment of the public company is beyond asked, resulting in increased number of people working on reducing leaks

very positive impact of investmet is dedication of 3 employees for water leakage reduction

financial leverage of relativly small money invested within project and cofinancing of water company on voluntary basis

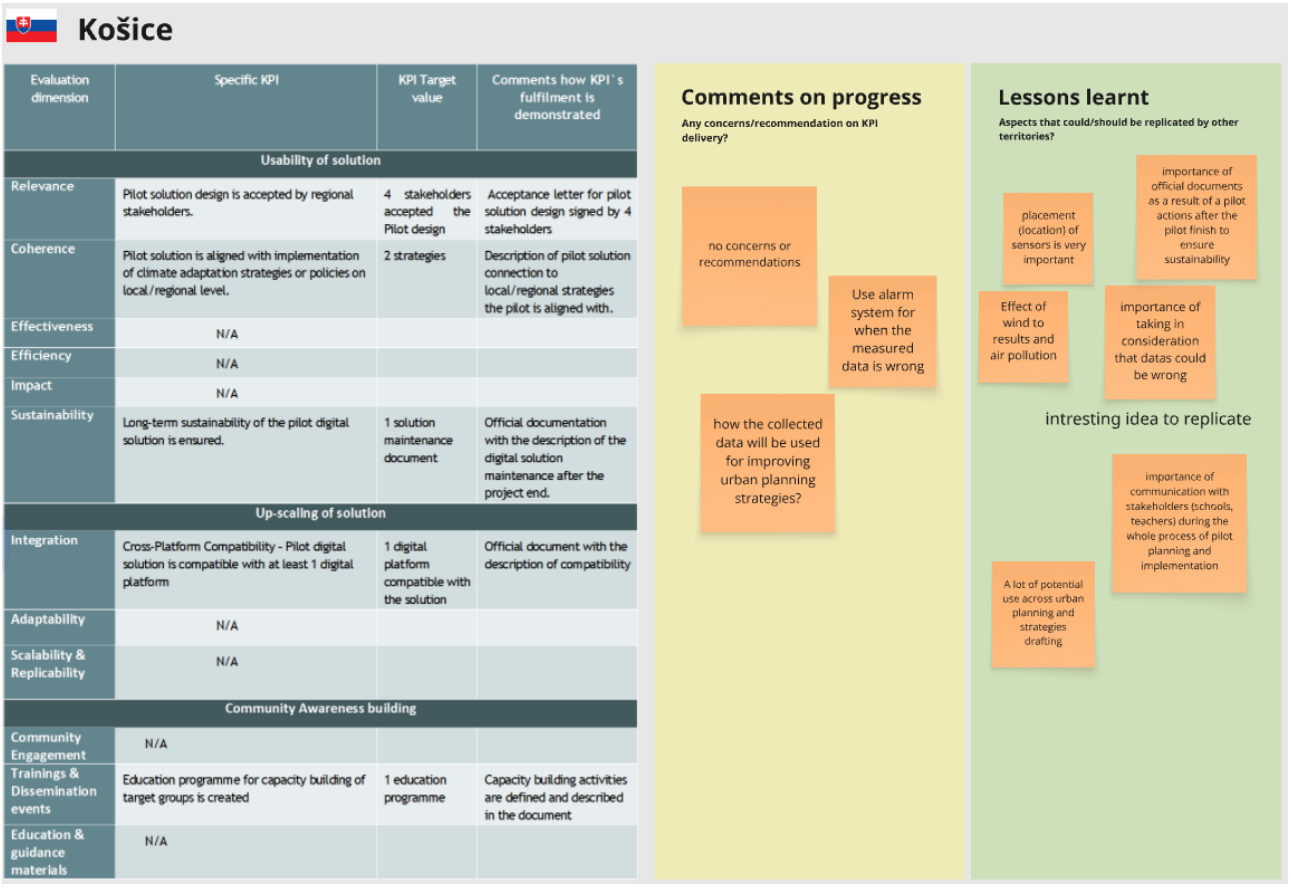
communicate also to the tourists about the efforts put in place to reduce the water losses and to enhance the water network efficiency in order to raise awareness and avoid unnecessary water waste

Lessons learnt

Aspects that could/should be replicated by other territories?

Very practical pilot

10.3. Annex 3: Miro board, Lignano Sabiadoro 2025



Košice

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfilment is demonstrated
Usability of solution			
Relevance	Pilot solution design is accepted by regional stakeholders.	4 stakeholders accepted the Pilot design	Acceptance letter for pilot solution design signed by 4 stakeholders
Coherence	Pilot solution is aligned with implementation of climate adaptation strategies or policies on local/regional level.	2 strategies	Description of pilot solution connection to local/regional strategies the pilot is aligned with.
Effectiveness	N/A		
Efficiency	N/A		
Impact	N/A		
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	1 solution maintenance document	Official documentation with the description of the digital solution maintenance after the project end.
Up-scaling of solution			
Integration	Cross-Platform Compatibility - Pilot digital solution is compatible with at least 1 digital platform	1 digital platform compatible with the solution	Official document with the description of compatibility
Adaptability	N/A		
Scalability & Replicability	N/A		
Community Awareness building			
Community Engagement	N/A		
Trainings & Dissemination events	Education programme for capacity building of target groups is created	1 education programme	Capacity building activities are defined and described in the document
Education & guidance materials	N/A		

Comments on progress

Any concerns/recommendation on KPI delivery?

- no concerns or recommendations
- Use alarm system for when the measured data is wrong
- how the collected data will be used for improving urban planning strategies?

Lessons learnt

Aspects that could/should be replicated by other territories?

- importance of official documents as a result of a pilot actions after the pilot finish to ensure sustainability
- placement (location) of sensors is very important
- Effect of wind to results and air pollution
- importance of taking in consideration that datas could be wrong
- intresting idea to replicate
- importance of communication with stakeholders (schools, teachers) during the whole process of pilot planning and implementation
- A lot of potential use across urban planning and strategies drafting

Maribor

Evaluation dimension	Specific KPI	KPI Target value	Comments on how KPI's fulfilment is demonstrated
Usability of solution			
Relevance	• No. of strategic documents identifying the local needs.	3	• In the pilot report - the reference to strategic documents.
Coherence			
Effectiveness	• No. of interventions with NBS solutions. • No. of climate datasets coming from sensors.	2 3	• In the pilot report - the reference to the no. of interventions and the no. of data sets.
Efficiency	• No. of exploited assets (assets already used in another project such as open data portals).		• In the pilot report - the reference to the no. of exploited assets.
Impact	• More green infrastructure in public spaces. • Improved well-being of citizens. • Pilot case possible to replicate in other locations in the city with the continued collection of data. • Improved micro-climate on the pilot site (better air quality and lower temperature).	1 (yes) 1 (yes) 1 1 (yes)	• In the pilot report - the reference to green infrastructure in public spaces. • In the pilot report - the reference to the survey results regarding the change in the well-being of citizens. • In reports connected to Activity 2.3 Transnational pilot replication system. • In the pilot completion report - the reference to the measurements from the pilot site.
Sustainability			
Up-scaling of solution			
Integration			
Adaptability	• No. of different NBSs to choose from in the process of the pilot definition (*several different greening suggestions make it easier to adapt the solution*).	3	• In the pilot report - the reference to the no. of different NBS solutions
Scalability & Replicability			
Community Awareness building			
Community Engagement	• No. of people participated in a survey (no. of citizens involved). • No. of stakeholders involved in the planning of the pilot action (solution).	100 10	• In the pilot report - the reference to the no. of people participating in a survey and the no. of stakeholders involved.
Training & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

Verification of monitoring data needs to be explained taking into consideration the initial verification method

Lessons learnt

Aspects that could/should be replicated by other territories?

Very nice promotional material

great idea and campain

Strong visibility

Promo activities going great!

Maintenance of pilot equipement is arranged - good job!

the importance of being resilient as a pilot implementer :)

Dornbirn

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	- Raises awareness of importance and effectiveness of nature-based solutions	1	- Achievable temperature reductions will be shown
Coherence			
Effectiveness	- Implementation of digtial and nature-based solution	1	- Implementation of the pilot study
Efficiency			
Impact	- Improved micro-climate at the pilot study site - Possibiltiy to replicate	1	- Achievable temperature reductions shown - Dissemination event
Sustainability			
Up-scaling of solution			
Integration			
Adaptability			
Scalability & Replicability	- The scalability of the pilot study is given	1	- Assessment of whether the pilot study can be replicated an up-scaled
Community Awareness building			
Community Engagement	- An event will be organized to disseminate the results	1	- Dissemination event took place
Trainings & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

not clear how was the micro-climate at the pilot study site improved if just measuremests were done (and none new NBS implemented)

What can be the next step. Measures to take based on the results

if you provide less scientific interpretation - we can use it as upscaling inspiration at elementary schools communities

Lessons learnt

Aspects that could/should be replicated by other territories?

Visualisation of results through 3D models

importance of surfaces, how they effect the temperature

Very good choice of measuring parameters and scenarios

importance of vegetation (greening), how they effect the temperature

Good manner of presenting the results to the public

how to comunicate and to engage people in this topics

trigger positive attitude rather than defeatism

lots sets of data for future plans

Pforzheim

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	Pilot solution design is accepted by regional stakeholders.	2	Pilot implementation reports
Coherence	Number of local/regional/national/EU strategies the pilot is aligned with.	2	Pilot is alinged both with Smart City strategy and climage resilienc eplan of Pforzheim. Extension to the Northern Balck Forest region is aimed for.
Effectiveness	**Error Rate Percentage** Definition: The percentage of user interactions or transactions that result in errors or failures within the pilot project's interface or applications, indicating the reliability and effectiveness of the system.	To be defined	Error rate data will be collected through system logs or error reporting mechanisms, capturing instances of user errors, system glitches, or transaction failures. The error rate percentage will be calculated based on the total number of errors detected relative to the total number of user interactions, and trends will be monitored to identify areas for improvement.
Efficiency	**Task Completion Time** Definition: The average time taken by users to complete specific tasks or transactions within the pilot project's interface or applications, indicating the efficiency of the user experience.	To be defined	Task completion time data will be collected automatically through system logs or user interactions tracking mechanisms integrated into the pilot project's infrastructure. The data will be analyzed to identify trends and improvements in task efficiency over time.
Impact	**User Satisfaction Score** A quantitative measure of users' satisfaction with the usability of the pilot project's interface, services, or applications, obtained through surveys or feedback mechanisms.	> 85%	User satisfaction scores will be collected through post-implementation surveys or feedback forms distributed to pilot project participants. The scores will be aggregated and analyzed to assess overall user satisfaction levels.
Sustainability	Long-term sustainability of the pilot digital solution is ensured.	Description of maintencna of the digital solution	Official document

Comments on progress

Any concerns/recommendation on KPI delivery?

good idea the ikea instruction, continue promoting to the people

Lessons learnt

Aspects that could/should be replicated by other territories?

Very nice that it is included in the next year's curriculum

hard to impement od our area but idea of shering sensors for other mesurment can be replicated

integration of sensors in different case study application

Very good ideas for use cases (weather forecast)

Wide network of sensors - good results despite some lack of citizen contribution

Change of mood (muting public climate discourse) in Germany on Climate change will be in five years also challenge for Slovakia :-(in adaptation projects

Lignano di Sabbiadoro

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	Number of climate risk hotspots identified within the SECAP and the Risk & Vulnerability Assessment performed under Mission CE Climate addressed by the pilot demo actions	2	Reference in planning documents for demo action (i) and (ii)
Coherence			
Effectiveness	• Implementation of executive project for Porto Casoni • Adoption of Green Management Plan	• 1 • 1	• City Council approval • City Council approval
Efficiency			
Impact	• Reduced number of flood events • Enhanced quality of ecosystem services provided by urban green spaces • Promotion of information campaigns and awareness events	• 0 • Climatological parameters to be identified • +20% usability by citizens and tourists • 2 events / year	• Flood monitoring system • Long-term assessment of ecosystem services • Attendance sheet
Sustainability			
Up-scaling of solution			
Integration	Number of mesures which integrates technological, social, economic, environmental systems. All foreseen demo actions embrace a multidisciplinary perspective.	3	Planning documents for demo action (i) and (ii); programme for demo action (iii)
Adaptability			
Scalability & Replicability			
Community Awareness building			
Community Engagement	Number of people participating in the participatory processes for demo action (i) and (ii) Number of people participating in demo action (iii)	> 50 >100	Attendance sheet
Trainings & Dissemination events			
Education & guidance materials			

Comments on progress

Any concerns/recommendation on KPI delivery?

no concerns or recommendations

Lessons learnt

Aspects that could/should be replicated by other territories?

Strong communication towards the public

Strong local involvement

organisation of a festival as a good approach to communicate with community

importance of attractive visibility (logo, communication camapign) to make event successful

importance of involvement of broad range of stakeholders

Excellent inclusion of citizens of Lignano in the process and activities

great event organized

Good collaboration with municipality and citizens

exellent marketing plan how to atracct local citizens

Splitsko-Dalmatinska County

Evaluation dimension	Specific KPI	KPI Target value	Comments how KPI`s fulfillment is demonstrated
Usability of solution			
Relevance	SECAP of the island of Brač and Annual report on the condition of the water supply system of the Brač water supply system	Annual report, implementation of SECAP	Analysis of annual report data
Coherence	A number of local/regional/national/ European strategies the pilot is aligned with?	2 strategies	Pilot action aligns with SECAP of the island of Brač, Split Dalmatia County Climate Change Mitigation Program.
Effectiveness	Recorded losses in the water supply system in the pilot area	Reduction of losses by 10%	Annual report by Vodovod Brač
Efficiency			
Impact			
Sustainability			
Up-scaling of solution			
Integration	Integration of pilot project results (verification of adaptation measures report) into the new tools for verifying adaptation measures.	1	This will be determined by the end of the project. So far, no tools are available.
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Scalability & Replicability	Number of water supply companies in the region that are familiar with the results of the project	10	Presentation of the project results (mail, live events, meetings...)
Community Awareness building			
Community Engagement	People familiar with pilot project implementation and results on adaptation to climate change.	30	Participant list signed, the pictures of events, a letter of support...
Trainings & Dissemination events	Number of organized dissemination events	2	Presentation on the official company site and social media.
Education & guidance materials	A number of dissemination materials (articles, news, reports...)	5	Number of materials

Comments on progress

Any concerns/recommendation on KPI delivery?

Process of integration of comapnies could bring opportunity to spread best practise on larger scale

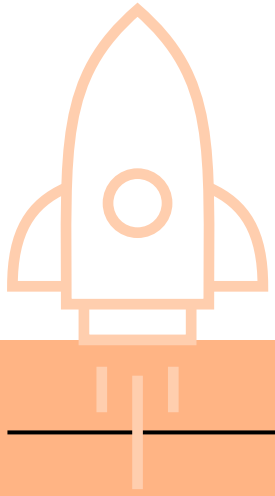
Lessons learnt

Aspects that could/should be replicated by other territories?

good explanation of datas that make visible the results

diffrent verification approaches according type of adaptationmeasure NBS, technical, digital

D.2.5.1 Igniting community-led climate initiatives manual



Interreg CENTRAL EUROPE

Co-funded by the European Union

MISSION CE CLIMATE

IGNITING COMMUNITY-LED CLIMATE INITIATIVES

MANUAL

- ✓ CLIMATE CITIZEN-LED INITIATIVES AT A GLANCE
- ✓ INITIATING COMMUNITY-LED CLIMATE INITIATIVES
- ✓ JOINT IMPLEMENTATION OF PILOT PROJECTS & CATALOGUE OF BEST PRACTICES
- ✓ TRAININGS FOR PARTICIPANTS OF CITIZEN-LED INITIATIVES

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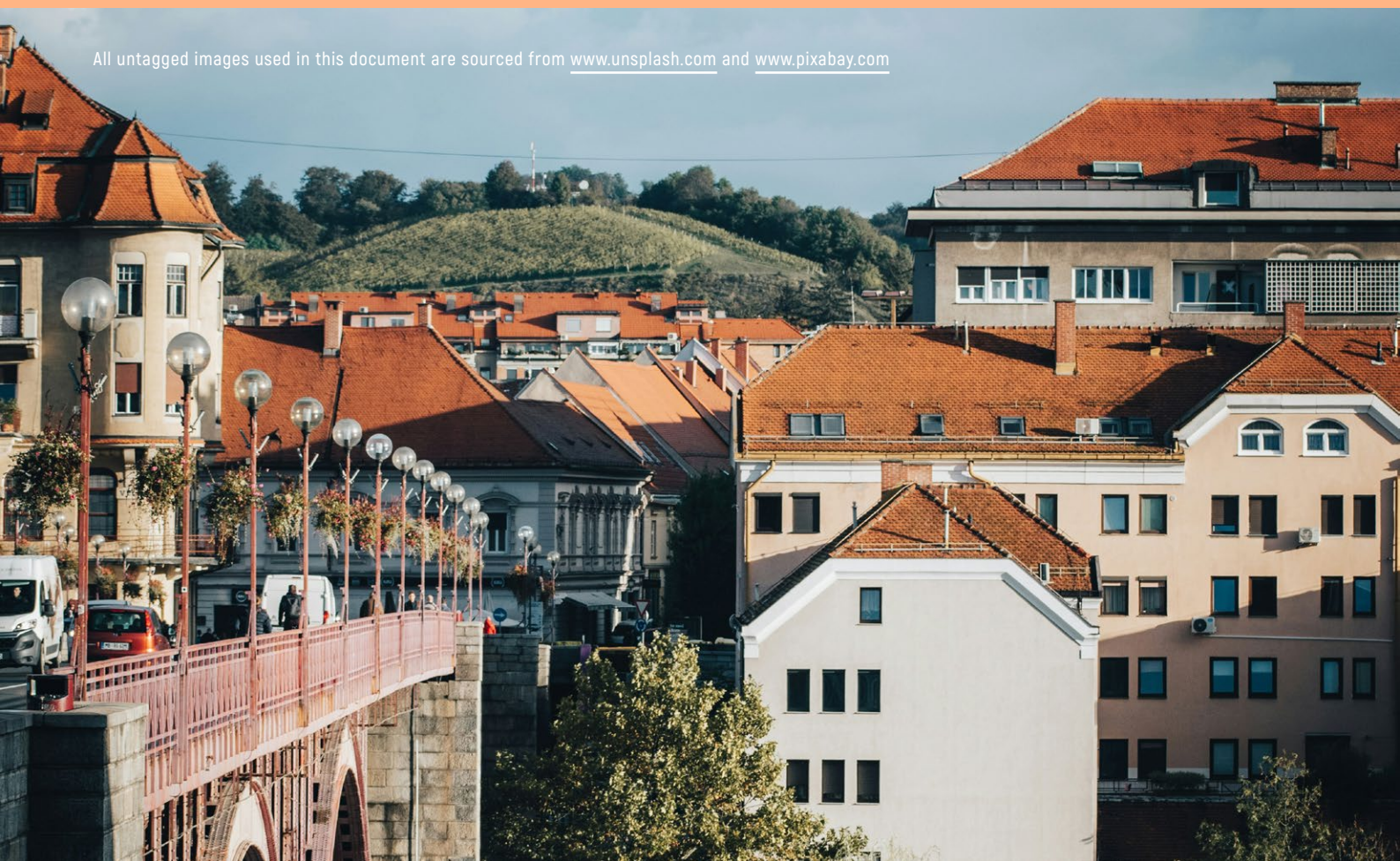


Introduction

Igniting Community-Led Climate Initiatives is a practical guide designed to support citizens, communities NGOs and civil associations in their climate mitigation efforts. It is aimed to showcase how together with their local governments, business and other organizations, launching and scaling climate action from the ground up is not only feasible, but oftentimes able to yield results faster and more effectively than separate top-down approaches.

Community-led climate initiatives are locally rooted efforts driven by citizens, municipalities, and stakeholders to adapt to and mitigate the effects of climate change through inclusive, participatory, and place-based solutions. These actions are essential for building long-term resilience and enabling a just green transition that responds to real local needs.

This manual presents a collection of experiences, actions, and insights drawn from the Interreg Central Europe project MISSION CE CLIMATE. Over the course of the project, co-creation processes were carried out across six Central European countries (Slovenia, Slovakia, Austria, Germany, Croatia and Italy), fostering collaboration between local governments, sectoral agencies, citizens, academia, businesses, non-governmental institutions and experts. This manual reflects the practical outcomes of these efforts–from targeted trainings and awareness-raising campaigns to the co-development and co-implementation of pilot projects–highlighting diverse pathways for increasing climate resilience at both local and regional levels, adapted to local context.

Each section combines lessons learned from the practical implementation of pilot projects within the established living labs in the cities of Maribor (Slovenia), Košice (Slovakia), Dornbirn (Austria), Pforzheim (Germany), Brač (Croatia) and Lignano Sabbiadoro (Italy).

Climate Citizen-Led Initiatives at a Glance

Citizen-led initiatives (CLIs) refer to grassroots actions and community-driven projects that aim to address social or environmental challenges outside of traditional governmental frameworks. In the realm of climate governance, CLIs encompass a diverse array of efforts, such as local energy cooperatives, urban gardening, transition towns, climate assemblies, and direct climate action. These initiatives are often characterized by decentralized decision-making, participatory governance, and a focus on local resilience (Seyfang & Smith, 2007). Unlike top-down policy instruments, CLIs emerge from bottom-up mobilization, driven by citizens who perceive gaps in institutional responses to climate change. They may operate independently or in collaboration with local authorities, NGOs, or international networks. Their core attributes typically include collective ownership, localized knowledge, experimentation, and a commitment to social innovation (Avelino et al., 2019). Community-Led approaches are those that are led not by an organization or other outsiders but by a collective, community process[1]. Community-led approaches are distinguished by their bottom-up structure, where residents of a geographically defined area lead the visioning, decision-making, and action process to address community challenges.

Citizen-led initiatives are natural partners to NGOs. They can amplify local voices, offer capacity support, and help scale successful models to other communities. CLIs are a way to build stronger, more connected places while addressing real climate risks. They help communities become not just more sustainable–but also more self-determined.

The future of climate governance can be shaped as much by local communities and civil society as by government decisions. CLIs are moving in promising directions:

Collaborating with Local Authorities - Increasingly, communities are partnering with local governments–through climate roundtables, participatory budgeting, or co-designed policies–to push for climate-friendly outcomes (Ostrom, 2010).

Leading Local Transitions - From food systems to clean energy, CLIs are experimenting with new ways of living and working that reduce emissions and build resilience.

Promoting Climate Justice - Citizen-led groups are often at the forefront of ensuring that the transition to a green future is fair–especially for marginalized communities (Scoones et al., 2015).

Creating Space for Dialogue - Tools like climate assemblies and citizens' juries give people a chance to deliberate and shape local climate responses, rather than being left out of the conversation.

Building Lasting Institutions - As they mature, some initiatives are moving beyond "projects" to become long-term community institutions–such as energy co-ops, eco-villages, and learning hubs.

Depending on their establishment and management, there are various types of community-led initiatives and categorization. One way to define different CLIs approaches is to analyse who holds the decision power. CLIs fully controlled by the community are oftentimes referred to as community-owned CLIs. Community-driven CLIs include collaborative planning between organizations and the community. Community-shaped CLIs are led by organization(s) and the community has strong inputs in the efforts led by organization(s). Community-shaped CLIs informs and consults the public, but the decision-making power remains within the organization(s) in charge.

Whether directed towards an individual looking to get involved, an NGO seeking impact, or a community network trying to build resilience, CLIs give tools, allies, and a voice in climate governance.

While citizen-led initiatives are not themselves a substitute for strong climate policy–they are a necessary part of the climate solution. They make climate governance more inclusive, resilient, and grounded in real people's lives. As the climate crisis deepens, our ability to support, scale, and sustain these initiatives will shape the future–community by community.

[1] Wessells, 2018, cited in Attygalle, 2020, p. 3

Quick Start

How to Initiate an Informal Community or Citizen-Led Initiative

An informal citizen-led initiative (CLI) does not need a legal structure to begin. Start small, build trust, and focus on one visible, local outcome.

Step 1 **Identify a shared local issue (1–2 days):** pick one concrete problem people already feel (heat at bus stops, flooding hotspots, schoolyard overheating, water loss, lack of shade, poor data access).

Step 2 **Form a core team (3–5 people):** include at least one organiser, one communicator, and one person connected to a local institution (school, NGO, municipality, utility, club).

Step 3 **Define a "first win" (1 week):** choose a low-cost action that proves momentum (a mapping walk, a survey, a workshop, a pilot micro-site, a public talk, or a small demonstration).

Step 4 **Invite allies (week 1–2):** reach out to local NGOs, municipal departments, schools, businesses, and citizen groups. Use a clear invitation: "We are testing one local solution and need your input."

Step 5 **Run a simple co-design session (week 2):** gather ideas, agree on one action, assign roles, and set a date.

Step 6 **Communicate and document (ongoing):** share what you are doing, why it matters, and how people can join. Keep notes, photos, and feedback.

Step 7 **Connect to long-term structures (after the first win):** either (a) remain informal and repeat small actions, or (b) connect your CLI to a CCRM / municipality process for scaling and funding.

Minimum outputs:

- ▶ **ONE AGREED GOAL**
- ▶ **ONE ACTION PLAN** (WHAT / WHO / WHEN)
- ▶ **ONE PUBLIC EVENT FOR SPREADING THE WORD**
- ▶ **ONE SHORT SUMMARY OF RESULTS AND NEXT STEPS**

Initiating Community-Led Climate Initiatives

The Concept, Establishment and Operating of CCRMs

Community Climate Resilience Missions - Missions or CCRMs for short, are local community-led and community-shaped initiatives that emerged within the MISSION CE CLIMATE project that bring together a wide range of community actors to build long-term resilience to climate change. Rather than functioning as temporary initiatives or isolated campaigns, the missions are well-established living labs for participatory planning, collaborative governance, and implementation of adaptation strategies at the community level in the project implementing countries.

PICTURE 1

Community Climate Resilience Missions map

Each climate resilience mission is designed around the specific context, needs and specifics of its region. They promote locally driven action by engaging key stakeholders: citizens, NGOs, civil society organizations, local governments, academic institutions, and private sector actors–in co-creating solutions and shaping sustainable futures. As part of developing creative, community-led climate resilience initiatives, the Quintuple Helix Model was chosen to guide collaboration across diverse sectors. This model brings together academia (knowledge and learning), industry (tools and innovation), government (support and policy), civil society (local voices and cultural expression), and the natural environment (the ecological foundation of our work). By involving these five dimensions, it is ensured that the initiatives are not only community-driven and imaginative, but also grounded in evidence, supported by policy, and aligned with environmental sustainability. The model supports co-creation processes where local creativity and climate action meet through inclusive, cross-sectoral cooperation (Carayannis & Campbell, 2010).

CCRMs are fundamentally inclusive and encourage participation of different stakeholders across society, reflecting the principles of the Quintuple Helix innovation model. Participants typically include:

Citizens and local communities (individuals, activists, students), who contribute insights on daily climate challenges and help shape responses that are grounded in lived experience;

Non-governmental organizations (NGOs) and **civil society groups,** which often bring expertise in climate change, social equity, advocacy, and local development;

Local and regional authorities, responsible for integrating resilience strategies into policy and urban planning;

Utilities and **infrastructure providers,** who manage essential systems such as water, energy, and mobility–each central to climate adaptation;

Sectoral agencies and **public service bodies**;

Research and **academic institutions,** which offer scientific knowledge, technical tools, and support for evidence-based decision-making;

Businesses, especially those involved in sustainability and innovation, who contribute technological solutions, investment potential, and business-driven resilience models.

The establishment of each mission followed a carefully designed process, rooted in collaboration and local knowledge. It began with stakeholder mapping in each pilot region, identifying key actors who could contribute meaningfully to the mission. Initial engagement took place through bilateral meetings, local workshops, and informal discussions. These early interactions helped in building trust and aligning goals. To formalize participation, a Memorandum of Understanding (MoU) was signed for the establishment of each of the Missions, stating the joint endeavours of its members to promote and mainstream climate governance processes in the local context. Once a core network was in place, each mission moved into co-design activities. Initial activities included public events for launching the missions and raising awareness, thematic discussions, joint preparation of risk and vulnerability assessments, and the joint formulation of priorities for each of the established CCRMs. The process ensured that local knowledge and lived experience informed the mission's trajectory from the outset.

The overarching aim of each community climate resilience mission is to improve the adaptive capacity of its community in the face of climate change. This involves both strategic and practical objectives.

Strategically, the Missions create a shared governance structure where climate risks are assessed collaboratively and priorities are defined transparently. They strengthen relationships across sectors and help institutionalize long-term thinking within local systems.

Practically, the Missions drive forward the development of local action plans, the implementation of pilot projects, and the creation of investment pipelines for climate resilience. They support climate resilience knowledge-building through public engagement, facilitate co-design of solutions, and encourage communities to take an active role in shaping the future of their communities.

It is important to note that the Missions **remain open to new partners over time.** Whether a new NGO, a youth-led movement, a regional agency or some other stakeholder decides to join the mission, the missions are open to evolve and expand over time. This flexibility allows them to grow organically and adapt to changing needs.

CCRM Establishment Checklist
(from idea to functioning mission)

1 | Set the foundation

- ☐ Identify the main local climate risks (heat, flooding, drought, coastal erosion, etc.).
- ☐ Define the mission purpose and scope (1–2 sentences).
- ☐ Choose a coordination lead (host organisation) and a backup.
- ☐ Confirm which existing strategies it connects to (e.g., Adaptation Plan, SECAP, Smart City strategy).

2 | Stakeholder mapping (Quintuple Helix Model)

- ☐ Local public authority (policy/coordination).
- ☐ Academia/research (evidence and tools).
- ☐ Business/private sector (implementation capacity/innovation).
- ☐ Civil society/NGOs (community outreach/justice lens).
- ☐ Environment/natural system actors (public utility companies, land managers, climate agencies).
- ☐ Citizens and community groups (lived experience and acceptance).

3 | Engagement and trust-building

- ☐ Conduct bilateral meetings with priority stakeholders.
- ☐ Agree shared benefits: what each partner gains from participation.
- ☐ Define "what success looks like" (3–5 indicators).

4 | Formalise cooperation

- ☐ Draft and sign a Memorandum of Understanding (MoU) or equivalent.
- ☐ Agree meeting cadence (e.g., monthly/quarterly).
- ☐ Set basic governance: roles, decision-making, transparency rules.

5 | Co-design priorities

- ☐ Run a launch event + listening session.
- ☐ Identify 2–4 priorities for the first cycle (e.g., action plan, pilot, data governance, engagement campaign).
- ☐ Select one pilot concept to test.

6 | Operate as a living lab

- ☐ Maintain an open invitation for new partners.
- ☐ Document decisions, learning, and data.
- ☐ Align pilots with municipal processes so results can scale.

CCRM Meeting Agenda Template

Agenda:

1. Welcome + round of updates
2. Climate risk focus (one issue) + evidence
3. Co-design / decisions needed
4. Actions assigned (who/what/when)
5. Communication plan + next engagement moment
6. Next meeting date + close

Minimum meeting outputs

- decisions made,
- clear "to-do" and action list,
- one public communication line ("What we did and what's next")

Communication Campaigns

Communication and Promotion Campaigns in Local Communities Preceding the Establishment of the Local CCRMs

The successful establishment of the community climate resilience missions did not happen in isolation—it was deeply interconnected with the communication campaigns implemented across the six project regions. From the earliest stages, communication was not simply about informing; it was about activating communities, building networks, and creating a sense of shared ownership.
In many cases, the very foundation of the Missions was laid through these campaigns.

The communication campaigns were designed to do more than just raise awareness about local current climate challenges. They served as an open invitation to citizens, NGOs, local institutions, and other stakeholders to step into a more active role in their local Missions. Public launch events, social media outreach, stakeholder dialogues, and media coverage provided both visibility, transparency, inclusiveness and legitimacy to the concept.
These activities generated interest and encouraged participation in the local CCRMs.

In Maribor, Slovenia, the communication campaign was centered around the slogan "Green Mission for Climate" (Zelena misija za podnebje), which aimed at promote community-level climate resilience through collaboration, awareness, and innovation. The campaign began with a series of targeted meetings with key local stakeholders, including NGOs, community representatives, and urban planning institutions. These meetings laid the groundwork for broader public engagement.

PICTURE 2 Green Mission for Climate cover photo. Source: Regional Development Agency Podravje-Maribor

A launch event organized in March 2024 brought together a number of participants: citizens, civil society organizations, sectoral agencies, environmental activists, and municipal officials came together to learn about the mission and explore opportunities for cooperation. The event served not just to present the local Mission but also to facilitate direct networking among participants, who shared their own initiatives and expertise.

The successful campaign in Maribor resulted in the successful establishment of the local CCRM by signing the Memorandum of Understanding between: Regional Development Agency for Podravje – Maribor, the Municipality of Maribor, E-institute, Institute for Comprehensive Development Solutions, Energy and Climate Agency of Podravje and Chamber of Commerce and Industry of Štajerska.

In Dornbirn, Austria, the campaign titled Climate Resilience Mission (Klimaresilienz-Mission) focused on identifying climate risks and fostering community discussion around solutions. The campaign began with bilateral meetings in February 2024 that brought together local stakeholders, community representatives, and public institutions to set up the mission framework. The objective of the CCRM in Dornbirn is to promote climate resilience, to raise awareness and to gain a better understanding of the risks and potential solutions and make this knowledge available to relevant stakeholders outside of the CCRM.

Four organizations formally committed to the Mission by signing Memorandum of Understanding: the Vorarlberg University of Applied Sciences – FHV, the City of Dornbirn, the Energy institute KLAR! Modellregion and the company Weaves which is active in the field of environmental city monitoring platforms and support.

PICTURE 3

Local CCRM meeting in Dornbirn, Austria

PICTURE 4 Natural hazard conference where the Dornbirn CCRM was featured

In Lignano Sabbiadoro, Italy, the local campaign was branded under the Lignano Community for Climate Resilience, emphasized direct public engagement from the outset. A public launch event was held on January 2024, drawing in citizens, representatives from environmental NGOs, and community associations, and followed by other meetings. These events were not just informative but interactive, providing opportunities for local people to share their concerns and discuss specific risks facing their coastal town.

Local newspapers like the Messagero Veneto published articles to reach wider community audiences, ensuring that even those not digitally connected were made aware of the mission's objectives and events. The campaign helped to foster a strong local dialogue and inspired continued collaboration through the creation of an advisory team of local experts and activists.

In June 2025, Lignano Sabbiadoro hosted Lignano 180°, a two-days sustainability festival to celebrate its progress towards a climate-resilient future and attended by hundreds.

LIGNANO

Sicurezza di Porto Casoni Parte la consultazione popolare

Il Comune studia un progetto per difendere l'area da mareggiate e acqua alta
Per tutto il mese in programma riunioni con le associazioni e i residenti

LIGNANO

Sono partite le consultazioni che porteranno alla definizione dei primi dettagli da inserire nel complessivo progetto di difesa e di riqualificazione dell'area di Porto Casoni, così come proposti da fruitori, associazioni e semplici cittadini, chiamati a esprimersi per dare vita a un percorso partecipativo, le cui modalità operative sono state presentate nel corso di un incontro pubblico.

«L'iniziativa nasce dalla necessità di mettere in sicurezza la zona dal fenomeno dell'acqua alta e dalle mareggiate che frequentemente si verificano, ma è al contempo un'occasione notevole per accrescere la qualità urbana di un importante angolo della città», ha spiegato l'assessore ai Lavori pubblici Marco Donà, presente assieme al sindaco Laura Giorgi e alle colleghe di giunta, Marina Bidin e Liliana Portello e di Consiglio, Carlo Teghil, all'architetto Daniele Daneluzzi dell'ufficio lavori pubblici, Stefano Carbone che avrà un ruolo di regia in questo processo partecipato e l'architetto Mauro Sarti dello studio Archpiùdue di Padova che si occuperà di trasformare in progetto le proposte raccolte.

«Sono tre i punti cardine che ruotano attorno alla riqualificazione di Porto Casoni – ha spiegato ancora Donà al numeroso pubblico presente –: lo sport, rappresentato dalle associazioni che nell'area di Porto Casoni svolgono le loro attività; il turismo, per il fascino dell'ambiente naturale della laguna e per la ciclabile che la costeggia, e l'esigenza di preservare quest'area dagli effetti, al momento ancora non noti, dei mutamenti climatici. Questa è la porta della laguna sulla città, è evidente che con cambiamenti climatici ha una sua pericolosità, lo abbiamo visto in occasione delle maree eccezionali del 2019 e dello scorso novembre».

A spiegare quanto potrebbe accadere nei prossimi 80 anni è stato l'architetto Daneluzzi: «Per quanto riguarda l'andamento delle precipitazioni si ipotizza al 2100 un incremento del 30% in inverno e un calo del 25% in estate; si prevedono all'anno 6/8 ondate di calore con temperature superiori alla media per più giorni, contro le 1/2 volte che si verificano ora. Si parla di un innalzamento delle maree tra 70 e 100 cm e un aumento della temperatura del mare di circa 3 gradi».

Alla serata era presente anche l'Agenzia regionale per l'energia partner di Lignano con l'obiettivo di creare una serie di occasioni di incontro con la comunità per parlare dei cambiamenti climatici.

Tornando alla presentazione del progetto partecipato, l'assessore Donà in una nota aggiunge che «il percorso prevede altri incontri che in alcuni casi saranno riservati a specifiche categorie di utenti e in altri saranno aperti a tutti. Durante la presentazione pubblica sono stati fissati i primi appuntamenti che continueranno con intensità per tutto il mese e si concluderanno con un incontro aperto alla cittadinanza nei primi giorni di marzo. Per metà aprile potrebbe esserci una prima presentazione del progetto. La modalità scelta per la definizione del progetto è quella della consultazione, sia di chi quell'area la vive, sia di tutti i cittadini che hanno piacere nell'esprimere il proprio punto di vista».

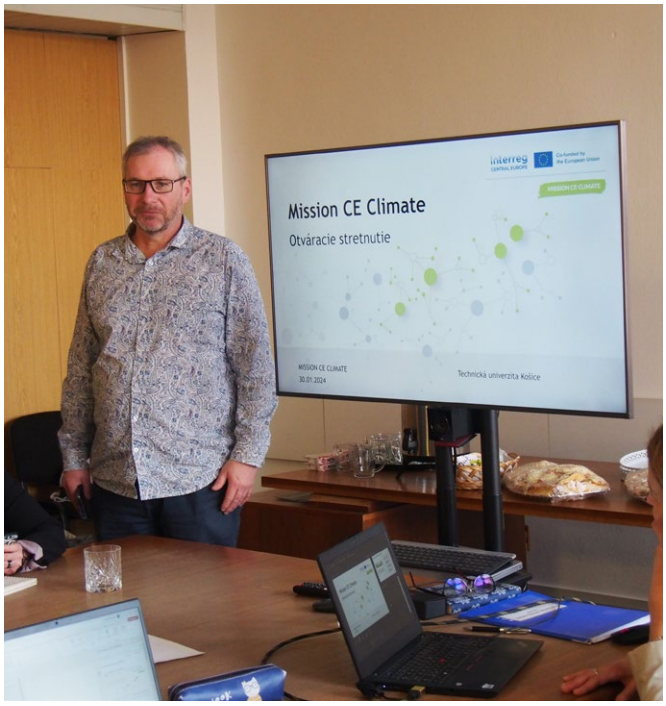
Per informazioni o per partecipare al percorso è possibile contattare l'Ufficio Urbanistica del Comune di Lignano alla mail urbanistica.demanio@lignano.org o chiamando lo 0431 409100.—

Il sindaco Laura Giorgi in occasione del primo incontro per discutere della sicurezza di Porto Casoni

PICTURE 5 Press review, news on Messaggero Veneto, Feb 4th 2024

In Košice, Slovakia, the outreach began with the identification of potential stakeholder organizations, including citizen associations, NGOs, and community development groups. The core of the public campaign was a kick-off meeting held on January 2024. Participants included representatives from local communities, civic organizations, and academia. The event enabled stakeholders to share ideas on the city's climate resilience strategy and helped establish the foundation for more inclusive, cross-sector governance.

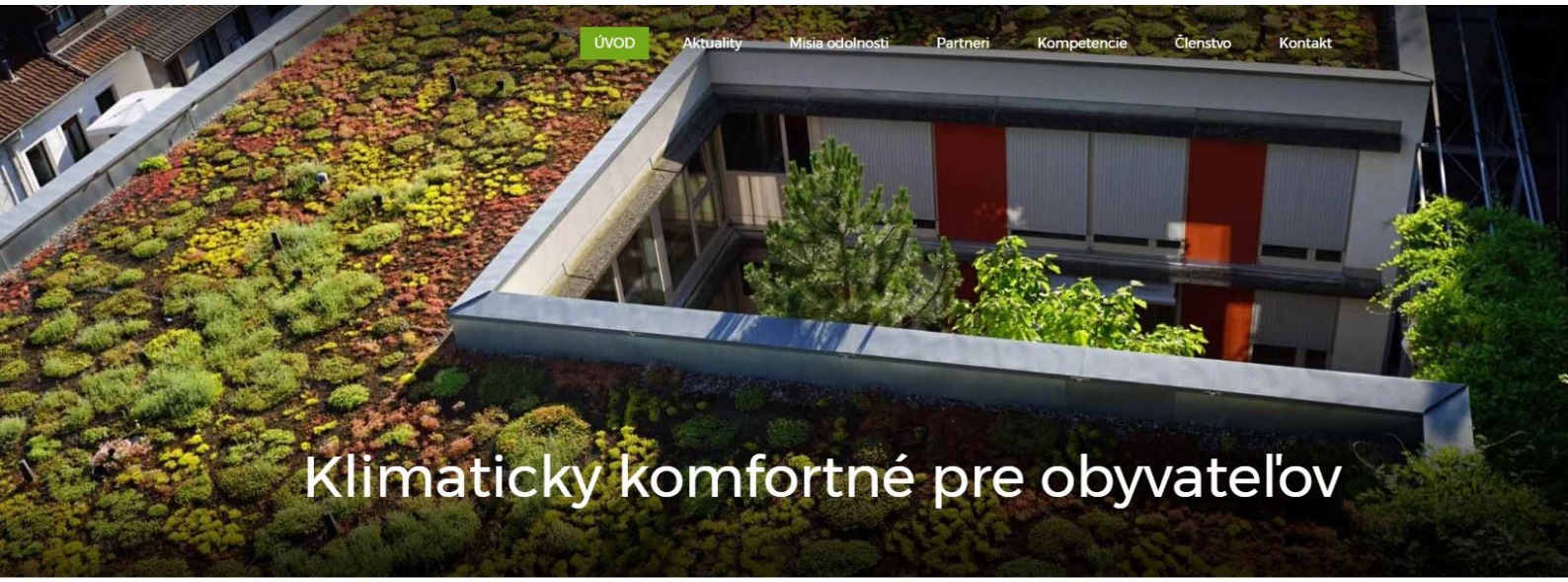
To ensure broader community engagement, a dedicated website was launched in March 2024. It features stories, updates, and resources tailored for citizens. A PR article was prepared for publication in local print media to reach citizens who are less active online, ensuring inclusivity in outreach.



PICTURE 6 Košice CCRM launch event

PICTURE 7

Snapshot from the Košice CCRM website (www.odolnekosice.sk)



In Brač, Croatia, the local campaign preceding the establishment of the local CCRM centered on updating the island's Sustainable Energy and Climate Action Plan (SECAP) and developing new solutions to address the specific climate risks faced by the local community, particularly regarding water scarcity. Community engagement began with stakeholder meetings in February and March 2024. These meetings included local NGOs, citizen groups, water utility providers, and municipal departments. During a study visit to Vodovod Brač, the local public water supply company, participants–including local experts and civil society members–discussed water conservation and adaptation strategies. This hands-on engagement helped translate technical knowledge into actionable community-led solutions, resulting in the establishment of the local CCRM by: Split-Dalmatia County, Energy Institute Hrvoje Požar, public water company Vodovod Brač, City of Supetar, Municipality of Sutivan and the Local Action Group Brač.

PICTURE 8

Coordinative meeting of the Brač CCRM

In the City of Pforzheim and throughout the Northern Black Forest region in Germany, the project team conducted a very community-targeted campaign through a series of "Citizen Dialog" events. These were open public forums organized in four different towns—Nagold, Calw, Freudenstadt, and Pforzheim in April 2024, attended by hundreds of citizens from the area, organized in collaboration with Pforzheim University and the Economic Development Agency of the Northern Black Forest Region (WFG).

PICTURE 9

CCRM presented at a community event in Pforzheim, Germany

Discussions focused on local city transformation and adaptation challenges, with climate resilience as a key topic. Citizens shared their experiences, asked questions, and expressed a strong interest in smart city solutions and technologies for sustainability. Following the successful campaign, the local CCRM was established by the University of Pforzheim, the digital company Krumedia and the Regional Public Authority of Nordschwarzwald (WFG)- representing 10 cities and 2 districts from the region.

The feedback from all of the communication events was overwhelmingly positive. Participants appreciated the opportunity to engage directly with researchers and policy experts, and many expressed interest in continued involvement in mission activities. Information regarding all of the CCRMs establishment, events and activities were communicated through webpage, social media, online local and regional media, and MISSION CE CLIMATE project channels. In order to reach citizens that have no online presence, articles in local newspapers and other printed media were published to inform and call citizens to action.

These efforts did more than raise awareness—they actively mobilized citizens, built networks, and created a sense of shared ownership across diverse local contexts. Communication served as a foundation for engagement, making the missions more visible, inclusive, and legitimate in the eyes of both the public and institutional stakeholders.

Recommendations for Similar Initiatives

For other citizen-led initiatives looking to strengthen their impact, the following recommendations can serve as guiding principles:

Start early and stay consistent – Engage your community from the very beginning, and keep communication flowing throughout the journey.

Use a mix of tools and channels – Combine digital outreach with face-to-face meetings, local media, and creative formats to reach as many people as possible.

Make it personal and local – Focus on issues that resonate with your community and highlight the voices of local people and organizations.

Create spaces for dialogue, not just information – Encourage co-creation and open exchange through workshops, forums, and informal gatherings.

Build partnerships – Collaborate with NGOs, schools, institutions, and local associations to strengthen legitimacy and pool resources.

Celebrate milestones and share stories – Visibility helps build momentum. Share successes and lessons openly to inspire others and keep your community engaged.

Campaign Planning Checklist
(for missions and pilots)

1 | Define the campaign

- ☐ What behaviour or action are we trying to trigger? (join, attend, co-design, volunteer, test a pilot, adopt a practice)
- ☐ Who is the audience? (citizens, NGOs, youth, schools, businesses, seasonal users/tourists)
- ☐ What is the key local message? (link to a lived local risk and benefit)

2 | Plan channels (mix digital + offline)

- ☐ Social media + website updates
- ☐ Local press / radio / community newsletters
- ☐ Posters / flyers / public noticeboards
- ☐ In-person events (launch, workshop, citizen dialogue)
- ☐ Schools or clubs as multipliers
- ☐ Festival / public fair / open day (where relevant)

3 | Design engagement moments

- ☐ One "invite" moment (launch)
- ☐ One "co-design" moment (workshop)
- ☐ One "see results" moment (pilot visit, dashboard demo, public summary)

4 | Make it inclusive

- ☐ Provide low-barrier entry points (short events, simple sign-up, accessible times/locations)
- ☐ Ensure non-digital reach (print media, community venues)
- ☐ Collect feedback (survey / comments / quick interviews)

5 | Measure and learn

- ☐ Track participation (numbers, diversity of groups)
- ☐ Track actions triggered (sign-ups, volunteers, pilot inputs)
- ☐ Track awareness (reach, shares, press mentions)
- ☐ Publish a short "what we learned" note after each campaign phase

Make Use of the "Benefit Framing" Communication Technique

Benefit framing in resilient climate governance means describing policies and governance tools in terms of the real-world outcomes they deliver–reduced climate risks, lower recovery costs, improved health and safety, and more reliable essential services–rather than listing technical features or institutional steps. For example, instead of saying "establish an interagency resilience committee," benefit-frame it as "coordinate decisions across departments so responses are faster and residents get consistent information during floods and heatwaves." Instead of "update building codes for future climate conditions," say "build and retrofit so homes and public facilities stay safer and functional during extreme weather, reducing repair bills and disruption." Used consistently, benefit framing helps stakeholders understand why governance changes matter and how resilience actions protect livelihoods, budgets, and community wellbeing.

Health and comfort: cooling, shade, safer public spaces during heatwaves.

Safety and disruption reduction: better preparedness for floods and storms; fewer service interruptions.

Cost and efficiency: reduced water losses; smarter maintenance and resource use.

Quality of life: greener public spaces, better schoolyards, more liveable neighbourhoods.

Education and empowerment: open data and monitoring that citizens can understand and use.

Tourism resilience (where relevant): protecting natural assets and seasonal infrastructure.

Simple invitation lines

- "Help us co-design one local climate solution."
- "Join the mission meeting and bring your lived experience."
- "Test the pilot with us and tell us what works."
- "See the data, learn the risks, and shape the response."

Joint Implementation of Pilot Projects & Catalogue of Best Practices

This chapter presents the joint implementation of pilot projects developed within the Community Climate Resilience Missions (CCRMs) and compiles the resulting insights as a catalogue of best practices. Building on the governance and co-creation approach described above, each pilot translates local climate risks into concrete, community-shaped actions—designed and delivered through collaboration between citizens, civil society, local authorities, academia, and the private sector in line with the Quintuple Helix Model.

The pilots reflect diverse local contexts and hazard profiles across six regions: urban heat stress and nature-based cooling solutions (Maribor), climate data governance and education through school-based monitoring (Košice), participatory regeneration of a flood-prone coastal space (Lignano Sabbiadoro), evidence-based assessment of nature-based cooling potential through microclimate monitoring (Dornbirn), smart city and citizen science applications for climate resilience using IoT sensors and dashboards (Pforzheim), and water-scarcity resilience through upgraded monitoring, leak detection, and organisational capacity-building in a tourism-sensitive island context (Brač).

For each region, the chapter provides an overview of the local CCRM, the pilot project rationale, co-creation methods, stakeholder roles, implementation steps and timelines, risks and challenges encountered, and practical recommendations for replication. Together, these examples show how locally grounded experimentation—supported by structured collaboration and continuous learning—can accelerate climate resilience action and strengthen long-term community capacity beyond individual projects.

Pilot Co-Design & Implementation Checklist
(from concept to replication)

1 | Define the pilot

- ☐ Local problem statement (one paragraph).
- ☐ Pilot goal (one sentence).
- ☐ Expected benefits (health, safety, governance, efficiency, awareness).
- ☐ How the pilot supports local policy/s trategy (SECAP, adaptation plan, smart city).

2 | Build the co-creation group

- ☐ Identify key stakeholders (Quintuple Helix).
- ☐ Confirm who decides what (citizen input, technical validation, municipal approval).
- ☐ Agree roles and responsibilities.

3 | Co-design the solution

- ☐ Run a co-design workshop (or interviews + workshop).
- ☐ Select site(s) and include backup sites (to avoid permitting delays).
- ☐ Define indicators (technical + social): e.g., temperature, humidity, water losses, participation, perceived comfort.

4 | Plan delivery

- ☐ Permissions, procurement, safety measures.
- ☐ Maintenance protocol and responsible persons.
- ☐ Data governance (where applicable: dashboards, open data, access rules).

5 | Implement + communicate

- ☐ Implement the pilot in a visible and learnable way.
- ☐ Run a public communication moment (launch/demo).
- ☐ Collect citizen feedback (short survey or interviews).

6 | Evaluate and replicate

- ☐ Compare baseline vs. results.
- ☐ Document lessons learned and bottlenecks.
- ☐ Identify scaling requirements (budget, policy change, standards, partners).

Overview of the Maribor CCRM

The establishment of the Community Climate Resilience Mission (CCRM) Maribor – "Green Mission for Climate" – followed a participatory, multi-stakeholder process designed to foster collaboration and shared ownership.

Below is an overview and sequence of activities:

1 | Stakeholder mapping

Key actors from the public, private, research, and civil society sectors were identified during the preparatory phase. This mapping was based on Maribor's Local Energy and Climate Concept (2021) and other strategic documents.

2 | Early engagements

One-on-one consultations and coordination meetings with potential partners (e.g., Municipality of Maribor, RDA Podravje – Maribor, ENERGAP, E-Institute, Štajerska Chamber of Commerce and Industry) were held to discuss the mission's scope, expected outcomes, and synergies with ongoing initiatives.

3 | Signing of the Memorandum of Understanding (MoU)

In 2023, five key institutions formalized their cooperation by signing the MoU, confirming their commitment to jointly establish and operate the CCRM Maribor. The CCRM functions as a living lab embedded in the city's governance framework, coordinated by key partners (Municipality, RDA, ENERGAP, E-Institute). Regular meetings, monitoring, and updates will ensure sustainability beyond the project lifecycle.

4 | Co-design activities

Stakeholders participated in co-creation sessions and the inaugural expert consultation event "Green Mission for Climate" (March 2024), where over 30 representatives from 14 organisations discussed challenges, shared knowledge, and defined next steps.

5 | Priorities set

Partners agreed on joint priorities, including development of a local climate resilience strategy, creation of a local action plan, testing of pilot solutions, and continuous engagement of citizens and additional stakeholders.

The process emphasized cross-sectoral cooperation, transparency, and mutual learning, laying the foundation for a sustainable governance structure of climate resilience in Maribor.

The CCRM Maribor represents a practical application of the Quintuple Helix Model, integrating collaboration across political, economic, academic, environmental, and social systems.

Helix Dimension	Stakeholders / Examples
Political system	Municipality of Maribor, Regional Development Agency for Podravje – Maribor, Environmental Protection Service (Joint Municipal Administration Maribor)
Economic system	E-Institute, Chamber of Commerce and Industry of Štajerska, Public Holding Maribor (JHMB)
Academic system	University of Maribor, University Medical Centre Maribor
Natural environment	Energy and Climate Agency of Podravje (ENERGAP), EIT Climate-KIC Hub Slovenia
Civil society	NGOs: Ekološko-kulturno društvo za boljši svet, Mariborska kolesarska mreža – Društvo za vzpodbujanje kolesarjenja in trajnostnega prometa
Citizens	Engaged through awareness campaigns, participatory workshops, and living lab activities within the CCRM framework

Maribor Pilot Project

The pilot addresses the growing vulnerability of Maribor to heat stress caused by climate change. The city faces challenges related to urban heat islands, declining precipitation, and water management. The project focuses on improving coordination among local stakeholders and citizens to strengthen resilience and adaptive capacity

The city of Maribor faces increasingly intense summer heat waves and limited greenery in the city centre. Urban heat islands significantly affect public spaces such as bus stops, where passengers are directly exposed to high temperatures. The Municipality of Maribor launched a pilot project to test **nature-based solutions (NBS)** by greening bus shelters–installing green roofs and adding vegetation–to improve microclimate conditions, enhance well-being, and raise public awareness of climate resilience. Under the MISSION CE CLIMATE project, Maribor developed and began implementing the first green bus shelters in the city.

The pilot focused on a central bus stop at Vetrinjska Street–one of the busiest, with over 324,000 passengers in 2023–and several alternative micro-locations. The intervention included planting greenery on bus shelter roofs and surrounding urban furniture, installing sensor systems to monitor temperature, humidity, and air quality, and engaging citizens through on-site surveys.

Due to administrative and technical constraints, implementation began with greening five shelters at alternative city-centre locations (e.g., Glavni trg, Krekova and Trubarjeva Streets). These served as test sites for vegetation performance, microclimate measurement, and citizen feedback. The pilot brought together municipal departments, public companies (Nigrad, Snaga, Europlakat), private contractors, and the Regional Development Agency for Podravje – Maribor.

challenges

The pilot faced several urban governance and regulatory challenges. Implementing a nature-based solution in a dense city centre revealed a complex web of overlapping competencies and conflicting regulations. The pilot team had to navigate between multiple authorities responsible for traffic, advertising, cultural heritage protection, and urban design. These fragmented responsibilities led to delays in permits, public procurement, and location approval.

Additionally, funding restrictions during the temporary municipal financing period (early 2025) further postponed site works. The limited space, need for heritage protection consent, and coordination between concessionaires complicated even minor modifications. These factors reflect a broader governance issue: the lack of integrated urban management systems for climate adaptation projects.

Despite obstacles, strong interdepartmental coordination and the municipality's flexibility were key to sustaining progress. The project team adapted by identifying alternative sites and maintaining compliant with technical standards. Parallel communication campaigns, citizen engagement, and testing across several locations helped maintain momentum and collect valuable data for future replication.

methods and inclusion

Co-creation methods used: **workshops, expert consultations, regular stakeholder meetings, participatory planning, and co-design sessions for local action and resilience strategies.**

Citizens are engaged through **awareness campaigns, consultations, and involvement in pilot implementation and evaluation.** Their participation is key for testing adaptive solutions and ensuring long-term ownership.

Implementation steps & timeline of the Maribor pilot:

2023–2024: Stakeholder mapping and MoU signing.

March 2024: Inauguration event "Green Mission for Climate".

2024–2025: Development of local action plan and pilot testing.

2025 onwards: Expansion, replication, and long-term governance of resilience measures, continuous stakeholder dialogue. Cooperation between the City of Maribor, RDA Podravje, and public service providers enabled practical compromises–such as focusing on greening new shelters already.

The use of existing stakeholder infrastructure (predominantly RDA premises and municipal support), combined with the project-funded activities via Interreg Central Europe – MISSION CE CLIMATE project and in-kind contributions from partners (expertise, data, venues) were the main pillars of the Maribor pilot.

The risk & safety considerations in regard to this pilot were mainly in terms of climate and weather events during outdoor events, stakeholder engagement fatigue, as well as the need for transparent governance to avoid overlapping initiatives.

recommendations

Recommendations for shaping similar initiatives:

- **Integrate early:** Involve all relevant municipal departments and concessionaires from the start to reduce approval bottlenecks.
- **Plan flexible sites:** Anticipate location-specific constraints and prepare backup sites for pilot implementation.
- **Secure cross-departmental leadership:** Designate a coordinating unit for climate resilience projects to avoid fragmented responsibilities.
- **Combine technical and social monitoring:** Pair environmental measurements with citizen surveys to assess holistic benefits.
- **Institutionalize learning:** Use pilot data to update municipal urban design and maintenance standards for broader NBS integration.

Overview of Košice CCRM

Košice, the second-largest city in Slovakia, faces increasing impacts of climate change. The following are its key climate change challenges:

- **Heat waves,** the effects of which are amplified by the effect of urban heat island;
- **Surface flooding,** which is caused by heavy and torrential rainfalls, when the ground rainfall is more than 20 mm per hour;
- **Prolonged periods of drought** as a secondary impact of irregular rainfall patterns.

In the group of hazard indicators, the city of Košice is particularly vulnerable due to two indicators:

- Observed trends in the **frequency of meteorological droughts**.
- Moderate risk with increasing tendency is posed by the **risk of floods and torrential rains,** which are interrelated with each other

CCRM setup process in the initial phase took into consideration identified challenges of the area based on the preliminary results of the vulnerability assessment and on the already adopted Adaptation plan of the City of Košice for Climate Change 2022-2030. The Mission is established with the assumption of a long-term operation beyond the period of individual climate-oriented projects and initiatives on the territory of the city, communication will focus on further engagement and mobilisation of local community members with identified potential to contribute to a systematic increase in the community climate resilience. Community Climate Resilient Missions are integrated, cross-sectoral and transdisciplinary networks. Due to this peculiarity, in this kind of context climate resilience processes can find fertile ground for developing.

A mechanism for providing permanent flexibility and openness as well as simplicity was established for continuous cooperation by signing the Memorandum of Understanding – first signed by the two founding members, the City of Košice and the Technical University – TUKE, and then by the partners, the sectoral Agency for Economic Development and the Vychodne pobrezie civic association, providing sectoral diversity.

The objective of the Košice CCRM is to support local community in becoming climate resilient and enable them to react with coordinated response to the impacts caused by climate change through acting beyond sectoral approach and introducing cross-sectoral governance. Under the CCRM umbrella, Košice received a durable cooperation system for joint community actions and inclusive climate resilience projects.

Košice Quintuple Helix Model matrix:

Institution name	Target Group Category	Quintuple helix category	Competencies & Responsibilities
Technical University of Košice, Faculty of Economics	Higher education and research organization	Education system	Climate Adaptation Science, Solution Design, Climate Resilience Research, Change Management
City of Košice	Local public authority	Political system	Leadership, Decision Making, Climate Change Science, Strategy & Planning, Risk Assessment, Climate-informed Professional Practice, Vulnerability & Impact Analysis
Regional Development Agency of Košice Region	Sectoral agency - Regional economic social development	Economic system	Economic Analysis, Risk Assessment, Climate Adaptation Science, Building Capability
Východné pobrežie	Interest group / NGO / network / association	Civil society	Cultural Agility, Climate Communication, Climate Change Science, Facilitation, Climate Adaptation Science
Technical University of Košice, Faculty of Civil Engineering	Higher education and research organisation	Education system	Climate Resilience Research, Climate Change Science, Climate Adaptation Science, Building Capability
Institute of Geography Faculty of Science, Pavol Jozef Šafárik University in Košice	Higher education and research organisation	Education system	Climate Change Science, Climate Resilience Research, Vulnerability & Impact Analysis
Klíma ťa potrebuje	Interest group / NGO / network / association	Civil society	Cultural Agility, Climate Communication, Climate Change Science, Facilitation, Climate Adaptation Science

TThe Košice pilot places schools at the center of community climate action by turning schools into long-term monitoring points for local air quality and heat-related indicators. By openly publishing data from seven elementary schools on the city's Open Data platform and using it directly in classrooms, the pilot connects children, teachers, families, and city planners around shared evidence. This "measure–learn–act" approach helps communities understand how heat waves or air pollution affect daily life. While the pilot is digitally driven, it intentionally guides communities toward future nature-based responses based on measured local climate conditions. By connecting classrooms, households, and planners through shared data, Košice translates climate concern into community-owned knowledge that supports both education and informed local decision-making.

methods and inclusion

Co-creation methods used: **Mapping of relevant locations for sensor placement, regular consortium meetings to gain comments and recommendations to pilot implementation and local Community Climate Mission meetings to discuss the relevance of the interventions.**

Creative workshops for creation of data use scenarios: **pedagogical, strategic, community, and spatial. Co-design sessions for local education plan preparation within the local community. Collaborative meeting for designing of platform for data visualization.**

Citizens are engaged through awareness campaigns and communication activities as well as through the education curriculum within the educational process in the schools.

Implementation steps & timeline:
2023-2024: Stakeholder mapping and MoU signing.

2024: Pilot design and Analysis activities in cooperation with stakeholders from CCRM and other stakeholders.

2025: Implementation of pilot activities within the pilot area, communication activities to public, collaboration with local stakeholders and communities.

The existing stakeholder infrastructure (Municipality office experts, education and technical know-how from TUKE experts) was put in use for the successful implementation of the pilot, combined with the project-funded activities via the Interreg Central Europe – MISSION CE CLIMATE project.

The main risks for this pilot are connected with the hardware installation issues and digital platform performance, and were addressed by establishing maintenance protocol and responsible personnel for technical and data quality assurance.

The pilot solution design was accepted by 4 regional stakeholders and pilot solution is aligned with implementation of 2 climate adaptation strategies or policies on local/regional level. The long-term sustainability of the pilot digital solution is ensured by officially described maintenance process. Cross-Platform Compatibility is ensured by development of digital dashboard for gathering and interpretation of climate data compatible with Open Data Košice platform by providing technical description. Analytical activities for sensor placement and selection were executed and documented in all 7 schools participating in the pilot implementation by installing and operating 7 sensors in their facilities. Thematic education program for climate data reading and operating was created and implemented in the 7 schools.

The output converts scattered climate concerns into a routine, evidence-based practice. City of Košice gains continuous, high-resolution readings (schoolyards) and human-centred signals (e.g., perceived heat, health relevance). This enables timely micro-decisions (activity timing, shading, ventilation) and strategic choices (where to plant trees, cool routes, permeable surfaces). Continuous data monitoring will serve educational purposes. Integrating data from sensors into Open Data Košice dashboard allows the general public to access the data.

The flow of climate data to related digital platform - Open Data Košice dashboard will continue to be managed by designated project partner organization (City of Košice). The municipality committed to long-term institutional support, ensuring continued accessibility and maintenance of the platforms. The maintenance of sensor network for the data collection will be ensured by these organizations through identified sensor network providers.

Best practice within the implementation activities
The Technical University of Košice and City of Košice, in cooperation with representatives of elementary schools, prepared an innovative educational program focused on the use of data from climate sensors installed directly in school premises. The aim of the program is to combine modern technologies, environmental education, and practical teaching of natural sciences. During the Curriculum Development workshops in 2025, 4 different approaches to data usage have been identified. Teachers and TUKE experts gathered in co-creating educational content for preparation of environmental curriculum for 2025/2026 school year.

The aim is to use climate data in school subjects like Physics, Biology, Chemistry, Civic Education. Teaching worksheets have been developed for these subjects, instructing teachers on how to incorporate data from climate sensors into teaching in the given subject.

The educational program supports the development of students' digital, environmental, and analytical skills, while enabling teachers to innovate their teaching using real data and project-based learning.

challenges

Time constraints associated with implementing the educational program in classrooms were noted, as working with the relevant data is time-consuming and needs to be structured to follow the school year cycle. Furthermore, summer months will not be observed in real time due to school vacation period. In order to be successful in climate data monitoring, students need to be taught how to use the dashboard correctly to complete the assigned tasks in a narrow timeframe.

To simplify access to the right data, specific links have been created that provide students with relevant data for individual tasks directly on school dashboards.

recommendations

Always design educational programs together with those for whom they are intended, so that their needs and specificities are reflected. Collect their feedback and implement improvements to make the work effective and time efficient.

Overview of the Lignano Sabbiadoro CCRM

The City of Lignano Sabbiadoro is a very tourist-oriented area, with one of its peculiarities being that the population increases exponentially during the summer season, reaching up to 100,000-150,000 people staying in the city, which is more than 20 times increase from the general population of 6.800 inhabitants outside the summer season. From a climate perspective, the greatest influence comes from the presence of the Adriatic Sea, a shallow sea, the Marano Lagoon and the Tagliamento River delta. Coastal erosion affects the coastline. In the area facing the lagoon, the greatest criticality is due to sea flooding and high tides. As a matter of fact, **flooding** – pluvial, coastal and river - caused by extreme weather events is another critical climate risk. On top of this, the analysis of current and projected climate trends shows that **sea level rise and heat waves** add on the overall frame of the climate hazards that need to be taken into consideration, as well as wildfires.

The establishment of the Community Climate Resilient Mission (CCRM) in Lignano Sabbiadoro was initiated by the Municipality as part of its commitment to implementing the Sustainable Energy and Climate Action Plan (SECAP) adopted in 2022. The Mission aims to enhance community engagement in the city's pathway towards climate resilience, in line with local objectives for awareness-raising and participatory governance by 2030. The process followed a structured sequence. The Municipality, in collaboration with APE FVG, conducted a comprehensive stakeholder mapping based on the Quintuple Helix approach, identifying key actors relevant to the local climate transition. Initial engagement activities involved stakeholders previously contributing to the SECAP under the Interreg IT-HR RESPONSe project, namely LISAGEST and the Civil Protection office, selected for their operational knowledge of local climate impacts. Afterwards, other local stakeholders were contacted and engaged in the CCRM and to formalise the Mission establishment a Memorandum of Understanding (MoU) was signed between the Municipality of Lignano Sabbiadoro, APE FVG, Civil Protection unit, the Lignano Rowing Club, the Lignano Yacht Club and Lignano Sabbiadoro Gestioni (LISAGEST).

Subsequently, co-design activities were launched through meetings aimed at identifying shared priorities and defining the pilot actions under the Mission CE Climate project.

As a result, the CCRM defined three main priorities: updating and enhancing local adaptation tools (revising adaptation measures); testing for the first time a public space co-design process involving citizens and stakeholders, to be replicated in future circumstances; and strengthening awareness-raising and capacity-building actions targeting residents and tourists.

As mentioned before, the Lignano Sabbiadoro CCRM fully reflects the Quintuple Helix Model, integrating actors across diverse systems and with peculiar competences:

- **Public authorities,** which provide institutional leadership and coordination.
- **Business actors** contribute with operational expertise and a direct link with tourism and coastal management.
- **Academic and expert stakeholders,** including professionals engaged in the RVA updating, support evidence-based approaches and climate knowledge transfer.
- **Civil society** and NGOs participate in awareness and co-design activities, ensuring inclusiveness and community ownership.
- Finally, **citizens and tourists** are directly engaged through outreach and participatory processes, fostering shared responsibility and behavioural change towards a more climate-resilient Lignano Sabbiadoro.

Lignano Sabbiadoro faces increasing climate risks including **sea level rise, coastal erosion, heat waves, and flooding from extreme weather events.** The pilot project addressed the urgent need to enhance climate governance by fostering civic participation, co-designing adaptation measures, and raising awareness among residents and tourists.

The pilot in Lignano Sabbiadoro exemplifies the Quintuple Helix Model by actively involving actors across five key domains:

Public sector: Municipality of Lignano Sabbiadoro as coordinator, promoter and catalyst of the initiative; competent Regional Authority bodies and Civil Protection.

Private sector: business stakeholders and public-owned maritime concessionaires contributed operational expertise and insights into tourism and coastal management.

Academia and experts: University of Udine, University of Trieste, OGS provided technical support and climate risk data, and facilitation of participatory processes.

Civil society: local sports associations, arts & culture groups, and environmental NGOs played a vital role in co-design activities and awareness campaigns.

Citizens: Residents, tourists, and citizen representatives were engaged through consultations, public events, and the Lignano 180° Festival, fostering shared responsibility and behavioral change.

Lignano Sabbiadoro Pilot Project

Porto Casoni, a flood-prone area in Lignano Sabbiadoro, faces increasing vulnerability due to sea level rise and storm surges. The area is used by diverse stakeholders - from sports clubs to restaurants – and holds significant ecological and social value. These factors prompted the municipal administration of Lignano and APE FVG to launch the local activities of the MISSION CE CLIMATE project, starting from this area. Porto Casoni is, in fact, the first demonstration action of this pilot project and was therefore aimed at regenerating the space through a participatory process designed to ensure climate resilience and community ownership.

To achieve this, the Municipality, supported by APE FVG, launched a co-design process involving 16 stakeholder groups through interviews, public events, and consultation meetings. A facilitator guided the participatory process, which culminated in the development of a Masterplan integrating stakeholders' inputs. The plan was approved by the City Council in October 2024 and is now seeking funding for implementation. The process was transparent and inclusive, and marked the first time the local administration adopted such approach.

The second demonstration action focused on the development of a Green Management Plan aimed at enhancing the municipality's climate resilience. The Plan, developed by external consultancy and approved by the City Council, represents a strategic tool to guide the long-term and sustainable management of urban green areas across the city. Urban green management plays a critical role in enhancing climate resilience, biodiversity, and quality of life in cities. It refers to the planning, maintenance, and sustainable use of green infrastructure to provide ecological, social, and economic benefits.

In parallel with the drafting process, the Municipality and the consultancy team planned a dissemination and engagement strategy to ensure that the objectives, results, and foreseen actions of the Plan and the Regulatory Framework were shared with local stakeholders, particularly the general public. To this end, awareness-raising activities with local schools and a free arboriculture course for citizens (4 lessons, 10 hours in total), delivered with the involvement of a forestry expert as instructor, were organized at the end of 2025.

The third demonstration action focused on promoting climate awareness, sustainable urban transformation, and civic engagement through a sustainability festival to celebrate the city progress towards a climate-resilient future: held in June 13 and 14, 2025, **Lignano 180°** was conceived as a space for dialogue, participation, and collective imagination about the future of coastal cities in a changing climate, bringing together technical experts, researchers, public administrators, urban designers, local citizens and tourists. The name "180°" symbolizes the need for change – a radical shift in how we think about and shape our urban environments. The festival aimed to promote a new mindset that embraces sustainability, inclusiveness, and resilience as guiding principles in planning the city of tomorrow. It also served as a platform to showcase recent initiatives led by the Municipality to address climate challenges, improve urban liveability, and protect the city's rich coastal and ecological heritage, alongside the results achieved throughout the MISSION CE CLIMATE project. In this context, guided study visits were also organized, allowing participants to explore firsthand key sites involved in Lignano's transformation. The 2025 Festival is intended as a first edition, as the administration aims to establish it as an annual event for citizens.

The co-creation methods used so far to engage the local community during the pilot's climate governance activities are the following:

- Stakeholder mapping and bilateral interviews
- Public hearings and consultation events
- Participatory design workshops
- Festival panels and guided study tours
- Coordination meetings with facilitators and experts.

In particular, citizens acted as co-creators in the regeneration of Porto Casoni, were actively involved in informative events on topics linked with the Green Management Plan, and participated in the Lignano 180° Festival. Their input influenced planning decisions, validated priorities, and built ownership of climate resilience strategies.

Hereafter are listed the implementation steps and related timeline per each demo activity completed under the Pilot:

1 | Porto Casoni co-design activity

Oct 2023: **Design of engagement process for the regeneration of Porto Casoni**

Jan–May 2024: **Stakeholder consultations and Masterplan of Porto Casoni development**

Oct 2024: **Masterplan approved by City Council**

2 | Green Management plan drafting and regulatory framework

Nov 2024–Apr 2025: **Green Management Plan drafted and approved**

Feb–Sep 2025: **Regulatory framework and civic engagement strategy developed**

Nov-Dec 2025: **Events targeting the citizens**

3 | Festival Lignano 180°

Jan-Jun 2025: **Design and planning of Lignano 180° Festival**

Jun 2025: **Lignano 180° Festival**

Pilot activities were finalized by December 2025 and long-term activities have been planned for proceeding beyond the project end.

Pilot activities have been co-funded by the Interreg Central Europe – MISSION CE CLIMATE project and the City of Lignano Sabbiadoro's budget (with total costs amounting at around 100 000 €).

Implemented activities have taken into account risk and safety aspects, including a flood risk analysis for the Porto Casoni area and the definition of safety protocols for public events and site visits.

In terms of progress, the Porto Casoni Masterplan has been approved by the City Council and the Green Management Plan adopted. Moreover, the Sustainability Festival has been successfully launched and implemented, serving as a key moment for engagement and awareness-raising.

Among the main results and early outcomes, three integrated demo actions have been completed: over 800 participants have been engaged through the Festival, 60–70 stakeholders have taken part in the Porto Casoni consultation process, a total of 10 people have participated in the arboriculture course, and 250–280 students have been involved in the awareness-raising activities implemented in schools (200–220 from primary schools and 50–60 from middle schools). These activities have contributed to increasing public awareness and institutional commitment, laying the foundations for long-term climate governance.

For the post-pilot phase, the Municipality will continue implementing the Green Management Plan and seek additional funding for the construction works at Porto Casoni. The Lignano 180° Festival is planned as an annual event, while civic engagement activities will continue beyond the pilot to consolidate participatory governance practices within future climate initiatives.

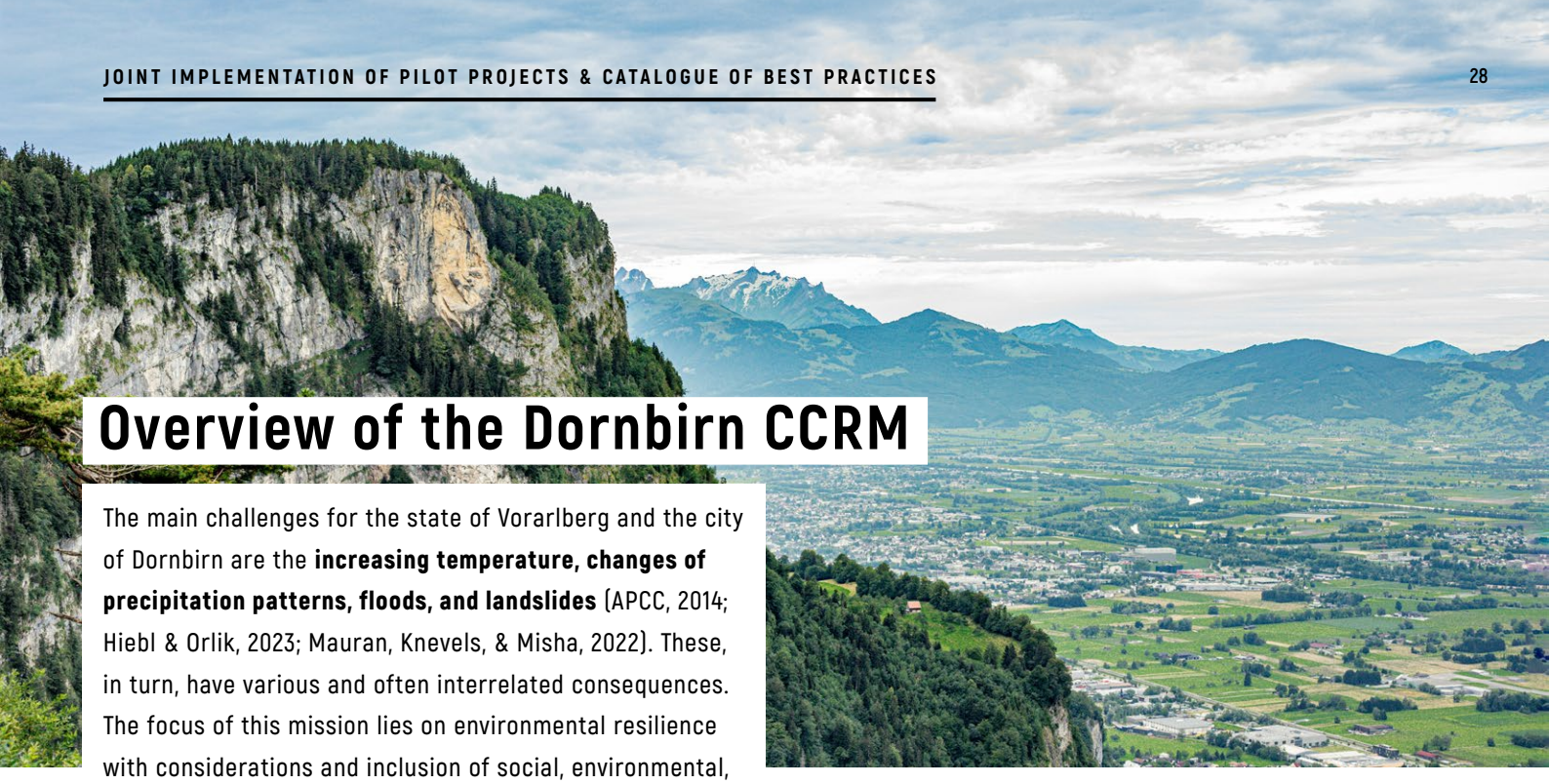
challenges

One major challenge was coordinating diverse interests – recreational users, businesses, environmental groups – in a redesign process of a flood-prone area with competing priorities and clashing interests. Another was ensuring meaningful participation within tight project timelines and limited prior experience with inclusive climate governance.

Success stemmed from early stakeholder mapping, dedicated facilitation, and strong institutional commitment. The Mayor and Councillor actively participated, reinforcing trust among the stakeholders and the local community. A communications secretariat ensured consistent outreach, while technical data from APE FVG grounded the process in climate evidence.

recommendations

- Start with thorough stakeholder mapping and needs assessment.
- Engage professional facilitators to guide co-design.
- Ensure political leadership is visible and consistent.
- Combine technical planning with cultural and civic engagement.
- Use festivals or public events to amplify visibility and connect actions.



Overview of the Dornbirn CCRM

The main challenges for the state of Vorarlberg and the city of Dornbirn are the **increasing temperature, changes of precipitation patterns, floods, and landslides** (APCC, 2014; Hiebl & Orlik, 2023; Mauran, Knevels, & Misha, 2022). These, in turn, have various and often interrelated consequences. The focus of this mission lies on environmental resilience with considerations and inclusion of social, environmental, and economic resilience as they are highly interconnected with all the other aspects of the climate resilience.

The Dornbirn's local CCRM enables a cross-sectoral and interdisciplinary collaboration, with stakeholders from different backgrounds invited to join the formation of the CCRM. First, a key stakeholder mapping occurred to define who should be invited to gain a better understanding of climate risks from different perspectives. The CCRM-Vorarlberg aims at understanding climate risks better and drawing informed recommendations for climate resilience from them. To kick-off this CCRM, a half day workshop (focus group) was organized to understand climate hazards from different perspectives and map the interdependencies between them and secondly, the focus was put on possible solutions.

Key stakeholders that have signed the MoU for joining the CCRM: The city of Dornbirn, Vorarlberg University of Applied Sciences, Weavs and Energieinstitut Vorarlberg.

Dornbirn Quintuple Helix Model matrix:

Institution name	Target Group Category	Quintuple helix category	Competencies
City of Dornbirn	Local public authority	Political system	Climate change communication; engagement of citizens; strategy & planning; leadership and decision-making; policy & governance
University of Applied Sciences	Higher education and research organisation	Educational system	Climate change adaptation; research & analysis; climate resilience research; climate change communication
Weavs	Service providers / private sector	Economic System	Development of digital solutions for monitoring climate change impacts to enable climate change adaptation
Energieinstitut Vorarlberg	Sectoral Agency	Natural System	Expertise in climate change adaptation and energy-related topics, research; experience with collaboration of diverse stakeholder groups

Dornbirn Pilot Project

The main goal of the pilot project is to demonstrate the temperature reduction potential of nature-based solutions. Specifically, different climate data indicators (surface and air temperature, humidity) are collected to compare the perceived temperature on different surface types, as well as on places with and without shade from trees. To minimize external influences on the microclimate, all data collection for different surfaces and shading conditions will be conducted within the same park, ensuring consistent general weather conditions for accurate comparison.

Heat islands are a pressing issue for the city of Dornbirn and nature-based solutions such as tree planting can reduce the heat island effect. This preliminary pilot study focuses on exploring the potential impact of trees and different surfaces on temperature reduction. The aim is to quantify the extent of temperature reduction achievable through nature-based solutions. The sensor network in place measures the cooling effect of trees. By using sensors, data is gathered on surface and air temperature, as well as humidity levels.

methods and inclusion

Co-creation happened through several bilateral meetings where climate risks were discussed not only in terms of climate hazards, but also in terms of their social, environmental, and economic consequences. A specialized risk workshop was organized for the members of the local CCRM.

challenges

Challenges and delays happened in the search and finding a suitable location for the on-field pilot activities and obtaining the needed permissions for setting up the equipment. Nevertheless, intersectoral and joint close collaboration, being open to changes and focusing on the shared objective proved crucial for the timely and successful completion of this pilot project.

Subsequently, the perceived temperature (heat index) is calculated, enabling an assessment of the actual reduction in perceived temperature. This pilot can be described as a digital solution, supporting the decision for nature-based solutions through climate data results.

The primary objective is to gain insights into the potential of nature-based solutions and unsealed surfaces to improve urban microclimate by mitigating the heat island effect. A secondary objective of the pilot project is to raise public awareness and educate citizens. Additionally, the pilot project aims to support the city of Dornbirn´s existing climate action plan by providing data-driven evidence on the importance of nature-based solutions and temperature-reducing surfaces. The third objective is to provide data-driven insights to strengthen Dornbirn´s climate action plan. The project results are integrated into the Citymonitor dashboard for transparency and informed decision-making. The city of Dornbirn ensured continutation of the pilot study and maintenance of the sensor network after pilot completion.

Citizens were informed about the pilot project through media, newspapers and through our participation at conferences.

Implementation steps & timeline of the Dornbirn pilot project:

2023–2024: Stakeholder mapping, MoU signing, Pilot planning.

January 2025: Risk Workshop

2024-2025: Development of action plans

Spring 2025: Implementation of Pilot study

Fall 2025: Natural hazards conference

2025 onwards: Scale-up of the pilot study

All pilot activities were funded by the Interreg Central Europe – MISSION CE CLIMATE project.

recommendations

- Involve relevant stakeholders from the beginning.
- Make sure that all stakeholders involved have the same understanding of the purpose of the project, initiative, or pilot to ensure flexibility and adaptability to project changes without loosing the overall objective out of sight.
- Be flexible and open to changes.
- Clear division of responsibilities.

Overview of Pforzheim CCRM

The city district of Pforzheim is affected by climate change in many ways. Trends that can already be observed will intensify in the future. Both the number and duration of **heatwaves** will increase significantly. **Due to the increased amount of water vapour in the air, heavy precipitation will be more intense in the future.** An increase in **thunderstorms and hailstorms** with grains larger than 2 cm in diameter is to be expected (Schröder 2019, Rädler et al. 2019). Examples of priority climate impacts include the increased cooling requirements of buildings in summer (construction and housing action area) or the increase in dry and drought periods (forestry and agriculture areas). The increase in heat stress in Pforzheim was also identified as a priority for various fields of action (tourism and leisure, citizen wellbeing and public health).

The initial set of stakeholders to be involved in the local CCRM had already been identified during the preparation phase of the MISSION CE CLIMATE project and builds on solid existing partnerships in Pforzheim and the Northern Black Forest region. This was confirmed by the signing of the MoU in April 2024.

Since the beginning of the project, it was agreed that the activities of the CCRM would be aligned with the overall Smart City strategy of the City of Pforzheim. Under the Comprehensive Climate Resilience Management (CCRM) umbrella, a series of activities were defined, focusing on enhancing the capabilities of Stadtwerke Pforzheim in implementing smart solutions and fostering knowledge among citizens to mobilize them effectively.

The following priorities have been defined for the local CCRM:

Development of Smart City Infrastructure

This action involves deploying IoT devices and other information and communication technology (ICT) infrastructure to monitor and manage the city's climate risk mitigation efficiently. The data collected will be used to inform decision-making, optimize resource allocation, and improve climate risk mitigation.

Community engagement

This action involves organizing communication and awareness-raising activities to inform and engage the community about climate resilience initiatives. Activities may include public campaigns, community events, and educational programs.

The following stakeholders from the Quintuple Helix Model are included in the Pforzheim CCRM:

Institution name	Target Group Category	Quintuple helix category	Competencies
Hochschule Pforzheim	Higher education and research organisation	Educational system	Climate change adaptation; research & analysis; climate resilience research; climate change communication Development of digital solutions for monitoring climate change impacts to enable climate change adaptation
krumedia	Service providers / private sector	Economic System	Development of digital solutions for monitoring climate change impacts to enable climate change adaptation
WFG Nordschwarzwald	Sectoral agency – Regional economic social development	Economic System / Political system	Climate change communication; engagement of citizens; strategy & planning; leadership and decision-making; policy & governance
City of Calw	Local public authority	Political system	
City of Bad Teinach			
City of Mühlacker			
District of Calw			
Enz district			
City of Knittlingen			
City of Nagold			
City of Niefern-Öschelbronn			
City of Maulbronn			
City of Pforzheim			
City of Illingen			

Pforzheim Pilot Project

The pilot addresses the challenge of enhancing climate resilience in Pforzheim and the Northern Black Forest by empowering citizens with practical tools and smart city-based solutions. It seeks to overcome barriers to effective climate action, such as limited public engagement and fragmented access to relevant information, by fostering active participation and collaboration among local communities.

methods and inclusion

Municipal staff, citizens, students, SMEs, and the regional development agency were engaged from design to rollout. Co-design sessions defined use cases and data needs; students built and installed sensor packs, wrote decoders, and configured dashboards. Municipal teams hosted pilots (flood sites, green areas, traffic spots) and tested alerts in daily operations. Citizens participated in placements and data interpretation via workshops and realized public event together with feedback surveys drove iterative updates and governance choices.

The most prominent example of the use of a co-creation method in the pilot is the joint definition of use cases, which was made through the interaction of the students at Pforzheim University with the representatives of the utility company of the city of Pforzheim. They jointly developed potential use cases, decided on the locations where to place the sensors and the definition of feedback mechanisms to trigger a reaction to the measures and data collected. Citizens participated via interaction during public events and related consultations, and pilot projects.

Implementation steps of the Pforzheim pilot project:

Feasibility - The project includes the development and deployment of sensor boxes designed for environmental monitoring. A comprehensive data acquisition and processing workflow has been established to ensure efficient collection and analysis of sensor data. Field tests were conducted using eight sensors to evaluate their performance under real-world conditions. Additionally, procedures for data acquisition and storage have been implemented to securely manage the collected environmental data.

Prototype Development - Based on the identified objectives, stakeholders collaborate to develop prototypes of the IoT sensor technology and the Citizen Toolkit. This involves designing and testing sensor configurations, as well as drafting instructional materials for the Citizen Toolkit.

Pilot Testing - Once prototypes were developed, pilot testing was conducted in the designated pilot area within the Pforzheim community. This involved deploying IoT sensors in real-world environmental monitoring scenarios and assessing their functionality, usability, and effectiveness.

Data Collection and Analysis - Throughout the pilot testing phase, data is collected from the deployed IoT sensors to monitor environmental parameters such as air quality, temperature, and humidity. This data is then analysed to evaluate the performance of the sensors and assess their impact on environmental monitoring efforts.

Iterative Improvement - Based on the findings from pilot testing and data analysis, stakeholders iterate on the design of the IoT sensors and the Citizen Toolkit to address any identified issues or areas for improvement. This iterative process ensures that the final products meet the needs and expectations of end-users.

Documentation and Reporting - Throughout the implementation and testing phase, comprehensive documentation is maintained to track progress, record findings, and document lessons learned. This documentation serves as a valuable resource for future initiatives and informs the final reporting of project results.

recommendations

One of the most significant lessons is the symbiotic relationship between technological advancement and societal involvement. Technology alone cannot drive meaningful or lasting change in urban sustainability.

It is the convergence of innovative tools with motivated, informed citizens that has brought about palpable results–from optimized salt logistics and more resilient flood prevention to improved public resource management and greener mobility.

The ongoing analysis and visualization of sensor data through user-centric dashboards proved essential for turning raw numbers into actionable intelligence. For example, continuous records of air quality, soil moisture, traffic density, and public-space occupancy allowed both municipal authorities and everyday citizens to track trends, benchmark progress, and intervene with timely, sustainability-minded actions.

Beyond the technical realm, the integration of citizen science emerged as a crucial ingredient for project success and for realizing a deeper dimension of sustainability. Engaging citizens–both as data collectors and informed users–transformed the project from a purely technological exercise into a participatory movement. Citizens actively contributed by installing sensors in their homes, gardens, and workplaces, as well as by responding to emergent insights from the dashboard data. For instance, real-time alerts regarding flood risks or road salt depletion empowered local communities to take preemptive, sustainable actions. The "Do It Yourself" instructions, which were initially devised during the first campaign, enabled broader public participation and enhanced the project's reach and impact.

The citizen science approach also enriched the educational process, as students and non-experts gained hands-on experience in sensor deployment, data analysis, and digital literacy. This democratization of technology resulted in increased public awareness of sustainability challenges and the value of open data. Participants developed a sense of ownership and agency, recognizing that environmental impact is not solely the domain of experts but something shaped by everyday actions and informed decisions.

On the operational side, several valuable lessons surfaced. The effectiveness of collaboration between stakeholders was amplified by clear communication and well-defined roles from the very beginning.

challenges

Routine data collection worked best when both technological and human factors were given equal attention. Challenges–such as the theft of water level sensors–underscored the need for robust security measures and contingency planning. In response, future deployments will emphasize sensor protection and rapid replacement strategies.

The implementation of the pilot was funded by the Interreg Central Europe MISSION CE CLIMATE project. In-kind contribution was obtained from Pforzheim University professors and students, as well as in-kind participation from the utility company of the city of Pforzheim.
Some public events organised by the city were used to communicate about the pilot.

Overview of the Brač CCRM

The Island of Brač in Croatia faces rising climate risks driven by **hotter, drier summers, more frequent heatwaves, and unreliable rainfall, all of which directly intensify drought and water scarcity concerns across the island.** Brač is a tourism-dependent island with limited freshwater sources and a seasonal population surge, which places additional pressure on its water supply system. The old water supply system is contributing to high water losses, but the water supply company, Vodovod Brač, is now responding through modernisation efforts—including the replacement of outdated metering technology, leak-detection upgrades, and the creation of a dedicated water loss reduction team—to strengthen resilience.

The establishment of the Community Climate Resilient Mission (CCRM) on the island of Brač was initiated by the **Split Dalmatia County (SDC)** and **Energy Institute Hrvoje Požar (EIHP)** as part of its commitment to implementing equipment procured during the Mission CE Climate project and to implement the Sustainable Energy and Climate Action Plan (SECAP). The objective of the CCRM is to support the Island of Brač to become climate resilient and enable a coordinated response to the local challenges of climate change. The process followed a structured sequence. The SDC and the EIHP conducted a comprehensive stakeholder mapping based on the Quintuple Helix approach, followed by consultation rounds with local government, public utilities and community actors to identify shared priorities and identify key actors relevant to the local climate transition.

These interactions led to the signing of a Memorandum of Understanding between core stakeholders:

- Split-Dalmatia County
- Energy Institute Hrvoje Požar
- Vodovod Brač

AThe City of Supetar

- The Municipality of Sutivan
- Local Action Group Brač

The Memorandum formalized collaboration and responsibility-sharing and enabled the launch of co-design activities under the Climate Mission framework. Through workshops, technical exchanges and participatory meetings, stakeholders co-identified **water scarcity, heat risks and infrastructure vulnerability as priority resilience topics,** leading to the upgrading of Brač's water distribution system. The mission unites multiple sectors, with representation from public institutions (regional and municipal authorities), science and research (EIHP), public utilities (Vodovod Brač), local development organizations (LAG Brač), and community representatives.

Brač Pilot Project

The pilot relies on the Quintuple Helix Model by involving actors from government, public utilities, research, civil society, and the local economy. Regional and local public authorities–Split-Dalmatia County, the City of Supetar and the Municipality of Sutivan–provided governance, political support and access to local knowledge. Vodovod Brač, the publicly owned water utility, served as the technical implementer, installing equipment and creating a leak-detection team. EIHP contributed scientific and technical expertise in project design, monitoring and validation. Citizens were included indirectly through events and community engagement activities, while the Local Action Group Brač represented civil society and acted as a bridge between community actors and institutions.

methods and inclusion

- Stakeholder mapping
- Bilateral interviews with stakeholders
- Coordination meetings with core team (SDC, Vodovod Brač, EIHP)
- Coordination meetings and knowledge exchange with stakeholders
- Participation at local festival to raise awareness about climate change
- Distribution of educational materials

Citizens participated primarily through awareness and behaviour-change activities–adjusting consumption habits, learning how to use water more efficiently, and supporting adaptation actions identified in the SECAP. Outreach events, including the Mission CE Climate presentation and public guidance materials, equipped residents and seasonal users with practical water-saving measures. Over time, residents are expected to help shape demand management and provide feedback on system improvements.

Project implementation followed a clear timeline:

2023 – early 2024: early scoping and equipment planning

Mar 2024: stakeholder mapping and MoU signing

Mid-late 2024: procurement of technical equipment by Vodovod Brač and Split-Dalmatia County

Sep 2024 – Apr 2025: installation of data loggers and meters

Early 2025: establishment and training of a three-person leak-detection team

May 2025 – present: active monitoring and verification

Sep – Oct 2025: public dissemination, including local presentations and stakeholder events

The procured equipment, consisting of 15 magnetic-inductive meters, 10 data loggers, 1 remote water flow detector, and Vibrophone MTC, was funded partially by the SDC, through the Mission CE Climate project, and partially by direct investment of Vodovod Brač. The total investment is valued at aproximately 70.000 euros. EIHP contributed technical consultancy, and the SDC supported coordination and administrative processes.

Key risks centered on equipment installation in functioning water facilities, working during night or winter periods to avoid service disruption, especially during tourist season, and ensuring the safe handling of pressurized infrastructure. Operational risks included service interruptions, limited access due to tourism traffic and differences in material costs compared to initial market research.

As of late 2025, all planned equipment had been delivered and installed, and the pilot entered full operational testing. A new loss-detection team was established, monitoring systems are live, and data is being verified in structured phases.

As expected, the most tangible result has been a reduction in water losses. Additional outcomes include the formation of a dedicated water-efficiency team, improved system transparency through real-time monitoring, increased institutional capacity across municipal stakeholders, and community awareness increase by producing materials, including a household water and energy guide to support broader climate and drought resilience.

Vodovod Brač is responsible for the continued operation, now equipped with modern tools and human capacity to maintain and manage the upgraded system. Monitoring will continue beyond the project period, and findings are expected to potentially be replicated on other Adriatic islands. Split-Dalmatia County and EIHP will maintain advisory roles through ongoing regional planning processes, while LAG Brač and municipalities will continue community engagement.

The pilot focused on upgrading leak detection and management capabilities within Vodovod Brač's water supply system. The installation of new equipment was paired with the formation of a dedicated leak-detection unit—three employees trained to operate the new equipment, analyse data and intervene rapidly when losses were detected. Monitoring began gradually, with staged verification periods aligning with procurement, testing and full rollout, enabling the utility to transition from manual estimation to real-time system insight. In parallel, project partners, Split-Dalmatia County and EIHP, coordinated planning, reporting and communication, ensuring that municipalities and civil society actors remained informed.

challenges

The initiative encountered administrative and technical barriers. Procurement planning was complicated by price changes, forcing partners to adjust purchase lists and split procurement responsibilities between SDC and Vodovod Brač. Technically, installation had to be conducted while ensuring uninterrupted drinking-water delivery, often requiring nighttime or off-season work to avoid tourist-season disruptions. These constraints lengthened installation timelines.

Close cooperation, adaptation and flexibility among partners were decisive in overcoming these challenges. Splitting procurement tasks, securing additional investment from the utility and forming a specialised internal team ensured both continuity and ownership. Working during low-demand seasons and coordinating calendars with residents and tourism cycles allowed installations to progress without compromising service. Strong communication between partners sustained momentum and kept delays manageable.

recommendations

- Anticipate cost changes and design procurement plans with flexible scopes or phased purchasing options
- Align technical work with community rhythms in your area (peak tourism, school holidays or seasonal workloads)
- Combine technological upgrades with organisational change—hardware alone is insufficient without trained staff and monitoring routines.
- Treat pilots as learning platforms—monitor data, document lessons, create public materials and communicate results

Pilot Draft Template

Pilot title: .....

Location(s): .....

Local climate risk addressed: .....

Goal: .....

Co-creation method used: .....
(e.g., workshop, interviews, citizen dialogue,
school curriculum co-design)

Key stakeholders: .....
(Quintuple Helix list)

Implementation steps + timeline: .....

Data/indicators: .....
(technical, economic, social, etc.)

Risks and safety considerations: .....

Maintenance and sustainability plan: .....

Replication notes: .....
(sustainability, what must be in place to upscale or mirror in other
initiative or within a different context)

Participatory Tools for Community-Led Initiatives and Co-Designing Pilot Projects with Citizens

This toolbox provides practical methods used across the CCRMs and pilots in this manual. Each tool includes purpose, when to use it, and minimum outputs so communities can apply it immediately.

Tool 1:

Stakeholder mapping (Quintuple Helix Model)

Purpose: Identify who must be involved for legitimacy, knowledge, implementation, and community ownership.

When to use: Before forming a CCRM, launching a campaign, or designing a pilot.

How: List actors under the five helix categories; then prioritise by influence and willingness.

Minimum outputs: Stakeholder list + contact points + engagement plan (who to meet first and why).

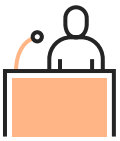
Tool 2:

Bilateral interviews / one-to-one meetings

Purpose: Build trust early, surface concerns, and identify resources and constraints.

When to use: Before workshops; when dealing with sensitive topics or fragmented responsibilities.

Minimum outputs: Short notes capturing (a) needs, (b) offers, (c) risks, (d) decision constraints.



Tool 3:

Launch event + networking session

Purpose: Make the mission visible, invite participation, and connect actors who do not normally collaborate.

When to use: At the start of a CCRM or pilot cycle.

Good practice: Combine short presentations with small-group discussion and a clear "how to join" step.

Minimum outputs: Attendance list, top priorities, sign-ups for next meeting/workshop.

Tool 4:

Citizen dialogue / open forum

Purpose: Collect lived experience (heat, flooding, mobility constraints, seasonal pressures) and validate priorities.

When to use: Early in problem definition; when trust and inclusion are key.

Minimum outputs: List of issues, locations, and community ideas; agreement on one focus area.

Tool 5:

Co-design workshop (solution shaping)

Purpose: Move from problems to a feasible solution design with shared ownership.

When to use: Once a priority is chosen; before procurement/permissions.

Format: 60–120 minutes. Use a simple canvas: Problem → Users → Ideas → Constraints → Actions → Roles.

Minimum outputs: One selected solution concept, roles, timeline, and next steps.

Tool 6:

Participatory mapping (risk and opportunity)

Purpose: Identify hotspots (heat islands, flood-prone streets, overheated schoolyards, water-loss areas) and feasible pilot sites.

When to use: When location matters (most adaptation pilots).

Methods: Mapping walk, printed map session, or digital map tool.

Minimum outputs: Priority locations + site notes + backup options.

Tool 7:
Surveys and rapid feedback (on-site or online)

Purpose: Capture user experience and perceived benefits (comfort, safety, usability, acceptance).

When to use: During or after pilot implementation (e.g., at bus stops, schools, public events).

Minimum outputs: 3–8 key questions, response summary, and at least 2 actionable improvements.

Tool 8:
Living lab routine (regular mission meetings)

Purpose: Maintain momentum beyond one-off events and projects.

When to use: Throughout the CCRM lifecycle.

Good practice: Keep meetings short; publish decisions; rotate hosts; invite new partners periodically.

Minimum outputs: Action list, decision log, one outward-facing update message.

Tool 9:
Risk and vulnerability workshop (expert + community)

Purpose: Understand hazard interdependencies and prioritise responses.

When to use: For complex hazards (heat + flooding + landslides; coastal risks; infrastructure vulnerability).

Minimum outputs: Priority risk list, interdependencies, and recommended adaptation actions.

Tool 10:
Data and dashboard co-design (open data for climate action)

Purpose: Make climate data usable for citizens, schools, and municipal decision-making.

When to use: When using sensors, monitoring, or open data platforms.

Steps: Define use cases → choose indicators → design visualisation → test with users → refine.

Minimum outputs: Agreed indicators, user-friendly dashboard layout, maintenance protocol.

Tool 11:
Education co-creation (schools as climate hubs)

Purpose: Convert monitoring into learning and community awareness.

When to use: When schools can host sensors or climate learning modules.

Good practice: Co-create content with teachers; align with the school year; simplify data access with direct links.

Minimum outputs: Lesson plan(s), worksheets, and a simple student task tied to local data.

Tool 12:
Public festivals / open days (amplification tool)

Purpose: Scale visibility and engagement beyond "already involved" groups.

When to use: After pilots or major milestones; in tourism-heavy locations for seasonal outreach.

Minimum outputs: Engagement numbers, key messages delivered, sign-ups, and feedback.

Tool 13:
Implementation coordination (multi-competence management)

Purpose: Reduce delays caused by fragmented responsibilities (permits, heritage protection, concessionaires, utilities).

When to use: Urban pilots and infrastructure-linked pilots.

Minimum outputs: Named coordination lead, responsibility matrix, and a "permissions/procurement" timeline.

Tool 14:
Learning capture and replication note

Purpose: Convert pilot experience into a best practice others can adopt.

When to use: At pilot completion and after major milestones.

Minimum outputs: What worked, what did not, costs/effort, prerequisites, and replication steps.

Tools at a Glance

Tool	Purpose	When to use	Minimum outputs
1. Stakeholder mapping	Identify who must be involved for legitimacy, knowledge, implementation, and ownership	Before forming a CCRM, launching a campaign, or designing a pilot	Stakeholder list + contact points + engagement plan (who to meet first and why)
2. Bilateral interviews / one-to-one meetings	Build trust early, surface concerns, identify resources and constraints	Before workshops; for sensitive topics or fragmented responsibilities	Short notes: needs, offers, risks, decision constraints
3. Launch event + networking session	Make the mission visible, invite participation, connect actors	Start of a CCRM or pilot cycle	Attendance list + top priorities + sign-ups for next meeting/workshop
4. Citizen dialogue / open forum	Collect lived experience and validate priorities	Early problem definition; when trust and inclusion are key	Issues + locations + community ideas + agreement on one focus area
5. Co-design workshop (solution shaping)	Turn problems into a feasible, shared solution design	After choosing a priority; before procurement/ permissions	Selected solution concept + roles + timeline + next steps
6. Participatory mapping (risk and opportunity)	Identify hotspots and feasible pilot sites	When location matters (most adaptation pilots)	Priority locations + site notes + backup options
7. Surveys and rapid feedback (on-site or online)	Capture user experience and perceived benefits; improve implementation	During or after a pilot (e.g., bus stops, schools, public events)	3–8 questions + response summary + at least 2 actionable improvements
8. Living lab routine (regular mission meetings)	Maintain momentum beyond one-off events and projects	Throughout the CCRM lifecycle	Action list + decision log + one outward-facing update message
9. Risk and vulnerability workshop (expert + community)	Understand hazard interdependencies and prioritise responses	For complex hazards (e.g., heat + flooding + landslides)	Priority risk list + interdependencies + recommended adaptation actions
10. Data and dashboard co-design (open data for climate action)	Make climate data usable for citizens, schools, and decision-makers	When using sensors, monitoring, or open data platforms	Agreed indicators + user-friendly dashboard layout + maintenance protocol
11. Education co-creation (schools as climate hubs)	Turn monitoring into learning and community awareness	When schools host sensors or climate learning modules	Lesson plan(s) + worksheets + simple student task tied to local data
12. Public festivals / open days (amplification tool)	Scale visibility and engagement beyond "already involved" groups	After pilots/milestones; tourism-heavy locations for seasonal outreach	Engagement numbers + key messages delivered + sign-ups + feedback
13. Implementation coordination (multi-competence management)	Reduce delays from fragmented responsibilities (permits, utilities, etc.)	Urban and infrastructure-linked pilots	Named coordination lead + responsibility matrix + permissions/ procurement timeline
14. Learning capture and replication note	Convert pilot experience into a best practice others can adopt	At pilot completion and after major milestones	What worked/what didn't + costs/effort + prerequisites + replication steps

Trainings for Participants of Citizen-Led Initiatives

Community-led climate resilience depends not only on people's motivation to act, but also on their capacity to do so. Across Europe and globally, communities are increasingly stepping forward to address the impacts of climate change—flooding, heatwaves, drought, and ecological degradation. However, to ensure their efforts are informed, inclusive, and effective, communities must be equipped with the right tools, knowledge, and skills.

This chapter outlines the critical role of training and capacity-building in enabling and sustaining citizen-led climate initiatives. It presents key training themes for climate-resilience for citizens, highlights successful examples from across Europe, and demonstrates how structured learning can turn grassroots enthusiasm into resilient and equitable action.

Training is not a peripheral activity in climate governance—it is central. When communities are well-informed, they are better positioned to:

- **Understand and assess their specific climate risks;**
- **Design and implement locally relevant solutions;**
- **Participate in decision-making processes with confidence;**
- **Access funding and resources;**
- **Monitor progress and adapt over time.**

Our Approach

A series of structured training sessions were developed within the MISSION CE CLIMATE project to build foundational knowledge and strengthen the capacity of local actors involved in Community Climate Resilient Missions (CCRMs). Climate resilience requires not only strategic planning and technical solutions but also shared understanding among all stakeholders. The training programme was designed to equip CCRM members with the scientific background, policy frameworks, and practical tools needed to respond effectively to climate challenges in their communities.

Covering essential themes such as climate adaptation, temperature and precipitation-related risks, and urban resilience within planetary boundaries, the sessions aimed at support a common learning baseline while addressing the specific needs of different local contexts. This approach ensures that all participating communities, regardless of scale or focus area, can develop informed, collaborative, and adaptive responses to the climate crisis.

To build the knowledge and capacity of citizens, NGOs, and local actors in addressing climate challenges, initiatives should offer structured training sessions that combine scientific grounding, policy awareness, and practical application. The aim is to establish a **shared understanding among stakeholders** while tailoring content to the unique needs of each community.

Below are some training topics organized within the MISSION CE CLIMATE project that any CLI can adopt or adapt to strengthen community climate resilience.

1. Introductory training on climate change and its effects

Provided a clear introduction to climate change and its local and global impacts.

What the training covered:

- The science of climate systems and the greenhouse effect;
- How cities contribute to CO2 emissions;
- The importance of vulnerability assessments as a basis for adaptation planning;
- Practical examples of vulnerability assessments from other cities to inspire local action.

2. Understanding Temperature-Based Climate Risks

Educated participants on the health, environmental, and social risks of rising temperatures.

What the training covered:

- The urban heat island effect and its implications
- Climate projections under different emission scenarios
- Strategies for urban cooling and nature-based solutions
- Examples of both incremental and transformational adaptation actions from other cities

3. Addressing Precipitation-Based Climate Risks

Help communities prepare for floods, droughts, and shifting rainfall patterns.

What the training covered:

- Current trends and projected changes in precipitation;
- Types of flooding (riverine, pluvial, coastal) and related vulnerabilities;
- Adaptation measures such as flood defenses, water conservation, and ecosystem restoration;
- The economic and environmental costs of inaction.

4. Building Resilient Cities Within Planetary Boundaries

Guide participants in aligning urban development with the planet's ecological limits.

What the training covered:

- Introduction to the concept of planetary boundaries;
- Key resilience qualities: flexibility, inclusiveness, integration;
- Approaches for upgrading infrastructure and applying nature-based solutions;
- Ensuring equity in adaptation and engaging communities in decision-making;
- Setting up monitoring and evaluation processes for continuous improvement.

5. Using the Copernicus System for Climate Action

Introduced the EU Copernicus Earth Observation Programme and how communities can use its free data and tools.

What the training covered:

- Monitoring climate trends
- Assessing local risks
- Supporting evidence-based decision-making

6. Financing Strategies for Climate Adaptation

Provided guidance on how to secure and manage funding for climate resilience measures.

What the training covered:

- Public and private funding sources
- Innovative financing models (e.g., green bonds, climate funds)
- Building compelling proposals and partnerships
- Ensuring financial accountability and transparency

7. The Potential of Civic Participation

Highlighted how community engagement can accelerate climate action.

What the training covered:

- Methods for involving residents in planning and implementation
- Building trust and fostering collective ownership
- Case studies where civic participation led to stronger climate outcomes

8. Data for Climate Action: OpenData & CLIMAAX Tools

The journey towards an Open Data Platform (concept, key milestones, and enabling process).

What the training covered:

- Barriers and challenges encountered (technical, organisational, and data-related) and how to address them;
- Presentation of core datasets (environmental, climate, and geospatial) and their practical value;
- CLIMAAX tools: functions, ecosystem overview, and data requirements;
- Case study: Košice – how OpenData and CLIMAAX tools support local climate-risk analysis;
- IoT & LoRaWAN networks and practical applications to monitor climate-relevant data;
- Practical examples and peer learning from experts involved in the MISSION CE CLIMATE project.

Recommendation for Development of Training Curriculums for Community-Led Climate Initiatives

A robust training program for community-led initiatives should address both technical knowledge and organizational capacity. Below are some recommended topics that form the foundation of such programs:

Climate Science and Local Risk Awareness

Communities need to understand how climate change manifests locally. Training in basic climate science, risk mapping, and local projections helps individuals and groups recognize how flooding, heatwaves, sea-level rise, or biodiversity loss may affect them directly. This knowledge is often the catalyst for action.

Community-Based Vulnerability and Capacity Assessment (CVCA)

Participatory tools like vulnerability mapping, seasonal calendars, and asset inventories allow communities to assess their risks and strengths. These tools enable self-reflection and set the foundation for locally driven planning.

Nature-Based Solutions (NbS) and Green Infrastructure

Green roofs, rain gardens, urban forests, and restored wetlands are low-cost and multifunctional responses to climate impacts. Training on how to design, implement, and maintain such solutions enables communities to enhance local resilience while co-benefiting from improved health and biodiversity.

Community Organizing and Governance

Sustained climate action depends on organized structures and strong leadership. Training in local governance, meeting facilitation, consensus-building, and transparency ensures that groups can coordinate effectively and inclusively.

Project Planning and Management

Even grassroots projects require structure. From writing a project plan to managing budgets and evaluating outcomes, communities benefit from learning professional planning tools that help translate ideas into tangible results.

Climate Finance and Fundraising

Understanding where and how to access funding is critical for scaling community initiatives. Training might include how to apply for EU grants, pitch to donors, manage funds transparently, and report effectively.

Communication and Climate Storytelling

Communities need to tell their stories—to engage others, influence policy, and attract resources. Training in media engagement, public speaking, and visual storytelling can amplify local voices and inspire broader change.

Just Transition and Climate Justice

Climate change affects communities unequally. Training in equity, social justice, and intersectional inclusion ensures that resilience initiatives reflect the needs and priorities of all residents, especially those most at risk.

Community Engagement

This action involves organizing communication and awareness-raising activities to inform and engage the community about climate resilience initiatives. Activities may include public campaigns, community events, and educational programs.

Training Programme Design Checklist
(for citizens, NGOs, local actors)

Design

- ☐ Define training purpose: awareness, skills, implementation, funding readiness.
- ☐ Segment target groups (citizens, NGOs, municipal staff, teachers, youth, SMEs).
- ☐ Choose format: short workshop / modular series / mentoring / blended.

Make training practical

- ☐ Link each module to one real local task (mapping, pilot design, communication, data reading).
- ☐ Include one hands-on exercise per session (e.g., vulnerability mapping, co-design canvas, dashboard demo).
- ☐ Provide take-home materials (worksheets, checklists, links).

Integrate learning with pilots

- ☐ Use local pilot examples as teaching cases.
- ☐ Invite pilot partners (municipality, utility, school, NGO) for credibility.
- ☐ End training with an action commitment: who will do what by when.

Accessibility and inclusion

- ☐ Offer non-digital access where needed (print, local venues, short sessions).
- ☐ Schedule around school calendars, seasonal workloads, and tourism peaks.
- ☐ Collect feedback and refine content each cycle.

European Case Studies: Impact of Community Training

Across Europe, communities are increasingly stepping into leadership roles in responding to the climate crisis. While policy frameworks and infrastructure investments are essential, it is the knowledge, skills, and agency of local people that often determine the success–or failure–of climate adaptation efforts on the ground. Community training plays a pivotal role in this transformation. It bridges the gap between awareness and action, enabling residents to understand climate risks, co-design solutions, and sustain long-term resilience measures.

This chapter presents a selection of European case studies that demonstrate how strategic, inclusive training programs have catalyzed citizen-led climate initiatives.

From rain gardens in Rotterdam to climate-sheltering schoolyards in Barcelona, each example shows how empowering people with the right tools and understanding can lead to meaningful environmental and social outcomes. These cases highlight not only the diversity of training formats and topics but also the shared principles of participation, ownership, and capacity-building that underpin successful community resilience.

By examining these stories, practitioners and policymakers can gain valuable insight into how to design and scale community training programs that are not only technically effective but also socially inclusive and locally grounded.

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Rotterdam, Netherlands – Water Sensitive Neighborhoods and the Sponge Garden

In response to increasing rainfall and urban flooding, Rotterdam developed an ambitious strategy to become a "water-sensitive city." Central to this effort was the active involvement of local communities in understanding and co-designing nature-based flood management solutions. One of the most prominent examples of this approach is the **Sponge Garden**, a living laboratory established in collaboration with community members, local designers, and water experts.

Residents participated in training sessions and workshops where they learned how green-blue infrastructure works– specifically how soil, vegetation, and landscape features can be designed to store and slowly release rainwater. They were involved in testing various soil compositions, choosing plant species, and designing small-scale bioswales and rain gardens. Local participants also learned how to monitor water absorption and contribute to long-term maintenance.

The Sponge Garden not only reduced flood risks in the area, it also became a model for similar community-based projects across Rotterdam. The initiative demonstrated how well-informed and engaged citizens can play a meaningful role in urban climate adaptation, creating more livable, green, and flood-resilient neighborhoods.

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Barcelona, Spain – Climate Shelters in Schools

As part of its urban climate adaptation strategy, the city of Barcelona developed an innovative program to **transform schoolyards into climate shelters.** These redesigned spaces aimed at reduce the effects of urban heat, increase access to green infrastructure, and serve as safe community hubs during extreme weather events.

The success of the program relied heavily on the active involvement of school communities–teachers, students, parents, and local organizations. Through participatory workshops and hands-on training sessions, community members learned about climate risks, thermal comfort, and landscape design. Children were taught how green spaces could cool the environment, reduce flooding, and support biodiversity. Adults collaborated with city planners to identify the best features to include, such as trees, shaded seating areas, water play zones, and permeable pavements.

The program resulted in the transformation of eleven schoolyards into multifunctional climate shelters. Families reported improved comfort during heatwaves, increased usage of outdoor space, and stronger community engagement. Based on this success, the initiative has been expanded to additional schools and integrated into Barcelona's long-term urban resilience strategy. It has become a leading example of how participatory design and climate education can turn everyday public spaces into hubs of resilience and well-being.

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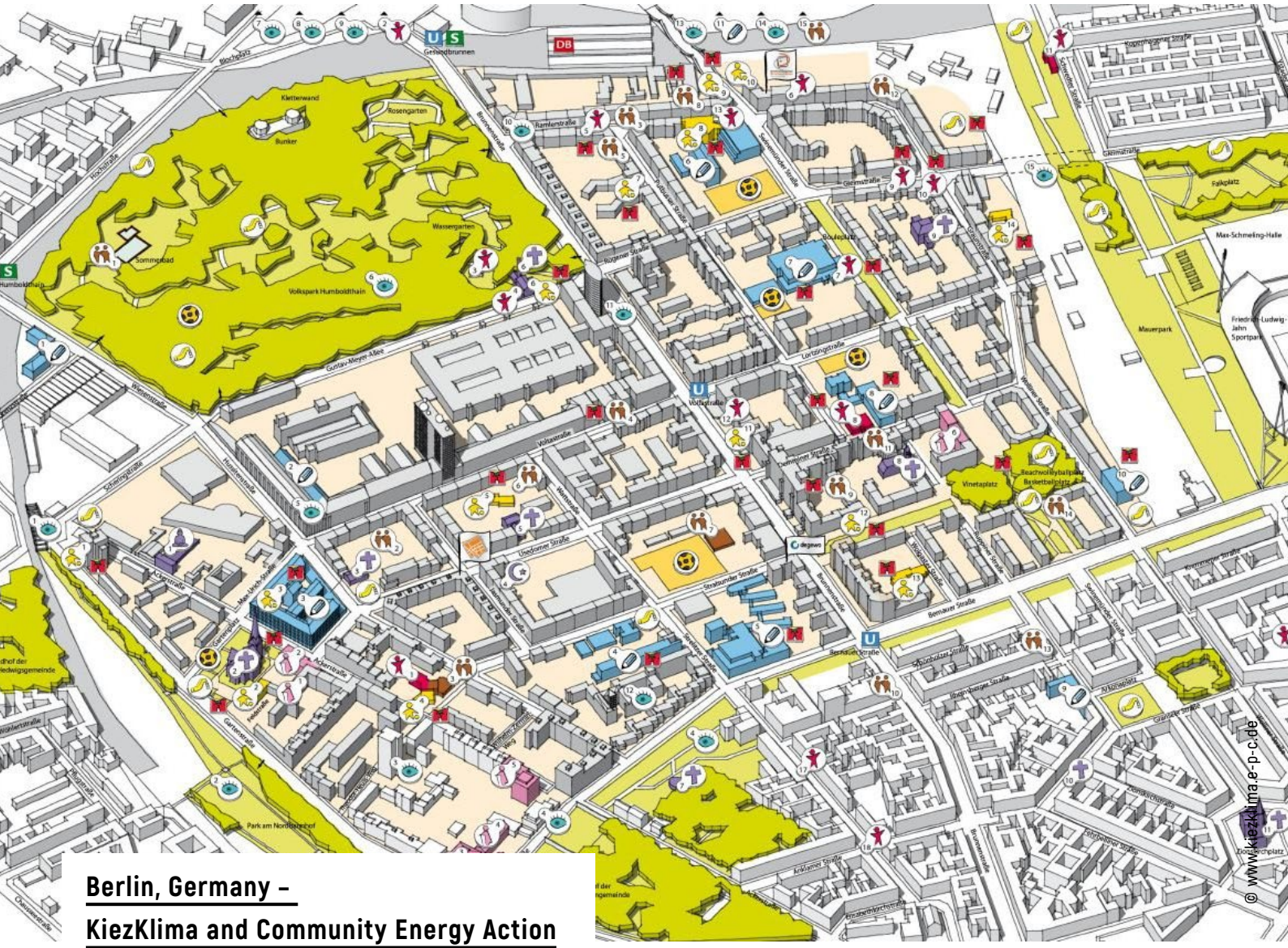

Berlin, Germany – KiezKlima and Community Energy Action

In Berlin, the **KiezKlima initiative** targeted inner-city neighborhoods where residents faced both socioeconomic challenges and exposure to environmental risks such as heat and poor air quality. The program focused on empowering local people through environmental education, hands-on greening activities, and energy-saving initiatives.

Community workshops were held to teach residents how to reduce household energy consumption, improve building insulation, and implement small-scale renewable energy solutions. At the same time, participants received training on urban greening techniques, including rooftop gardening, planting shade trees, and managing shared green spaces.

Residents applied their new skills by creating small neighborhood parks, greening inner courtyards, and forming local groups to monitor energy use and promote behavior change. The program fostered a strong sense of ownership and mutual support, particularly in areas where trust in public institutions had historically been low.

Although its outcomes were less formally measured than other programs, KiezKlima demonstrated the power of knowledge-sharing and grassroots collaboration in fostering climate resilience. It showed that when people are given the opportunity and tools to act, even small interventions can have a cumulative and transformative impact on urban environments.

Cluj-Napoca, Romania – Urban Labs and Youth-Led Climate Action

In Cluj-Napoca, Romania's growing interest in climate governance intersected with a vibrant civic culture and youth activism. Through a series of **urban living labs** supported by EU-funded initiatives, local residents–particularly young people–were trained in participatory planning, climate risk analysis, and sustainable neighborhood development.

Workshops introduced participants to tools like participatory mapping, scenario planning, and systems thinking. These sessions encouraged citizens to explore how different climate risks–such as extreme heat, air pollution, and flooding–could be addressed through nature-based solutions and low-carbon infrastructure. One flagship outcome was the "Net Zero Champions" initiative, which trained young people to advocate for and co-develop retrofitting strategies for apartment blocks, helping entire communities reduce energy use and emissions.

The project not only resulted in concrete proposals for climate-resilient neighborhoods, but also strengthened youth leadership in local governance. Many participants continued to collaborate with municipal planners, influencing public policy and budget decisions related to sustainability. Cluj's experience shows that empowering communities–especially young people–with knowledge and planning skills can result in long-term civic engagement and system-level change.

The case studies in this chapter illustrate that when communities are equipped with the knowledge, confidence, and tools to act, they become powerful drivers of climate resilience. In cities across Europe–from Rotterdam to Cluj-Napoca–training has proven to be more than a learning exercise; it is a strategic investment in social infrastructure. It transforms residents from passive recipients of climate policy into co-creators of adaptation and sustainability.

What unites these diverse examples is the central role of inclusive, context-sensitive training that reflects local realities and builds on community strengths. Whether it involves technical skills like designing green infrastructure or soft skills like facilitation and advocacy, training fosters both individual empowerment and collective capacity. It builds trust, unlocks creativity, and supports long-term stewardship of climate solutions.

As climate impacts continue to intensify, the need for localized, community-driven responses will only grow. These European experiences offer clear guidance: for resilience to take root and endure, community training must be seen not as a support activity, but as a core pillar of any climate initiative. Integrating such training early and consistently into climate planning can ensure that local people are not only prepared for what's ahead–they are leading the way.

Next Steps for Practitioners

Effective training does more than transfer information—it builds confidence, trust, and the practical ability to act. When communities understand their climate risks and have the skills to respond, participation becomes meaningful and sustained rather than symbolic or reactive. In the context of escalating heatwaves, floods, droughts, and coastal risks, strengthening local capacity is one of the most cost-effective and socially beneficial investments in resilience.

Building on the experiences of the CCRMs and pilot projects presented in this manual, the following steps can help practitioners (local governments, NGOs, schools, utilities, universities, and community groups) embed training as a core pillar of community-led climate resilience:

1 | Start with a training needs assessment

Map the target groups (citizens, municipal staff, teachers, youth, SMEs, community organisations) and assess what they need in order to participate effectively. Identify barriers such as time constraints, digital literacy gaps, language accessibility, or lack of prior experience with participatory processes.

2 | Co-design training with the community

Co-create learning objectives, formats, and materials with those who will use them. The Košice experience shows that training works best when teachers and practitioners shape content together, test it in real settings, and improve it through feedback.

3 | Combine scientific grounding with practical application

Balance core climate knowledge (local hazards, vulnerability, adaptation options) with hands-on tools: participatory mapping, nature-based solutions design principles, data interpretation, monitoring routines, and project planning. Link training directly to ongoing initiatives (pilots, local action plans, SECAP/Adaptation Plans) so learning immediately translates into action.

4 | Offer modular and accessible formats

Use a mix of short workshops, online sessions, peer-learning exchanges, mentoring, and practical demonstrations. Schedule activities around local rhythms (tourism peaks, school calendars, seasonal workloads) and ensure accessibility for those less digitally connected by using local media, printed materials, and in-person outreach.

5 | Build long-term capability, not one-off events

Treat training as an ongoing process that strengthens the CCRM as a living lab. Develop local trainers and facilitators, document materials for reuse, and create simple onboarding packs so new partners can join missions over time without losing momentum.

6 | Connect training to governance and implementation

Training should reinforce clear roles, shared decision-making, and transparent processes within the CCRM. This includes facilitation skills, conflict management, and collaboration across sectors—especially important when pilots involve many competencies and approvals, as seen in dense urban settings.

7 | Integrate monitoring, evaluation, and learning

Define how progress will be tracked (e.g., participation, knowledge gain, behaviour change, pilot performance indicators). Pair technical monitoring (sensor data, microclimate measures, water-loss metrics) with social feedback (surveys, interviews, community reflection sessions) to capture full benefits and inform replication.

8 | Link capacity-building with funding and sustainability

Support communities in identifying funding sources, preparing proposals, and managing resources transparently. Where possible, combine external project funding with local budgets, in-kind contributions, and institutional commitments to ensure continuity beyond individual project cycles.

Ultimately, community-led climate resilience succeeds when people are equipped to lead: when citizens can interpret local risks, co-design solutions, and sustain long-term stewardship of climate actions. By embedding training early and consistently—alongside real projects and inclusive governance—practitioners can strengthen local ownership, accelerate implementation, and make resilience a lasting feature of everyday decision-making.

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MISSION CE CLIMATE Project

Climate Resilient Communities of Central Europe

Central Europe faces many climate change challenges like the rest of the world. The main aim of the MISSION CE CLIMATE project is to overcome the disjointed sectoral responses to climate change by introducing a coordinated, cross-sectoral approach that puts local/ regional authorities at the centre of the governance and management of the climate resilience process. The overall objective is to support communities in Central Europe to become resilient to climate change and to enable them to respond in a coordinated way to the impacts caused by climate change. The project will build sustainable systems (community climate missions) and community capacities (integrated strategy, local action plans, and solutions).

THE PROJECT'S INTENDED OUTCOMES ARE:

1. Establishment of climate resilience systems in partner communities (Community Climate Missions) supported by a joint 2030 Climate Resilience Strategy (definition of actions, business models, financing mechanisms) and locally tailored action plans (project portfolio approach);

2. Enhancing community capacity to adapt to climate change with new skills and tools;

3. Activated citizens contributing to community climate resilience through increased awareness and capacity (tools, etc.);

4. Solutions developed through pilot projects that respond to community adaptation challenges.

For more information on climate adaptation and good practices, consult our websites:

www.interreg-central.eu/projects/mission-ce-climate/
www.climatehub.si

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IGNITING COMMUNITY-LED CLIMATE INITIATIVES

O2.2 - Climate resilience solutions for CE communities – 5 factsheets

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MISSION CE CLIMATE

CITIZEN SCIENCE AND PARTICIPATION

CITIZEN TOOLKIT FOR ENVIRONMENTAL MONITORING.

INNOVATIVENESS

The solution presents high integration of digital technologies. Its innovativeness lies in combining:

- open data principles,
- participatory and data-driven education,
- a functional link between technical monitoring and community engagement.

OBJECTIVE

Develop and implement a Citizen Toolkit focused on environmental monitoring and engagement within the Pforzheim area. This toolkit aims to empower citizens to contribute data and insights using IoT sensors, thereby fostering community participation in smart city initiatives and promoting environmental stewardship.

GEOGRAPHICAL COVERAGE:

THE PILOT PROJECT WAS IMPLEMENTED IN THE CITY OF PFORZHEIM. UPTAKES ARE PLANNED IN FURTHER AREAS OF THE NORTH AND BLACK FOREST REGION.

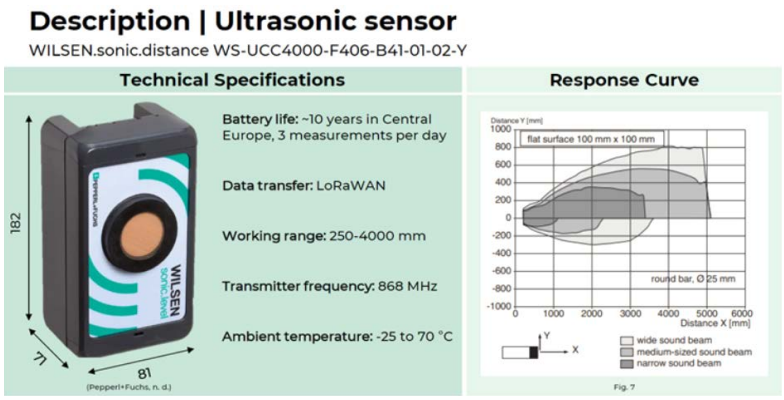
CLIMATE RESILIENCE SOLUTION IN MUNICIPALITY OF PFORZHEIM

The pilot delivered a working end-to-end civic-sensing stack–LoRaWAN devices feeding an enerchart dashboard–validated in real conditions across multiple use cases (water level, air quality, noise, soil humidity, and indoor/urban microclimate, etc. Most sensors have been running continuously; only early water-level units were lost to theft, prompting plans for secured replacements.

A "v1 Citizen Toolkit" with step-by-step guides was produced, with updates queued from subsequent field learnings. The approach for a wider citizen-science rollout was set with local partners, and a public presentation on 6 May 2025 drew roughly 250 attendees, surpassing awareness goals and generating demand for a follow-up. Data is already informing practical decisions–such as road-salt silo logistics, flood preparedness, green-space care, urban climate tracking, and mobility flows.

Key lessons include the robustness and scalability of LoRaWAN and the need for stronger device security. Interim KPIs indicate strong relevance and smooth technical operation, with user satisfaction to be quantified as the rollout expands.

Overall, the pilot progressed from feasibility to stable, real-world sensing with a documented, citizen-ready toolkit and clear momentum for regional scaling.



Description of ultrasonic sensor

IMPLEMENTATION STEPS

The development of the digital solution within the City of Pforzheim took place according to the following steps:

1) PROTOTYPE DEVELOPMENT
2) PILOT TESTING
3) DATA COLLECTION AND ANALYSIS
4) ITERATIVE IMPROVEMENTS

STEP 1 – PROTOTYPE DEVELOPMENT

Based on the identified objectives, stakeholders collaborate to develop prototypes of the IoT sensor technology and the Citizen Toolkit. This involves designing and testing sensor configurations, as well as drafting instructional materials for the Citizen Toolkit.

STEP 2 – PILOT TESTING

Once prototypes are developed, pilot testing is conducted in the designated pilot area within the Pforzheim community. This involves deploying IoT sensors in real-world environmental monitoring scenarios and assessing their functionality, usability, and effectiveness. Citizens are actively involved in the testing process, providing feedback on the usability and utility of the Citizen Toolkit.

STEP 3 – DATA COLLECTION AND ANALYSIS

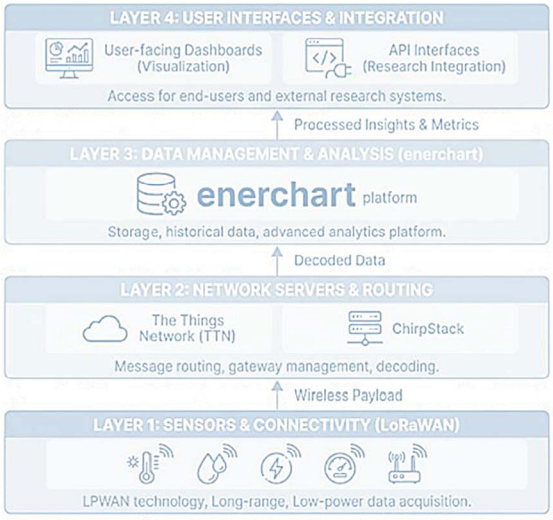
Throughout the pilot testing phase, data is collected from the deployed IoT sensors to monitor environmental parameters such as air quality, temperature, and humidity. This data is then analyzed to evaluate the performance of the sensors and assess their impact on environmental monitoring efforts.

STEP 4 – ITERATIVE IMPROVEMENT

Based on the findings from pilot testing and data analysis, stakeholders iterate on the design of the IoT sensors and the Citizen Toolkit to address any identified issues or areas for improvement. This iterative process ensures that the final products meet the needs and expectations of end-users.

USE CASE REPORTS

Visualisation of short use case reports in the enerchart dashboard can be found here: **enerchart**



Infrastructure layers visualization of digital solution

Over the course of this project, numerous lessons have emerged, encompassing both the technological aspects of IoT deployment and the broader impacts of engaging citizens in data-driven urban and environmental sustainability.

TECHNOLOGY APPROACH

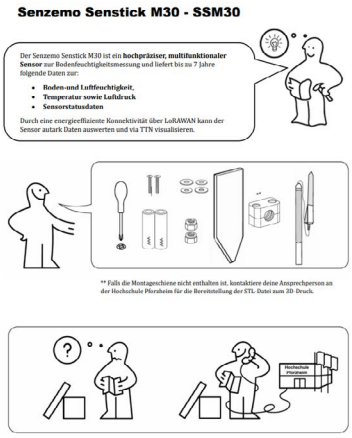
From a technological perspective, the adoption of LORAWAN technology has proven highly advantageous for connecting a diverse array of sensors to a robust, Internet-based dashboard. The long-range, low-power capabilities of LORAWAN enabled the installation of sensors in locations that are traditionally challenging for wired solutions or short-range wireless alternatives. The flexibility and scalability of the network have allowed stakeholders to continuously expand sensor coverage and experiment with new use cases with minimal incremental investment. Notably, LORAWAN's energy efficiency and reliable connectivity have facilitated real-time data collection for applications such as road salt silo management, flood level detection, soil condition monitoring, environmental sensing, and even dynamic crowd and traffic analysis.

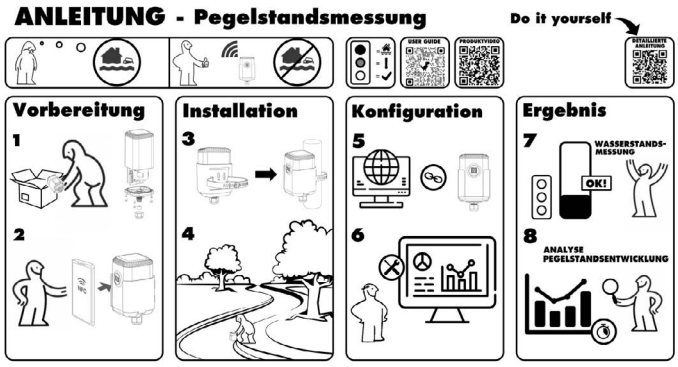
Utilizing **The Things Network** (TTN), an open, global platform, has further accelerated both technology adoption and knowledge sharing. With its suite of accessible tools and strong security features, TTN allowed project teams and citizen collaborators alike to rapidly prototype, test, and scale their IoT applications. The thriving TTN community proved instrumental not only in technical troubleshooting but also in fostering a sense of shared purpose. Local communities across Europe participated in parallel efforts, exchanging expertise and even integrating data streams, which laid a foundation for future cross-regional collaborations.

CITIZEN SCIENCE APPROACH

Beyond the technical realm, the integration of citizen science emerged as a crucial ingredient for project success and for realizing a deeper dimension of sustainability. Engaging citizens–both as data collectors and informed users–transformed the project from a purely technological exercise into a participatory movement. Citizens actively contributed by installing sensors in their homes, gardens, and workplaces, as well as by responding to emergent insights from the dashboard data. For instance, real-time alerts regarding flood risks or road salt depletion empowered local communities to take preemptive, sustainable actions. The Do It Yourself instructions, which were initially devised during the first campaign, enabled broader public participation and enhanced the project's reach and impact.

The citizen science approach also enriched the educational process, as students and non-experts gained hands-on experience in sensor deployment, data analysis, and digital literacy. This democratization of technology resulted in increased public awareness of sustainability challenges and the value of open data. Participants developed a sense of ownership and agency, recognizing that environmental impact is not solely the domain of experts but something shaped by everyday actions and informed decisions.





Examples of DYI manuals for sensors installation

COLLABORATION APPROACH

On the operational side, several valuable lessons surfaced. The effectiveness of collaboration between krumedia and Hochschule Pforzheim was amplified by clear communication and well-defined roles. Ongoing, routine data collection worked best when both technological and human factors were given equal attention. Challenges–such as the theft of water level sensors–underscored the need for robust security measures and contingency planning. In response, future deployments will emphasize sensor protection and rapid replacement strategies.

Perhaps one of the most significant lessons is the symbiotic relationship between technological advancement and societal involvement. Technology alone cannot drive meaningful or lasting change in urban sustainability. It is the convergence of innovative tools with motivated, informed citizens that has brought about palpable results–from optimized salt logistics and more resilient flood prevention to improved public resource management and greener mobility.

The ongoing analysis and visualization of sensor data through user-centric dashboards proved essential for turning raw numbers into actionable intelligence. For example, continuous records of air quality, soil moisture, traffic density, and public-space occupancy allowed both municipal authorities and everyday citizens to track trends, benchmark progress, and intervene with timely, sustainability-minded actions.

Demonstration of pilot approach at SMART CITY DAYS 2025, Pforzheim

PILOT SUMMARY

The pilot in Pforzheim contributes a practical, scalable pathway for tackling climate challenges by turning citizen participation into continuous environmental intelligence and actionable local decisions. It delivers a low-cost LoRaWAN sensing network, using The Things Network and an enerchart dashboard, that citizens and students help install and operate, shifting monitoring from occasional expert surveys to always-on, community data streams.

The project couples technology with a DIY Citizen Toolkit and campaigns that grow digital literacy and ownership. By blending open IoT, user-centric dashboards, and structured citizen science, the pilot accelerates how communities monitor and adapt to climate change while building the social capital needed for long-term resilience.

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CLIMATE DATA MANAGEMENT

DIGITAL SOLUTION FOR LOCAL CLIMATE MONITORING IN OUTDOOR AREAS TO SUPPORT DECISION-MAKING, AWARENESS, AND CLIMATE RESILIENCE.

INNOVATIVENESS

The solution presents high integration of digital technologies. Its innovativeness lies in combining:

- **open data** principles,
- participatory and **data-driven education**,
- a functional link between technical monitoring and **community engagement**.
- **multifactorial comparison** of combined and individual cooling effects of different surfaces and shading in urban environments

OBJECTIVE

To improve data governance for climate adaptation in the municipalities through systematic data collection, processing, and visualization of local climate data with the aim to gain insights into the potential of nature-based solutions in improving urban microclimate, enabling infirmed decisionmaking, and raising public awareness and educate citizens.

GEOGRAPHICAL COVERAGE:

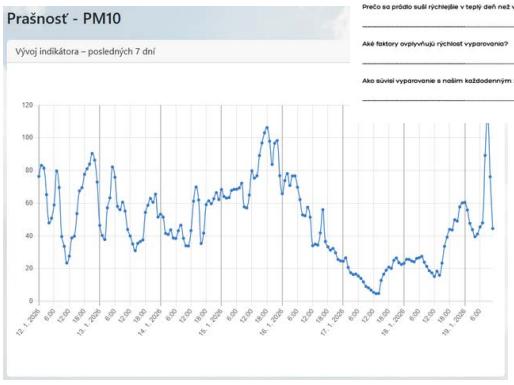
OUTDOOR SCHOOL AREAS OF THE CITY OF KOŠICE AND PARK AREAS OF THE CITY OF DORNBIRN

CLIMATE RESILIENCE SOLUTION IN MUNICIPALITY OF KOŠICE

The Košice school-based climate resilience pilot provides a controlled, real-world testbed for the full digital data lifecycle–from sensor readings to public interpretation.

The solution implemented by pilot project in the geographical area of City of Košice consists of:

- a network of IoT climate sensors installed in seven outdoor school areas.
- an open digital dashboard for visualization and interpretation of climate indicators published on www.klimatickedata.sk
- integration of collected data into the existing Open Data Platform of the City of Košice (See here)
- an Educational programme for participating schools and school communities based on real, locally measured data.



Climate sensors installed on rooftops of school buldings
Graphical visualization of measured climate indicator's values
Example of worksheet for studens of elementary schools

IMPLEMENTATION STEPS

The development of the digital solution within the City of Košice followed a structured, phased approach:

1. ANALYTICAL PHASE

- Identification of priority climate indicators based on Risk and Vulnerability Assessment (See here)
- Selection of suitable school locations for sensor installation based on local GISspatial analyses and local temperature maps (See here)
- Definition of technical specifications for sensors (in the case of pilot project on Košice following indicators were selected:

  Meteorological conditions: temperature, humidity, atmospheric pressure

  Wind dynamics: wind speed, wind gusts, wind direction

  Air quality – particulate matter: PM10, PM4, PM1

  Air quality – gases: CO, NO_2

2. TECHNICAL IMPLEMENTATION PHASE

Public procurement and installation of sensors

A public procurement process was conducted to acquire IoT climate stations, ensuring compliance with technical specifications and long-term warranty conditions. The sensors were installed in schoolyards and rooftops in early 2025, each measuring eleven indicators of air quality and meteorological conditions. The stations were connected to the Microsoft Azure IoT Central platform, enabling secure data transfer, cloud storage, and integration with visualization tools.

Establishment of data infrastructure

The solution generates continuous timeseries data with precise timestamps. These data allow both real-time analysis and longterm evaluation of local climate conditions. IoT devices are integrated into the Microsoft Azure IoT Central platform, supporting standard protocols (MQTT, AMQP, HTTPS). Data are stored in Azure Blob Storage and Azure Data Lake, while access and security are managed through Azure Active Directory (Entra ID). System monitoring and stability are supported by Azure Log Analytics, Azure Monitor, and Azure Security Center for IoT.

Preparation of dashboard visualization logic

Data are further processed and visualized in Microsoft Power BI dashboards dedicated for visualization of data and education purposes in schools and one integrated dashboard into the OPEN DATA KOŠICE platform for research, municipal governance, and transparency.

Testing and Fine-Tuning

Testing of the digital dashboard, resolution of technical issues and documentation of technical solution sustainability and maintenance.

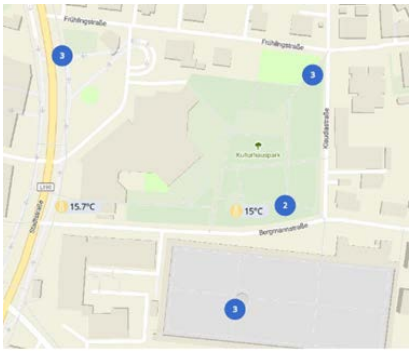
3. PARTICIPATORY EDUCATION AND COMMUNITY AWARENESS RAISING PHASE

Involvement of seven schools as active partners & joint development of educational worksheets and teaching instructions:

- Active collaboration with school representatives and educational experts in creation of curriculum for elementary schools consisting of educational worksheets for 4 school subjects and the implementation of the education program in schools.
- Awareness raising of school communities is ensured by presentation of climate monitoring dashboards at school premises via LED screens.

CLIMATE RESILIENCE SOLUTION IN MUNICIPALITY OF DORNBIRN

Rather than relying on satellite data or city-wide averages, the study directly measures surface temperature, air temperature, and humidity on the ground capturing microclimatic conditions that most affect human thermal comfort. It introduces a scalable and replicable low-cost methodology for assessing urban heat island mitigation which enables easy adaptation to other areas and climatic context.



Area where sensors are installed in City of Dornbirn

Climate sensors installed on street lamps

The solution implemented by the pilot project in the City of Dornbirn consists of:

- A network of climate sensors to measure air temperature, surface temperature, as well as humidity to assess a heat index and the perceived temperature. The sensors are located in sealed/unsealed and shade/no shade areas.
- The data is collected and visualized on the CityMonitor dashboard to to enable transparency and informed decision-making on the city level.

IMPLEMENTATION STEPS

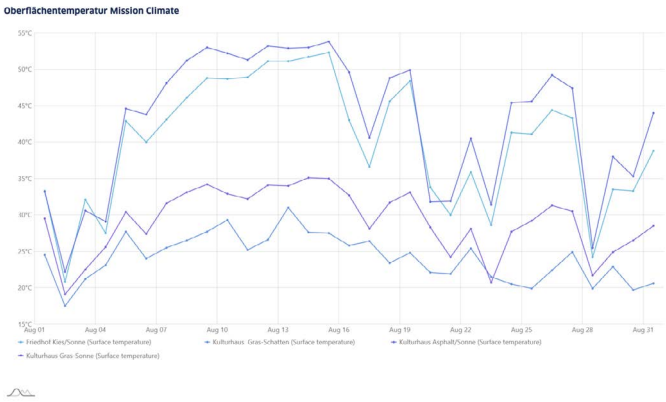
The development of the digital solution within the City of Dornbirn followed the following approach:

1. ANALYTICAL PHASE

- **Identification of climate indicators** based on the Risk and Vulnerability Assessment – heat and changes in the water cycle were the most relevant climate risks for the city of Dornbirn
- Selection of **suitable locations** for sensor installation in close cooperation with the relevant departments in the city of Dornbirn
- Definition of **technical specifications for sensors**. In the case of the pilot study in the city of Dornbirn, the following data is collected: air and surface temperature and humidity to calculate the heat index and the perceived temperature.
- To go beyond mere measurement of heat, a **multi-factor design** was chosen comparing temperatures between sealed and non-sealed and shade and non-shade to each other.

2. TECHNICAL IMPLEMENTATION PHASE

- **Public procurement and installation of sensors**
  A public procurement process was conducted to acquire the sensor network, ensuring compliance with technical specifications and long-term warranty conditions. The sensors were installed in the "Kulturhauspark" in 2025.
- **Establishment of data infrastructure**
  The solution generates continuous timeseries data with precise timestamps. The data allows both real-time analysis and longterm evaluation of local climate conditions. The data is used to assess the heat index.
- **Integration into the Dashboard**
  The Data is visualized in the already existing citymonitor dashboard dedicated for visualization of data and transparency within the city to enable informed decision-making.
- **Testing and Fine-Tuning**
  Testing of the digital dashboard, resolution of technical issues and documentation of technical solution sustainability and maintenance.



This graph shows the surface temperature of four locations within the time frame of a month, which highlights the temperature difference between shade and non-shade.

SCALE-UP OF THE PILOT STUDY IN DORNBIRN

Water, alongside heat, is one of the most significant climate risks in Vorarlberg in general, but also for the city of Dornbirn. Heavy rainfalls pose **a threat**.

In collaboration with the city's fire brigade, the pilot study is now being expanded to incorporate water into the climate monitoring system. This will include **tracking water levels of rivers and streams and monitor underground passageways for water**. This data will then be integrated into a dashboard to provide access to the data and the relevant **information in real-time** to enable the catastrophe response team to act swiftly and effectively in emergencies.

PILOTS SUMMARY

The Dornbirn pilot advances climate adaptation by proving a practical, city-ready pipeline for data acquisition, monitoring, analysis, and interpretation of urban heat. Using the heat index to compute perceived temperature, it translates raw sensor data into human-centric risk signals for planners. These insights are then published via the CityMonitor dashboard, which turns technical readings into clear visuals that support awareness, policymaking, and replication across new sites. In sum, the pilot operationalizes an end-to-end digital method– from robust sensing to meaningful public interpretation–that municipalities can reuse to target, validate, and prioritize nature-based cooling measures.

The Košice school-based climate resilience pilot provides a controlled, real-world testbed for the full digital data lifecycle–from sensor readings to public interpretation. Multi-parameter sensors installed on school grounds capture local air and weather conditions and transmit them to the city's Open Data platform. On top of this pipeline, a public "Climate data monitoring" dashboard transform raw streams into intelligible insights, linking values to health and environmental impacts and recommended behaviors. Thanks to cooperation with teachers, human-centered interpretation of data was ensured, and the solution was incorporated into the curriculum through prepared lesson plans and student projects, thereby promoting its lasting acceptance.

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COMBATING WATER SCARCITY IN COASTAL AREAS

UPGRADING THE EFFICIENCY OF THE WATER DISTRIBUTION SYSTEM AND DECREASING WATER LOSSES TO ADAPT TO POSSIBLE DROUGHTS CAUSED BY CLIMATE CHANGE.

INNOVATIVENESS

The presented solution demonstrates a high level of integration of digital technologies and team management to achieve the best possible results. Its innovativeness lies in combining:

- modern water consumption measurement systems and loss detection equipment
- the team organisation and new team for the detection of losses

OBJECTIVE

This pilot project aims to upgrade the water supply network for the island of Brač, which would directly reduce significant losses in the network and introduce monitoring and management of the water supply system to control losses / possible leaks and enable timely and appropriate intervention. This would improve the water supply of the population of the island of Brač and the general quality of life (especially in summer).

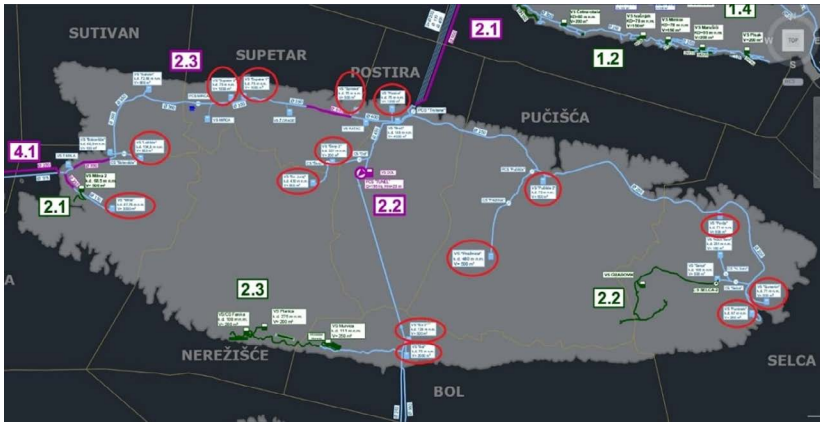
GEOGRAPHICAL COVERAGE:

THE PILOT PROJECT'S FOCUS IS ON REDUCING LOSSES IN THE ISLAND OF BRAČ'S WATER SUPPLY NETWORK, AND THEREFORE THE PROJECT AIMS TO IMPACT THE ENVIRONMENTAL SYSTEMS RELATED TO WATER USE ON THE ISLAND OF BRAČ.

CLIMATE RESILIENCE SOLUTION ON THE ISLAND OF BRAČ

The solution implemented by pilot project in the geographical area of the island of Brač consists of:

- improvement of the existing equipment in the Vodovod Brač water supply company with modern water consumption measurement systems and loss detection equipment
  See more here
- inauguration of the new team inside the organizational structure of **Vodovod Brač**, specialized in water leak detection in the water supply system.



- Circled in red are facilities where magnetic-inductive consumption meters were installed.
- Purple lines. Existing pipelines in the plan for re-construction.
- Green lines. New pipelines in plan for construction

IMPLEMENTATION STEPS

Implementation of the solution followed clear steps as listed below:

1) DEFINITION OF TOR
2) SIGNING OF THE CONTRACT WITH VODOVOD BRAČ
3) PUBLIC PROCUREMENT OF EQUIPMENT
4) DELIVERY AND INSTALLATION OF EQUIPMENT
5) MONITORING
6) VERIFICATION PROCESS

STEP 1 – DEFINITION OF ToR

The project partners EIHP and SDC have organized several meetings with members of Vodovod Brač in an effort to define the necessary equipment for the upgrade of the existing process of detecting water leaks in the water supply network of the Island of Brač. The major constraint for the equipment was the previously defined budget, which was sufficient for the planned investment at the time the project was prepared, but not after COVID pandemic and the rise of prices. The conclusion was two lists for procurement, one for the SDC to purchase and the other for Vodovod Brač.

STEP 2 – SIGNING OF THE CONTRACT WITH VODOVOD BRAČ

The contract regulating ownership, installation and service of the pilot project investment has been signed by SDC and Vodovod Brač

STEP 3 – PUBLIC PROCUREMENT OF EQUIPMENT

The close collaboration between project partners (EIHP and Splitsko/Dalmatinska County), the final beneficiary (Vodovod Brač), and members of CCRM was crucial for the relevant identification of technical and market analysis for the pilot project equipment and preparation of tender documentation. Following equipment was procured:

- 10 pieces of data logger
- VIBROPHONE MTC
- 15 Magnetic-inductive water meters for replacement of existing turbine meters
- 1 piece of remote water flow detection

STEP 4 – DELIVERY AND INSTALLATION OF EQUIPMENT

The installation schedule is done according to water consumer needs. The installation will stop the water supply, and the installation needs to be done when the effect of stopping the water supply will be minimal (mainly during nights on weekdays).

Therefore the implementation of the solution needs to be coordinated with the beneficiaries, including specific conditions (summer holiday season, traffic jams...)

The installation process took a long time due to the required additional electrical installation work and adjustments to ensure that the equipment functioned in accordance with the manufacturer's recommendations and the full product warranty.

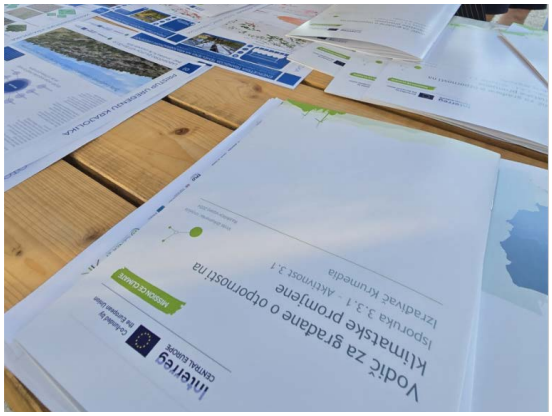
Examples of equipment investments into the water supply network

STEP 5 – MONITORING

- The initial steps of the monitoring process started from the beginning of the pilot project implementation. All activities were coordinated by EIHP and SDC according the plan and process was slightly delayed due to post-COVID changes in the market, but finalized with expected outcomes and tangible results.
- A dedicated Water Loss Department was established, demonstrating a systematic approach to leak detection.
- Household Guide for citizens was created, offering practical advice on reducing energy and water use.

STEP 6 – VERIFICATION PROCESS

- The verification of the results obtained from the pilot project implementation has been modified due to the equipment delivery timeline (and existing equipment before the pilot project implementation).
- Final equipment (existing + invested) of Vodovod Brač consists of: 16 data loggers: "ORTOMAT O4G data logger + 2 pieces of VIBROFON MTC-1.8 m cable + Antenna (GSM/UMTS+ MAGNET)" , 15 new magnetic-inductive water meters and an application for communication with them.
- Water loss was reduced from 26% to 20%, with plans to reach 15%, significantly improving energy efficiency and service reliability



Dissemination of Manual for citizens during local festival FOR FLAG Sustainable Development Festival in SUPETAR

Final presentation of the solution for local stakeholders

LESSONS LEARNED

- The close cooperation between project partners and beneficiaries is crucial for the implementation
- The budget planning needs to be done according to market analysis also revised by specialist
- The time for pilot project implementation needs to be coordinated with the beneficiaries, including specific conditions (summer holiday season, traffic jams...)
- The work on the water reservoirs and installation of equipment has been done during the winter season, and usually during the night, which caused extra work and a longer time for the installation.
- Before purchasing the equipment, make preparations for the installation, especially the electrical installation and metal joints
- The reduction of water losses has been a result of the new equipment and the new team that has the knowledge to use the new equipment most efficiently.

PILOT SUMMARY

The Brač pilot contributes a practical, scalable solution set for combating water scarcity in coastal areas by turning non-revenue water into a resilience resource. It replaces aging meters with magnetic-inductive units and expands telemetry and leak-detection capability to continuously find and fix losses, cutting distribution losses and stabilizing supply during droughts and peak tourist seasons. The project couples technology with governance–creating a dedicated Water Loss Unit, integrating data into simple operator dashboards, and validating savings over a full seasonal cycle–so utilities can act on evidence, not estimates. Night-time works and staged procurement show how to modernize coastal networks with minimal service disruption and within tight budgets, while citizen guidance materials reduce household demand. The result is a replicable "coastal playbook": instrument priority reservoirs and trunk lines, isolate sectors to pinpoint leaks, align interventions with tourism cycles, and use split-financing to de-risk delivery. Beyond securing potable water, the approach lowers pumping energy and emissions, strengthens drought preparedness, and offers a ready-to-adopt toolkit and operating model for other island and shoreline utilities facing climate-driven water stress.

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COMBATING URBAN HEAT ISLANDS

NATURE-BASED COOLING OF URBAN BUS STOPS SUPPORTED BY IOT MONITORING AND CITIZEN ENGAGEMENT

INNOVATIVENESS

The innovativeness of the solution lies in its integrated, micro-scale approach that combines:

- Nature-based solutions (green roofs on bus shelters and additional greenery in planters) implemented directly at places of everyday exposure to heat,
- Digital innovation, through the installation of IoT sensors measuring temperature, humidity, air quality, solar radiation, wind, and precipitation,
- Open data and transparency, by integrating collected data into the municipal data platform for further analysis and public use,
- Citizen participation, through pre- and post-intervention surveys capturing perceived comfort, heat stress, and acceptance of the measures,
- Awareness-raising and communication activities, including city-wide visual campaigns (city lights), informational leaflets explaining the pilot and resident-planted greenery, and branded bags distributed during surveys to increase public engagement and visibility of the initiative.

The pilot demonstrates how small-scale interventions at strategically selected locations can deliver tangible climate adaptation benefits while overcoming regulatory, institutional, and spatial constraints typical for dense historic city centres.

OBJECTIVE

The objective of the solution is to reduce heat stress and improve thermal comfort at highly exposed urban micro-locations by implementing nature-based solutions (NBS) at public transport stops. The solution aims to improve the well-being of public transport users, especially vulnerable groups, while generating measurable climate data to support evidence-based urban planning, awareness raising, and replication of the approach across the city and other Central European communities.

GEOGRAPHICAL COVERAGE:

CITY OF MARIBOR (SLOVENIA), WITH IMPLEMENTATION AT SELECTED BUS STOPS IN THE CITY CENTRE, INCLUDING THE MAIN PILOT LOCATION AND SEVERAL ALTERNATIVE BUS SHELTERS USED FOR INTERIM IMPLEMENTATION.

CLIMATE RESILIENCE SOLUTION IN MUNICIPALITY OF MARIBOR

The Maribor pilot implements a climate resilience solution focused on combating urban heat islands at public transport stops. Selected bus shelters were upgraded with green roofs and additional vegetation in planter boxes, providing shade, evapotranspiration cooling, and improved microclimatic conditions. All urban equipment installed within the pilot is newly procured and was selected in accordance with the specifications defined in the municipal Catalogue of Urban Equipment.

The intervention is supported by the installation of IoT sensor systems that continuously monitor key climate and environmental indicators, such as air temperature, humidity, particulate matter, selected gases, solar radiation, wind speed and direction, and rainfall. Data collected through the sensors are integrated into the existing municipal data infrastructure and prepared for open access and further analysis.

In parallel, citizen surveys were conducted before and after the intervention to assess perceived heat stress, comfort, and acceptance of nature-based solutions. The solution serves as a demonstrator for scalable, data-driven urban heat mitigation that can be replicated at other bus stops and public spaces.

Installation of green roof on bus stop

Vegetation installation next to bus stop for improved microclimatic conditions

IMPLEMENTATION STEPS

1. ANALYTICAL AND PREPARATORY PHASE

- Identification of urban heat challenges and priority micro-locations based on local strategic documents and stakeholder consultations
- Selection of suitable bus stop locations considering heat exposure, passenger frequency, spatial constraints, and regulatory conditions

2. DESIGN AND PLANNING PHASE

- Definition of appropriate nature-based solutions (green roofs, planters, plant species selection)
- Preparation of conceptual design, technical specifications, and cost estimations
- Coordination with municipal departments, concessionaires, and heritage protection authorities

3. PROCUREMENT AND IMPLEMENTATION PHASE

- Public procurement of urban equipment, greenery, and IoT sensor systems
- Installation of green roofs and additional greenery at selected bus shelters
- Preparation of pilot sites and integration of NBS into existing urban infrastructure

4. MONITORING AND DATA MANAGEMENT PHASE

- Installation of IoT sensors at selected bus stops
- Continuous measurement and collection of climate and environmental data
- Integration of data into the municipal platform and preparation for open access

5. CITIZEN ENGAGEMENT AND EVALUATION PHASE

- Implementation of surveys among public transport users before and after the intervention
- Collection of feedback on thermal comfort, well-being, and perception of greening measures
- Use of combined sensor data and citizen feedback to evaluate effectiveness and support replication

Anketiranje potnikov javnega avtobusnega mestnega prometa na postajališču Glavni trg -Elektro

Spoštovani potniki,

Mestna občina Maribor načrtuje prenovo avtobusnega postajališča Glavni trg - Elektro. Postajališče je v poletnih mesecih zelo **toplotno obremenjeno**, zato želimo v prihodnosti potnikom omogočiti **boljšo potovalno izkušnjo**. V okviru pilotnega projekta Mission CE Climate bomo, v sodelovanju s pristojnimi uradi, **ozelenili strehe novih avtobusnih nadstrešnic in namestili novo urbano opremo z dodatno ozelenitvijo.** Ozelenitev avtobusnih nadstrešnic izboljšuje kakovost zraka, saj rastline absorbirajo prašne delce, skladiščijo deževnico in zmanjšujejo učinek toplotnega otoka s hlajenjem okolice. Poleg tega zelene strehe spodbujajo biotsko raznovrstnost, privabljajo opraševalce, kot so čebele in metulji, ter prispevajo k trajnostnemu urbanemu okolju.
Prosimo vas, da odgovorite na nekaj vprašanj, ki nam bodo v pomoč pri načrtovanju aktivnosti. Prosimo upoštevajte, da se raziskava nanaša zgolj na omenjeno tematiko večjih toplotnih obremenitev, s katerimi se v zadnjih letih soočamo.

Zahvaljujemo se vam za sodelovanje! S pomočjo vaših odgovorov bomo ustvarili **prijetnejši in bolj zelen Maribor!**

1. Prosimo, zaupajte nam koliko ste stari?

Izberite vse primerne odgovore.

- od 10 - 25 let
- od 25 - 65 let
- več kot 65 let
- ne želim povedati

◀ Survey prepared for citizen feedback gathering and evaluation of intervention

Citizen engagement activity ▶

PILOT SUMMARY

The Maribor solution contributes to climate resilience by demonstrating a practical and replicable approach to mitigating urban heat at highly frequented public spaces. By combining nature-based solutions with digital monitoring and citizen participation, the pilot improves microclimatic conditions, supports evidence-based decision-making, raises awareness of climate adaptation measures, and provides a tested model that can be scaled up across the city and transferred to other Central European communities.

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MISSION CE CLIMATE

GOVERNANCE OF CLIMATE CHANGE

INTEGRATED PARTICIPATORY CLIMATE GOVERNANCE MODEL FOR LOCAL CLIMATE-RESILIENT PLANNING.

INNOVATIVENESS

The innovativeness of the solution lies in its systemic and governance-oriented approach to climate resilience. Rather than focusing on single adaptation measures, the method integrates participatory processes into formal decision-making and planning cycles, linking community engagement with binding instruments such as masterplans, management plans, and regulatory frameworks.

The solution also introduces a modular combination of tools – co-design procedures, green infrastructure management guidelines, capacity-building actions, and public engagement spaces – that can be scaled and adapted to different local contexts.

OBJECTIVE

The objective of the solution is to provide local and regional authorities with a structured and transferable framework to strengthen climate governance through coordinated, cross-sectoral and participatory processes. The solution supports municipalities in translating climate risks into shared planning priorities, co-designed spatial and management stategies, and longterm civic engagement mechanisms, thereby increasing institutional capacity, public ownership, and resilience to climate impacts.

GEOGRAPHICAL COVERAGE:

APPLICABLE AT LOCAL AND URBAN LEVEL ACROSS CENTRAL EUROPE AND OTHER EUROPEAN REGIONS, PARTICULARLY IN MUNICIPALITIES FACING CLIMATE RISKS RELATED TO FLOODING, HEAT STRESS, WILDFIRES AND ECOSYSTEMS DEGRADATION.

CLIMATE RESILIENCE SOLUTION IN MUNICIPALITY OF LIGNANO SABBIADORO

The climate resilience solution consists of an integrated governance model that enables public authorities to design, adopt, and implement climate resilience strategies through inclusive and coordinated processes.

The method is structured around three interconnected pillars:

- Participatory spatial and strategic planning, enabling the co-design of climate-resilient interventions in vulnerable areas;
- Institutionalisation of climate resilience tools, through the development and adoption of management plans, regulatory frameworks, and operational guidelines;
- Continuous civic engagement and capacity building, ensuring awareness, skills development, and long-term community ownership of climate action.

The method has been tested and validated through pilot actions, demonstrating its effectiveness in aligning technical expertise, political leadership, and stakeholder knowledge within a coherent climate governance framework.

Below are examples of individual results achieved through the application of the participatory model described above (Please note that all of these materials are currently available only in Italian):

- Green management plan documents
- Web page of the Lignano 180° Festival

Green Management plan activities - fostering civic engagement

Lignano 180° Festival

IMPLEMENTATION STEPS

1) CONTEXT ANALYSIS AND STAKEHOLDER MAPPING
2) DESIGN OF PARTICIPATORY GOVERNANCE PROCESS
3) CO-DESIGN AND VALIDATION OF CLIMATE RESILIENCE STRATEGIES
4) INSTITUTIONALISATION THROUGH PLANNING AND MANAGEMENT INSTRUMENTS
5) CAPACITY BUILDING AND CONTINUOUS CIVIC ENGAGEMENT
6) COMMUNICATION, DISSEMINATION, AND REPLICATION

STEP 1 – CONTEXT ANALYSIS AND STAKEHOLDER MAPPING

Assessment of local climate risks, existing policy frameworks, and governance structures, with specific reference to the Sustainable Energy and Climate Action Plan (SECAP) or equivalent local climate strategies and plans. The step ensures alignment of the participatory process with municipal mitigation and adaptation objectives already adopted or under development.

In parallel, a systematic stakeholder mapping is carried out to identify and engage relevant public authorities, technical departments, private actors, civil society organisations, and citizen groups with a role or interest in climate resilience and land-use management.

Example from the pilot: in Lignano Sabbiadoro, the process was grounded in existing climate planning frameworks (SECAP) and supported by a detailed stakeholder mapping of users and actors connected to a flood-prone coastal area.

Inputs/tools: climate risk assessments; SECAP (or equivalent climate action plans); stakeholder mapping templates.

STEP 2 – DESIGN OF PARTICIPATORY GOVERNANCE PROCESS

Design of a structured participatory governance process, including the clear definition of its scope, objectives, roles, and boundaries. This step establishes transparent premises for participation, clarifying from the outset which elements are open to co-design, which constraints are non-negotiable (e.g. legal, technical, financial), and how stakeholder inputs will inform decision-making.

The process design also defines participation principles, representation criteria, timelines, and decision-making responsibilities, ensuring a balanced, inclusive, and manageable engagement framework. Professional facilitation is identified to support dialogue, manage conflicting interests, and maintain trust among participants.

Example from the pilot: in Lignano, the engagement process was explicitly designed upfront, with clear rules, facilitation support, and shared understanding of the decision-making scope among all participants.

Inputs/tools: participatory governance guidelines; facilitation protocols; terms of reference defining scope, roles, and decision-making boundaries.

STEP 3 – CO-DESIGN AND VALIDATION OF CLIMATE RESILIENCE PROJECTS

Implementation of structured co-design activities (e.g. workshops, consultations, public hearings) to jointly develop climate resilience strategies, spatial concepts, and priority actions, integrating technical evidence with local knowledge and stakeholder perspectives.

The co-creation process is explicitly grounded in the principle of safeguarding people, assets, and ecosystems, ensuring that climate resilience strategies are primarily oriented towards risk reduction and safety of places. While the process seeks to balance and integrate the needs and expectations of different users and stakeholder groups, it also acknowledges that certain limitations or trade-offs may be necessary in order to protect the common good.

The validation phase ensures that co-created outcomes are technically sound, socially acceptable, and aligned with climate risk assessments and public interest objectives.

A core condition of this step is the active involvement of the technical professionals responsible for drafting plans and related instruments throughout the participatory process. Planners, consultants, and technical experts are required to participate in engagement activities, be familiar with participatory methodologies, and be willing to integrate public inputs into technical solutions, within the defined legal and safety constraints.

Example from the pilot: in Lignano, stakeholders contributed to the co-design of a regeneration project for a vulnerable area explaining their users-needs, while accepting certain limitations linked to flood risk mitigation and public safety. The external consultants already had expeperiences in participatory processes and actively participated during each plenary consultations.

Inputs/tools: participatory design tools; climate risk and safety analyses; draft masterplans or strategic climate resilience documents.

Porto Casoni co-design meeting

Porto Casoni Lignano rendering

STEP 4 – INSTITUTIONALISATION THROUGH PLANNING AND MANAGEMENT INSTRUMENTS

Design of a structured participatory governance process, including the clear definition of its scope, objectives, roles, and boundaries. This step establishes transparent premises for participation, clarifying from the outset which elements are open to co-design, which constraints are non-negotiable (e.g. legal, technical, financial), and how stakeholder inputs will inform decision-making.

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Example from the pilot: in Lignano, the engagement process was explicitly designed upfront, with clear rules, facilitation support, and shared understanding of the decision-making scope among all participants.

Inputs/tools: participatory governance guidelines; facilitation protocols; terms of reference defining scope, roles, and decision-making boundaries.

STEP 5 – CAPACITY BUILDING AND CONTINUOUS CIVIC ENGAGEMENT

Design and implementation of a systematic capacity-building framework that is automatically activated whenever new plans, regulations, or strategies affecting citizens and local stakeholders are introduced. This step ensures that capacity-building and information activities are not treated as ad-hoc actions, but as an integral and recurring component of climate governance processes.

The approach aims to equip citizens, stakeholders, and local actors with the knowledge needed to clearly understand municipal strategies, management choices, and related responsibilities, thereby enabling informed participation and compliance over time. Capacity-building actions are designed to accompany the full lifecycle of planning and regulatory instruments, supporting transparency, trust, and long-term public ownership of climate resilience policies.

Example from the pilot: in Lignano, capacity-building and awareness-raising activities were implemented in parallel with the introduction of the Green management Plan and regulatory framework, supporting citizens' understanding of municipal climate resilience strategies.

Inputs/tools: training and educational programmes; structured communication and learning modules linked to planning instruments; guidelines for institutionalised civic capacity building.

Green management plan Capacity building activities

STEP 6 – COMMUNICATION, DISSEMINATION, AND REPLICATION

Development of communication and dissemination activities to ensure transparency, public accountability, and knowledge-sharing regarding local climate strategies and plans. This step supports the visibility of results, the documentation of lessons learned, and the sharing of methodologies, tools, and planning instruments with peer authorities, stakeholders and general public.

The dissemination approach combines technical outputs (e.g. guidelines, plans, methodological documents) with accessible communication formats and public events, enabling knowledge exchange and peer learning. The step explicitly supports replication by providing adaptable tools and clear guidance for application in different territorial and governance contexts.

Example from the pilot: in Lignano Sabbiadoro, the communication and dissemination of pilot results and other climate-related initiatives implemented by the Municipality were centred around the Lignano 180° Sustainability Festival, conceived as a public platform for dialogue, awareness-raising, and knowledge exchange on climate resilience and urban transformation.

Inputs/tools: communication and dissemination strategies; methodological guidelines; knowledge-sharing platforms and public engagement formats.

Lignano 180° Festival

PILOT SUMMARY

The Lignano Sabbiadoro pilot contributes to addressing climate challenges in community climate governance by demonstrating a cross-sectoral, coordinated, and participatory model that translates strategy into broadly accepted action. It mobilised the municipality and a wide range of stakeholder groups to co-design interventions and resulted in a City Council–approved masterplan for a flood-vulnerable area, thereby building social licence for implementation.

The pilot also advanced city-wide governance by introducing a Green Management Plan and accompanying capacity-building activities linked to its regulatory framework, ensuring that objectives, responsibilities, and standards are clearly communicated to citizens and that everyday practices are aligned with climate resilience goals.

To mainstream awareness and coordination across initiatives and disciplines, the Lignano 180° Sustainability Festival connected technical planning, nature-based approaches, mobility, and public-space quality with civic dialogue, positioning climate governance as both a technical and a cultural endeavour.

D.3.2.1 Capacity building of key stakeholders report (learning materials)

Interreg CENTRAL EUROPE

Co-funded by the European Union

MISSION CE CLIMATE

D3.2.1 Capacity-building of key stakeholders Report

Activity 3.2

Issued by FHV

Document type: Report

FINAL

APRIL 2026

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D.3.2.1. CAPACITY BUILDING OF KEY STAKEHOLDERS REPORT

Actitivity 3.2.: Capacity building of key stakeholders

1. Introduction

Building climate resilience in communities requires not only innovative solutions and robust planning, but also the empowerment of local stakeholders through knowledge transfer and capacity building. This report outlines the project's approach to equipping key staff, stakeholders, and interested parties with the skills and tools necessary to implement climate-resilient practices in their daily work. Through targeted training campaigns, hands-on support, and the dissemination of digital tools, the project aims to foster a sustainable culture of adaptation and innovation.

The training program is designed to address critical gaps in urban and spatial planning, digitalization, and infrastructure implementation, ensuring that communities are prepared to meet the challenges of climate change. By combining study visits, webinars, and on-demand video tutorials, the project seeks to create a scalable and inclusive learning environment. This report provides an overview of the study visits, trainings, and video tutorials that were organized and conducted during the Mission CE Climate project. These capacity-building initiatives highlight the importance of long-term resilience and collaboration across Central Europe.

2. Study visits

2.1. ARA – Dornbirn

Study visit: ARA – a wastewater treatment plant in Dornbirn, Vorarlberg, Austria
Date: March 8th, 2024
Participants: 21 participants; participants included the project consortium as well as external data experts.
Organized by: PP2 – Vorarlberg Universtiy of Applied Sciences

Description:

This study visit was organized to show the relevance of climate monitoring for a wastewater treatment plan. The participants were informed by an expert how the climate monitoring works and how the processes involved in treating and managing wastewater to make it safe for discharge or reuse are functioning.

On the 8th of March 2024, the MISSION CE CLIMATE project organised a site visit to ARA – a wastewater treatment plant in Dornbirn, Vorarlberg. The first part of the site visit was held by an expert who showed the consortium how water flows are monitored and how hazards through heavy rainfall are forecasted and how they are monitored. The visit focused on how the plant monitors the volume of water entering, moving through, and leaving the facility. This involves sensors and meters placed at key points in the treatment process to track flow rates in real-time and how the facility uses weather and climate data to predict and prepare for heavy rainfall events. Real-time monitoring of rainfall intensity helps anticipate surges in water flow. The plant's role in handling increased water volumes during heavy rain events was emphasized, including its capacity to manage stormwater inflows in addition to regular wastewater. The second part was a tour of the facility to see the different treatments of the wastewater.

Lessons learned:

The site visit highlighted the relevance of climate monitoring and especially real-time monitoring. Continuous flow monitoring is critical for managing fluctuating water volumes, especially during heavy rainfall. Real-time data allows plant operators to respond quickly to sudden surges and prevent system overloads or untreated discharges.

The site visit highlighted the necessity of incorporating climate data into urban planning, particularly for decisions about sealing floors and buffer zones for heavy

rainfalls. The site visit heavily focused on the digital tools used to monitor water flows and the effects of heavy rainfalls. These tools allow real-time data access and tailored analysis and support informed decision-making.

2.2. Vodovod Brač - a public water distribution company

Place: Vodovod Brač – a public water distribution company, Island of Brač, Croatia
Date: October 2nd, 2024
Participants: 25 participants; project consortium and other local stakeholders
Organized by: PP9 – Split-Dalmatia County (SDC)

Description:

The event was organized as a study visit where the participants were informed about the relevance of water management and importance of lowering water losses in the system for the benefit of the environment and local population.

The first part of the visit was organized as a presentation of the pilot project to local stakeholders and the general public, followed by a lecture from an expert from Vodovod Brač on the topic of measuring water losses and equipment used in the process. This was followed by an analysis on how to reduce water losses by implementing thematic equipment procured through the project with emphasis on reducing CO_2 emissions as a result.

The second part was a study visit to a water distribution plant in Postira. There was a short lecture organized by the vodovod Brač technician in charge of the facility explaining how water distribution works, importance of renewing measuring equipment, impact on local population during tourist season and off season and measures for improvement of the general quality of life on the island all year round.

Lessons learned:

The site visit highlighted the relevance of real-time monitoring and water loss detection. Continuous flow monitoring is critical for managing fluctuating water volumes, especially during high tourist season during summer period. Real-time data allows plant operators to respond quickly to sudden changes and prevent system overloads or losses.

The purpose of the site visit was to visualize importance of digitalization of the tools used to monitor live water distribution and the immediate effects especially during high tourist season in the summer. Thematic equipment procured through the project allows real-time monitoring

and loss detection that immensely reflects on reducing water shortages and CO_2 emissions while improving everyday lives of local population.

The objective is to use the pilot project to kick-start larger renewal undertakings on the other neighbouring islands connected to same water distribution network, guided by the example of good practice achieved through Mission CE Climate project pilot.

2.3. Pforzheim University

Place: Pforzheim University, Pforzheim, Germany
Date: February 27th, 2025
Participants: 18 participants; project consortium and representatives of Pforzheim University
Organized by: PP12 - Krumedia GmbH

Description:

The study visit was organized as part of the Mission CE Climate project partner meeting held within the premises of Pforzheim University, a local stakeholder involved in the Climate Mission in the region of Pforzheim/Northern Black Forest. Participants received insights on how the Pforzheim University integrates sustainability and mitigation of climate risks in its operation.

Pforzheim University - Presentation of the integrated energy and climate concept of the organization

The operation of non-residential buildings (including colleges and universities) accounts for approximately 40% of Germany's greenhouse gas emissions, representing a significant proportion and thus a key lever for climate protection. Therefore, universities of applied sciences (HAW) in particular are called upon to set an example for citizens and, in accordance with the Baden-Württemberg Climate Protection Act (BW), are required to organise greenhouse gas-neutral operations by 2030. To this end, the Baden-Württemberg Ministry of Science and the Arts, in its letter dated 26 July 2022, requires all HAWen in the state to submit a qualified energy and climate protection concept by 31 December 2022.

Pforzheim University (HS PF) has already integrated the topic of sustainability into its mission statement under '#responsible'. In order to ensure that climate protection targets are also achieved, the Vice-Rectorate for Energy Management and Climate Protection (PEK) has been established within the university management. The central tasks of the PEK include preparing the energy and greenhouse gas balance, identifying potential and developing comprehensive measures for the greenhouse gas-neutral operation of the HS PF, in order to then draw up the Integrated Energy and Climate Protection Concept (IEKK). In accordance with the requirements of the MWK,

the Integrated Energy and Climate Protection Concept of the HS PF analyses and describes the initial situation and greenhouse gas reduction potential of the HS PF in areas such as energy, mobility, procurement and biodiversity. Going beyond the requirements of the MWK, selected measures will be evaluated in terms of energy saving potential, greenhouse gas saving potential and economic efficiency, and the greenhouse gas emissions of the HS PF in the areas of energy and mobility will be balanced.

A total of 112 individual measures are presented in a comprehensive catalogue of measures, and selected measures are evaluated in terms of savings potential, costs, and amortisation. The catalogue of measures serves to inform university members and is intended to provide a basis for discussion on the HS PF's climate protection activities – it does not constitute a transformation plan for greenhouse gas-neutral operations.

Pforzheim University – Laboratory for sustainable product development (link)
The Sustainable Product Development Laboratory focuses on the properties of products: What modules do they consist of? What materials are used? How are the individual components connected to each other? And also: How can such products be recycled?

Metals and their alloys can be identified using X-ray fluorescence, while plastics are analysed using an infrared spectrometer. Once you know which materials have been used in a product, they can be processed into other products. The laboratory has extrusion and injection moulding processes for thermoplastics for this purpose. Unfortunately, products are often dirty or aged after use. That is why the laboratory can also determine other important properties such as water content, degree of contamination, residual fill quantity and ash content.

All of this serves to understand the structure of products and learn more about their properties during manufacture, use and disposal. This allows products to be designed to be more environmentally friendly and recyclable. In addition to laboratory testing, determining the environmental properties of products through a life cycle assessment that takes into account all phases of the product's life cycle is an important addition to product evaluation and the development of recommendations.

Products are often tested in collaboration with companies, such as cordless headphones or headsets, to determine their properties, such as repairability or recyclability, and to suggest improvements to manufacturers.

Lessons learned:

The purpose of the site visit was show how an organisation like a university can contribute to local efforts towards climate risk mitigation. The integrated concept form Pforzheim University provides a good example for active strategic efforts in this regard.

The laboratory visit demonstrated the efforts of Pforzheim University to contribute on the long-term to sustainability efforts in productive activities.

2.4. Grenoble

Place: Grenoble
Date: May 13th- 15th, 2025
Participants: Organized by the Interreg Europe Climate – GO project consortium, together with local project stakeholders and representatives from the city of Grenoble. At the invitation of the RDA Podravje-Maribor, LP representative of MISSION CE CLIMATE from E-zavod attended the study visit as part of the synergy activities with the Climate GO project.
Organized by: PP1 – E-zavod (SI) & PP10 – RDA Podravje - Maribor

Description:

The event was organized as part of the Climate GO consortium meeting held on the premises of the city of Grenoble in combination with visiting sites in and around the city, under the organization of the City of Grenoble, a project partner in the Interreg Europe Climate GO project.

As part of Climate GO project, at the invitation of our project partner Regional development agency Podravje-Maribor (also a project partner in the Climate GO project as well as a PP in the MISSION CE CLIMATE project), together with the MISSION CE CLIMATE LP representative, attended a number of events related to Grenoble's path towards sustainability, climate resilience and smart climate governance. The delegation took part a number of activities, events, and field visits:

- Presentation of the social and environmental analysis grid and the Doughnut of the city of Grenoble. Starting with the presentation of the social and environmental analysis grid, the Doughnut of the city of Grenoble and an overview of Grenoble's sustainability initiatives, the attendees got familiarized with the many coordinated actions that the local government undertakes in the effort to improve the city's climate resilience. The visual journey that started there – data presented in a simple, easy-to-understand and graphically pleasing way, followed throughout the whole study visit. The city also hosts an exposition called "Facing risks" where the findings from the risk vulnerability assessments of Grenoble are translated in diagrams, pictures and short guides on risk mitigation and crisis management. During the expo, different city experts explained their department's efforts to include climate governance and resilience processes in their current and future endeavors.
- Overview of Grenoble's Sustainability Initiatives by a representative from the municipality working closely with the Doughnut economics team. From citizen science activities to opening "bike schools" for school children, attendees learned how the citizens keep on being interested, engaged, and proactive in the process of smart and green reshaping of their town. The city informs all citizens by mail about the local sustainability initiatives and their progress on an annual basis, oftentimes including them in a number of consultative workshops and city planning events.
- Visit of Coqueli'cours project. The city of Grenoble is transforming its playgrounds for children, by greening and increasing playground spaces in primary schools and simultaneously improving flood resilience. Different nature-based solutions are introduced on school premises, and infrastructure works are organized to incorporate existing vegetation in the final design.

- Visit of Le Bar Radis hub - Being a bar, a rooftop restaurant, the headquarters of an NGO, a café, greenhouse, urban garden, processing workshop and communal kitchen all at once, Le Bar Radis is a place where people come to discuss and do sustainability while picking vegetables off the rooftop garden in the middle of their city.
- Visit on water management. Freshness and swimmable lake project in a city neighbourhood in an effort to combat the hot summer days.
- Visit of the project “Place aux enfants”. The “Place aux enfants” or “The children’s place” project: Converting streets surrounding schools into car-free, walking and biking zones together with providing green communal spaces around the schools’ drop-off zones. First opposed by the surrounding habitants of the neighbourhood fearing for their loss of close-by car parking spaces, after a successful communication campaign, supported by the majority of the people living in the area.
- Visit of the project “Give back space for Isere to better protect against flooding”. The “Give back space for Isere river to better protect against flooding” project, a commitment to protect Grenoble’s urban area and its surroundings by a set of flood management and river management techniques: water level monitoring and warning systems, controlled flooding fields, draining structures and cascade weirs.
- Presentation of the Grenoble 2040 project. All these and many more initiatives are aligned with the City’s strategy for resilience and Grenoble 2040 project, which sets the basis for a greener, resilient, and inclusive Grenoble in 2040. It was said during one of the presentations that the city developed these measures and plans back in 2022 when Grenoble was proclaimed the European green capital of the year. The award European green capital was a nice recognition but also gave the city a legacy to continue to constantly improve it for future generations and aim for sustainability and climate resilience to be in the centre of their urban planning.

Recordings:

Photos and news published on MISSION CE CLIMATE and CLIMATE GO websites and social media.

MISSION CE CLIMATE - web post

MISSION CE CLIMATE - LinkedIn post

CLIMATE GO LinkedIn post

CLIMATE GO LinkedIn post - 2

Lessons learned:

- Local and regional climate governance is most successful when different departments and institutions within and outside of the municipal jurisdiction work together on climate-friendly processes that are implemented as part of an overall long-term sustainability strategy, making the process less vulnerable to changing political circumstances.
- Achieving climate sustainability milestones becomes faster and more effective when the local government establishes separate departments – (i.e. the Doughnut economics project office in Grenoble) that work closely and in sync with all other departments on topics climate change processes.
- Keeping citizens informed, interested, engaged, and proactive is key in providing them a greener, better and more sustainable city. When properly communicated, even processes perceived negatively at first (the loss of parking spaces before the "Place aux enfants" project) can and probably will be widely supported, once the project and its benefits are clearly and properly communicated to the affected population.

2.5. Porto Casoni area

Place: Porto Casoni area, Lagoon of Grado and Marano, Italy
Date: October 2nd, 2025
Participants: 14 participants, project consortium and invited stakeholders
Organized by: PP6 - APE FVG & **PP7** - City of Lignano Sabbiadoro

Description:

On the second day of the project meeting hosted by PP7 in October 2025, a study visit to the Lagoon of Grado and Marano was organized. The study visit began in the Porto Casoni area, giving the project partners the opportunity to see the location that will be renovated to mitigate the

impacts of rising sea levels based on the evidence from the participatory process that took place within the Lignano Sabbiadoro pilot demo action. The study visit was structured to combine an on-site tour of the natural environment in the northern part of Lignano Sabbiadoro with expert explanations provided by a local guide, alongside visits to two casoni: one functioning as a fish restaurant and another managed by a local resident under civic use regulations. This approach enabled the project partners to acquire detailed knowledge of the local environmental and socio-economic context, to understand the impacts of climate change on the lagoon ecosystem, and to recognize the urgency of implementing adaptation measures in the territory.

The project partners travelled by boat from Porto Casoni into the Lagoon of Grado and Marano with a local naturalist guide. During the visit, he provided an overview of the lagoon's fragile ecosystem balance, which is characterized by its unique geomorphological, biological, and socio-economic features, and is threatened by the effects of climate change. The Grado and Marano Lagoon, located in northeastern Italy, is a unique transitional ecosystem between land and sea. Its landscape of salt marshes, mudflats, tidal channels, and islands supports rich biodiversity, including migratory birds, fish, and halophytic vegetation. The lagoon’s delicate balance depends on tidal exchanges and freshwater inflows from rivers. Socio-economically, it sustains traditional fisheries, aquaculture, and shellfish farming, alongside tourism centred on nature and wellness. Local communities preserve ancient fishing villages and “casoni,” traditional reed huts, symbolizing the cultural heritage tied to sustainable resource use in this dynamic coastal environment.

Lessons learned:

Through this activity, project partners gained a deeper understanding of the complex dynamics shaping transitional ecosystems like the Lagoon of Grado and Marano, where ecological, social, and cultural dimensions are tightly intertwined. The visit emphasized how climate change impacts – such as rising sea levels and altered hydrological regimes – directly affect both biodiversity and traditional economic activities like fishing and aquaculture. The partners also learned about the value of local engagement and civic use practices in preserving the lagoon's heritage while promoting adaptation. Overall, the experience reinforced the importance of integrating scientific evidence with community knowledge and cultural values in designing nature-based and resilient solutions for climate adaptation.

During the study visit, the project partners analyzed the significant contrast between the natural environment surrounding Lignano and the highly urbanized areas of the city. Particular attention was given to the city's geographic configuration – bounded by the Tagliamento River to the west, the Lagoon to the north, and the Adriatic Sea to the south – which increases its vulnerability to climate-related hazards. The discussion highlighted the importance of integrating climate-resilient strategies into urban and spatial planning, including adaptive infrastructure, flood risk management, and the preservation of natural buffers, to enhance the city's capacity to respond to rising sea levels and other climate change impacts.

2.6. Study visit - Maribor

Place: VSGT Maribor; Vrtec Kobanček in Selnica ob Dravi; Park ob Pekrskem potoku Maribor

Date: February 10th - 12th, 2026

Participants: 27 participants, Project partners, Municipality of Maribor (MOM) and RDA Podravje-Maribor (RDAPM), invited speakers and local stakeholders (MOM, RDAPM, Alma Mater Europaea University, University of Maribor), Higher Vocational College for Hospitality and Tourism Maribor (VSGT Maribor), Municipality of Selnica ob Dravi. Please find the participants lists enclosed.

Organized by: Municipality of Maribor and Regional Development Agency Podravje - Maribor

Description:

Maribor hosted the study visit and final meeting of the MISSION CE CLIMATE project from 10-12 February 2026. The event was organised by the Municipality of Maribor in cooperation with the Regional Development Agency Podravje-Maribor. The programme combined capacity building and

pilot replication exchange through invited lectures on Maribor climate projects (sustainable mobility, green urban corridors, nature-based solutions and groundwater governance, implementation of sustainable measurements in education) and guided field visits to pilot and good-practice sites.

Purpose and overall scope of the study visit

The study visits and final project meeting of the MISSION CE CLIMATE – Climate Resilient Communities of Central Europe project were hosted in Maribor in February 2026 by the Municipality of Maribor, in cooperation with the Regional Development Agency for Podravje – Maribor. The visit brought together partners from all six CE partner countries and represented a culmination of project activities focused on climate change adaptation, nature-based solutions (NBS), and urban resilience.

The main objective of the study visit was to:

- present concrete pilot implementations of climate adaptation measures,
- exchange transferable good practices,
- strengthen institutional and professional capacities of participating partners,
- and assess long-term sustainability and replicability of solutions developed within the project framework.
-

Study visit activities – field-based learning and good practices

Sustainable approaches in education and public buildings

As part of the study visit, project partners visited Higher Vocational College for Hospitality and Tourism Maribor (VSGT Maribor), where the main focus was on sustainable food preparation and sustainable school management. The institution presented its holistic approach to sustainability, combining responsible sourcing of ingredients, reduction of food waste, energy-efficient kitchen operations, and the integration of sustainability principles into vocational education. Students and mentors demonstrated these concepts in practice by preparing a sustainably designed dinner for the project partners, effectively linking theoretical knowledge with hands-on implementation and showcasing how sustainability can be embedded into everyday educational and operational processes.

The study visit concluded with a visit to Vrtec Kobanček in Selnica ob Dravi, where participants were introduced to sustainability embedded in early childhood education and public infrastructure. The kindergarten is designed as a nearly zero-energy building, constructed primarily from wood and optimized for energy efficiency, indoor comfort, and reduced environmental impact.

The visit demonstrated how sustainable construction principles can be integrated into public educational facilities, environmental awareness and climate responsibility are introduced at an early age, buildings can simultaneously serve educational, social, and climate adaptation purposes. This example illustrated the importance of cross-sectoral approaches, linking education policy, spatial planning, and climate goals at the local level.

Park ob Pekrskem potoku - green urban corridor

Participants visited the Pekrski potok area, where the Park ob Pekrskem potoku project represents a flagship example of urban green corridor development.

As part of the EU Horizon 2020 co-funded UPSURGE project (City-centered approach to catalyse nature-based solutions…), a demonstration Nature-Based Solutions (NBS) intervention was implemented in the Park Pekrski potok area in Maribor. UPSURGE aims to support cities in applying regenerative, nature-based solutions to address climate change impacts, air pollution and enhance urban resilience.

Key activities and results in Park Pekrski potok included:

- Demonstration site, a 500-metre demonstration section along the Pekrski brook was chosen as a pilot area to test and showcase practical nature-based interventions.
- Tree and vegetation planting, In spring 2024, 216 trees were planted along the demonstration corridor. These species were selected for their capacity to improve air quality, enhance local biodiversity and contribute to climate regulation.
- Enhanced green infrastructure, the planting contributes to creating a green corridor that strengthens the link between blue (water) and green (vegetation) infrastructure, supports microclimate cooling, and helps filter airborne particulates and other pollutants.
- Community involvement & awareness: local residents, schools and community groups were actively involved through participatory design meetings, co-creation activities and workshops.
- The initiative included awareness campaigns and community events.

- The project installed monitoring mechanisms to track changes in air quality and microclimate conditions, which inform the effectiveness of the nature-based solutions and support future planning.

Under the UPSURGE project, Park Pekrski potok in Maribor begun its transformation into a greener, more climate-resilient public space. The new Municipality of Maribor project **Park ob pekrskem potoku (Park by the Pekrski Potok Stream)** aims to transform the stream corridor into approximately 2.6 hectares of new green public space, improving biodiversity, microclimatic conditions, and flood resilience.

The visit highlighted application of nature-based solutions for water retention, cooling, and ecosystem services, integration of green infrastructure into densely built urban areas, creation of multifunctional spaces for recreation, sustainable mobility, and social interaction. This site visit directly connected spatial planning with climate adaptation strategies and showcased how long-term urban regeneration can support climate resilience.

Mission CE Climate pilot project implementation – Greening of Maribor bus shelters

A key component of the study visit was the presentation of pilot implementations within the MISSION CE CLIMATE pilot project actions in Maribor, focusing on implementation of natural based solution to combat the effects of urban heat islands.

Participants observed:

- green roofs and additional vegetation on bus shelters;
- redesigned surfaces with reduced asphalt and increased permeability;
- newly placed urban equipment aligned with the municipal Catalogue of Urban Equipment;
- installed IoT sensors for measuring the effects of the NBS installed on site;
- promotion campaign performed, to promote NBS solutions and to raise awareness among citizens.

The pilot demonstrated how small-scale, targeted interventions can significantly reduce heat stress, improve user comfort, and provide measurable microclimatic benefits. The inclusion of IoT sensors for monitoring temperature, humidity, and air quality further illustrated data-driven climate governance and evidence-based planning approaches.

The bus stop greening project in Maribor demonstrates that small, well-targeted interventions can significantly contribute to urban resilience to heatwaves. At the same time, such measures foster cross-sectoral cooperation, trust, and capacity-building within the local community, reinforcing the broader transition toward climate-resilient cities.

Capacity building and expert lectures

A full day of the meeting was dedicated to capacity building and knowledge transfer, focusing on climate-related projects implemented in Maribor. Expert lectures provided participants with theoretical frameworks, methodological tools, and practical insights relevant for replication in other regions.

Key themes included:

- Sustainable urban mobility, illustrated through the MBajk bicycle sharing system and analysis of daily mobility habits,
- Green urban planning, with the Park ob Pekrskem potoku as a case study,
- Nature-based solutions, presented through the UPSURGE project,
- Water security and groundwater management in the context of climate change.

The lectures strengthened participants' understanding of:

- interdisciplinary climate adaptation approaches,
- stakeholder engagement and governance models,
- integration of climate data into decision-making processes.

This component clearly fulfilled the project's capacity-building objectives, enabling partners to enhance their institutional competencies and apply acquired knowledge in their local contexts. Please find the invited speakers programme enclosed.

Added value and outcomes of the work performed

The study visit combined field observation, expert knowledge exchange, and peer learning, resulting in:

- improved understanding of practical climate adaptation measures;
- enhanced capacity for replication of pilot solutions;
- strengthened cooperation among Central European municipalities and development agencies;

- increased awareness of the importance of linking spatial planning, mobility, education, and climate policy.

By integrating visits to educational institutions, urban green infrastructure projects, and pilot climate interventions with structured expert lectures, the study visit provided a holistic learning experience and significantly contributed to the long-term objectives of the MISSION CE CLIMATE project .

Documentation:

Photo 1: Partners in front of the Capacity building lectures venue – Vetrinjski dvor, 11.2.2026

Photo 2: Study visit – promotion campaign in the city center, 12.2.2026

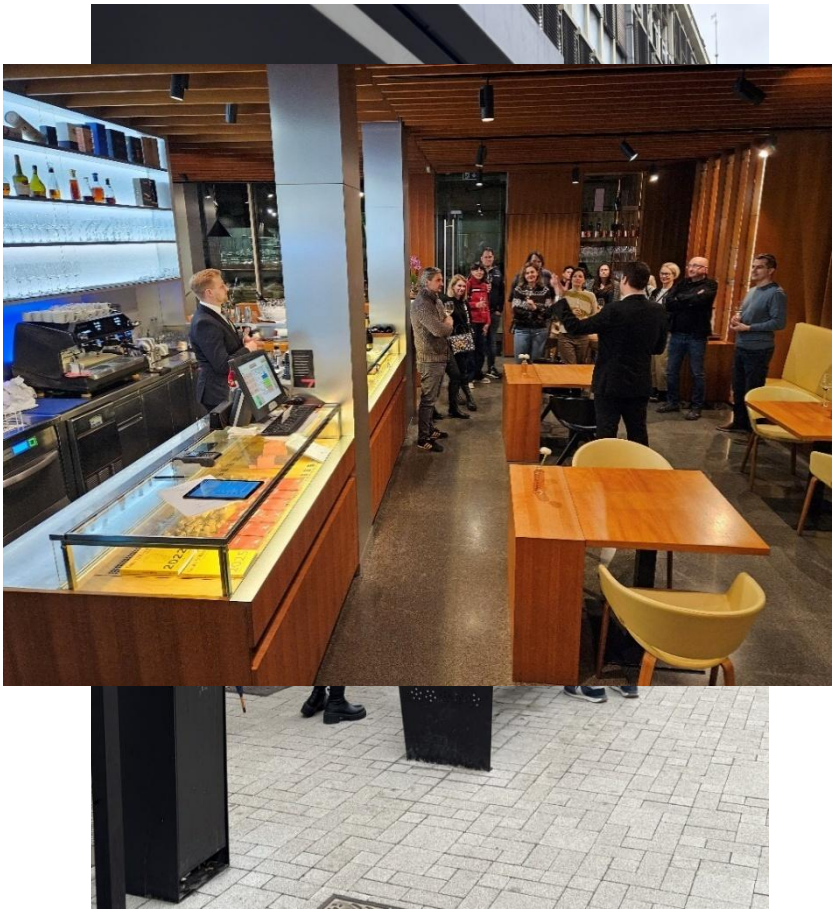


Photo 3: Project partners at the renovated bus stop Glavni trg – Elektro, 12.2.2026

Photo 4: Higher Vocational College for Hospitality and Tourism Maribor (VSGT Maribor) - sustainable school management, 10.2.2026

Photo 5: UPSURGE results – NBS interventions implemented, 12.2.2026

Photo 6: Kindergaten »Kobanček« study visit, 12.2.2026

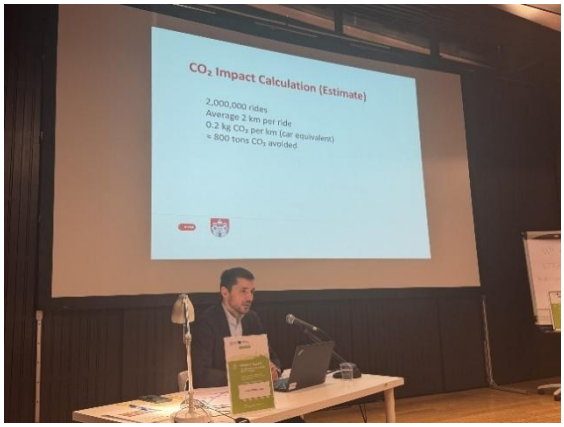


Photo 7: Invited speakers – lectures, 11.02.2026

Lessons learned:

The study visits in Maribor provided a strong, practice-oriented conclusion to the MISSION CE CLIMATE project. Its main added value lies in the clear linkage between strategic climate objectives and concrete, implementable measures at different scales (public buildings, public space, mobility infrastructure, and blue-green corridors). The combination of expert input, site visits, and open peer exchange created a highly effective learning environment and reinforced trust and cooperation among partners. The Maribor examples convincingly demonstrated that climate adaptation is most effective when embedded across everyday municipal operations and throughout all departments, aligned with the urban spatial planning and embeded in the education systems, rather than treated as isolated pilot actions of just one or few municipal sectors that work directly on the climate resilience topics.

The implementation of climate adaptation measures in Maribor highlights several key recommendations for transferring good practices to other municipalities aiming to strengthen climate resilience:

- Early involvement of all relevant municipal departments, public services, and concessionaires is essential to ensure feasibility, alignment, and timely implementation;

- Consistent adherence to clearly defined objectives, supported by strong substantive and political commitment from leadership, enables efficient decision-making and smooth execution;
- Coordinated and goal-oriented cooperation among all stakeholders increases responsiveness, implementation quality, and overall effectiveness;
- Selection of multiple alternative locations is crucial to address administrative, ownership, or permitting constraints;
- Combining technical measurements with residents' perceptions and feedback leads to solutions that are both evidence-based and socially accepted;
- Use of modular, scalable, and cost-effective nature-based solutions (NBS) allows flexible implementation and replication;
- Ensuring long-term maintenance and management is vital for sustaining climate adaptation benefits beyond the pilot phase;
- Plan early for post-project ownership and maintenance, with a clear division of responsibilities, to ensure continuity and transferability of solutions;
- Linking pilot measures with local strategies, development plans, and spatial planning documents strengthens institutional ownership and long-term impact;
- Cross-sectoral cooperation between municipal departments, regional actors and academia is key for effective climate action;
- Measurable indicators and regular monitoring (incl. short periodic reports) are needed to demonstrate impacts and support replication;
- Co-creation with residents and local stakeholders increases acceptance, usability and long-term sustainability of measures;
- Well-prepared campaigns help raise public awareness and shape positive attitudes towards climate change adaptation measures.

Urban and spatial planning approaches

The discussions emphasized the need to systematically integrate climate resilience into urban and spatial planning frameworks, particularly through the use of nature-based solutions (NBS) and multifunctional public spaces. In Maribor, climate adaptation is increasingly embedded into planning approaches by linking pilot projects to municipal spatial plans, sectoral strategies, and long-term development documents.

Key adaptations highlights included:

- Shifting from single-purpose grey infrastructure to multifunctional green infrastructure, such as greened bus stops and urban green corridors, which simultaneously address heat stress, stormwater management, biodiversity, and public comfort.
- Planning for heat resilience by prioritizing shading, vegetation, and cooling elements in public spaces, transport infrastructure, and high-exposure areas.
- Using pilot projects as testing grounds for innovative planning solutions, with monitoring results feeding back into formal planning and design standards.
- Ensuring flexibility in spatial planning, including the identification of alternative locations to overcome administrative or ownership constraints.
- Strengthening cross-sectoral coordination between urban planning, transport, environment, public utilities, and social services to ensure coherent and effective implementation.

Overall, the exchange demonstrated that climate-resilient urban planning requires both strategic alignment and practical experimentation, supported by data, stakeholder cooperation, and the gradual mainstreaming of successful pilot measures into statutory planning instruments.

Digitalization and digital toolsets

In Maribor, digital solutions play an important role in data-driven climate adaptation. The MBajk system uses digital platforms for real-time operation, user analytics, and mobility data analysis, supporting sustainable transport planning and reducing transport-related emissions.

Digital monitoring tools are also applied at the newly greened bus stops, where sensors measure microclimatic conditions such as temperature and thermal comfort, enabling the assessment of nature-based solutions during heatwaves. Similar monitoring approaches are used along the Pekre Stream corridor to evaluate the environmental performance of green infrastructure, including cooling effects and ecosystem benefits.

In addition, digital tools were highlighted during the visit to Kobanček Kindergarten, a nearly zero-energy building. The kindergarten uses digital building management and monitoring systems to optimize energy consumption, indoor comfort, and ventilation, while also serving as an educational tool for raising awareness of sustainability and climate adaptation among children and staff.

Overall, these examples demonstrate how digital tools support monitoring, optimization, learning, and evidence-based decision-making, thereby significantly contributing to urban and community climate resilience.s

Follow-up recommendations:

- Capitalise on monitoring data from pilots (e.g. greened bus stops, green corridors) by translating results into concrete planning and design standards at municipal and regional level;
- Formalise cross-sectoral cooperation mechanisms within municipalities to ensure continuity after project closure;
- Strengthen knowledge transfer by documenting pilots as concise replication guidelines for other cities;
- Integrate successful pilot measures into statutory spatial plans, sectoral strategies, and investment priorities to ensure long-term impact;
- Continue stakeholder and citizen engagement beyond the project timeframe to support acceptance, co-ownership, and maintenance of implemented solutions.

3. Trainings

Transnational training process aimed at imparting specific skills, information or expertise to individuals or groups, which are necessary to enhance climate resilience in communities.

Within the MISSION CE CLIMATE project, the following trainings were organized:

- Copernicus System
- Financing Strategies for Climate Adaptation Measures
- The potential of civic participation
- The Journey Towards Open Data and CLIMAAX Tools & Risk Analysis
- IoT & LoRaWAN Networks
- Urban water management

3.1. Copernicus System

Date: April 22nd, 2024

Form: online training

Video link: https://www.youtube.com/watch?v=LmPOvlS4yjI

https://www.interreg-central.eu/wp-content/uploads/2024/07/Copernicus-Platform-Workshop_22.-4.-Mission-CE-Climate.pdf

https://www.interreg-central.eu/wp-content/uploads/2024/07/Copernicus-Platform-Workshop_Links.pdf

Participants: 20 participants (Stakeholders, climate data professionals, urban planners, energy sector representatives, city representatives, universities and research centres)

Description:

On April 22nd 2024, the MISSION CE CLIMATE project organised a webinar focused on building the capacity of stakeholders through the Copernicus platform, which is integral to the European Union's Earth observation program. Led by experts from the Biotechnical Faculty of the University of Ljubljana, the event aimed to enhance the participants' skills in climate data interpretation, integration, and resilience planning. The workshop centred around the Copernicus Climate Change Service (C3S), which integrates satellite and in-situ data to provide a comprehensive view of the climate's past, present, and future states. This service supports European climate adaptation and mitigation policies across various sectors by providing essential climate change indicators. Participants gained insights into the types of data available through the Climate Data Store (CDS), including in-situ observations, satellite data, reanalyses of historical data, and climate projections

up to the year 2100 based on different global and regional climate models. The workshop particularly highlighted how these tools can enhance decision-making in urban and coastal regions, and the tourism sector. Participants were introduced to the Copernicus Climate Change Service (C3S), gaining a comprehensive understanding of data sources such as satellite observations, in-situ measurements, and reanalyses of historical data. The workshop also covered the practical application of climate data in urban, coastal, and tourism sectors, emphasising the importance of tools like the Climate Data Store (CDS) and APIs for data accessibility.

The workshop employed a mix of theoretical and practical methodologies, combining lectures with interactive sessions. Participants engaged in hands-on training using the Copernicus Climate Data Store (CDS), exploring how to access and visualize data for specific sectors like urban planning and tourism. The workshop utilized real-world scenarios and tools such as climate atlases to demonstrate the practical use of data in resilience planning. Digital tools and online platforms, including APIs, were emphasized for their role in tailoring climate data to the specific needs of the attendees' regions.

By offering an interactive climate atlas and other visualization tools, the Copernicus workshop has equipped attendees with the knowledge and skills to effectively interpret and utilize climate data, empowering them to contribute more effectively to climate-related planning and response strategies.

Lessons learned:

The workshop highlighted the critical role of data accessibility and visualization tools in enhancing climate resilience planning. The practical application of climate data in decision-making for urban, coastal, and tourism sectors was particularly impactful. Participants noted the importance of APIs and digital platforms in making data actionable for specific regional needs.

The workshop underscored the necessity of incorporating climate data into urban planning, particularly for coastal regions and urban heat islands. Spatial planning strategies discussed included using satellite data for long-term climate forecasting and adaptation planning.

The workshop heavily focused on the digital tools provided by the Copernicus platform, including the Climate Data Store (CDS) and APIs. These tools allow for real-time data access and tailored analysis, supporting climate resilience initiatives in various sectors.

3.2. Financing Strategies for Climate Adaptation Measures

Training topic:	Financing Strategies for Climate Adaptation Measures
Date:	October 28th, 2024
Form:	online training
Link:	https://www.interreg-central.eu/wp-content/uploads/2024/12/Financing-Strategies-for-Climate-Adaptation-Measures_Klar-Regions_Webinar.pdf https://www.youtube.com/watch?v=SzF_OnY537Y
Participants:	17 participants (key stakeholders from climate data professionals, urban planners, energy sector representatives, city representatives, universities and research centres)
Organized by:	PP2 - Vorarlberg University of Applied Sciences (FHV)

Description:

Project partner FHV organised a webinar about financing strategies for climate adaptation measures. Two financing strategies from different countries were covered by the two guest speakers. The webinar highlighted the importance of mainstreaming adaptation strategies with a bottom-up approach, by financing adaptation measures on a regional level as well as providing expertise and manpower. The importance of individual/region-specific adaptation measures as well as funding programs that increase greening in cities were mentioned.

The first speaker shared her expertise as program manager of “KLAR!”, a funding program initiated by the Climate and Energy Fund Austria in cooperation with the Ministry of Climate Action and Energy Austria. She gave insights into adaptation measures on state level, which is aiming for mainstreaming and multisectoral approaches, as well as the importance of implementing adaptation measures on regional level. The KLAR! program is a funding program for Austrian regions, to enable individual adaptation measures on regional level. KLAR! regions are supported financially on the one hand, with 75% of the total cost of adaptation measures for Klar! regions. On the other hand, every KLAR! region has a regional/local manager, which provides knowledge and manpower. Furthermore, regular trainings are conducted for the local manager, for knowledge increase and exchange between the adaptation measures of all KLAR! regions.

The second speaker is working as the commissioner for climate-adapted urban development and gave insights into the climate adaptation concept for the specific case of Friedrichshafen. The city´s climate adaptation strategy is based on 69 measures across 10 fields of action (multi-sectoral approach), working with an innovative financing strategy. It is based on a combination of fundings for climate adaptation and biodiversity (“Häfler Zukunftsgrün”) to increase green areas

in the city, specific adaption requirements (e.g. greening statutes on designing parking spaces, roofs and facades) as well as the so-called "climate budget", for the implementation of innovative adaptation projects with, funded with 100€ per citizen (63.000 citizens = 6.3Mio € budget). Impressions of specific measures gave some further insights into the adaptation strategy of Friedrichshafen.

Lessons learned:

The webinar highlighted the importance of mainstreaming adaptation strategies with a bottom-up approach, by financing adaptation measures on a regional level as well as providing expertise and manpower. The importance of individual/region-specific adaptation measures as well as funding programs that increase greening in cities were mentioned.

The presentations showed a good practice of a funding program at federal level as well as a good practice climate adaptation concept and the corresponding funding strategies of a city.

3.3. The potential of civic participation

Training topic:	The potential of civic participation
Date:	October 2nd, 2025
Form:	presence training
Link:	https://www.interreg-central.eu/projects/mission-ce-climate/?tab=media
Participants:	22 participants (project partners' representatives, visiting key stakeholders from the Split-Dalmatia County area. Among them there were energy sector representatives, water management sector representatives, city representatives, universities and research centres)
Organized by:	PP6 – APE FVG & PP7 - City of Lignano Sabbiadoro

Description:

On October 2nd, 2025 a training session for the MISSION CE CLIMATE consortium was held by psychologist Stefano Carbone, aimed at enhancing partners' understanding of the potential and importance of civic participation – also within the framework of climate resilience initiatives.

The training pursued the following objectives: to provide guidance on the design of participatory processes; to present the experience of Porto Casoni (Italian pilot demo #1) as a practical and successful case study; to reflect on contexts in which participatory approaches could be effectively applied and replicated.

Partners PP7 and PP6 proposed this training to the consortium, focusing on the highly positive effects that stakeholder engagement had during the preparation of the Porto Casoni Masterplan in Lignano Sabbiadoro. The goal was to share useful and transferable insights that other partners could apply within their own communities, projects, and future initiatives.

During the session, the trainer began by explaining what a participatory process is and why it matters, highlighting its psychological and social benefits:

- it responds to people's psychological needs;
- it allows for the collection of valuable local knowledge;
- it helps redefine the public arena, in which both individuals and the community have a role in the public debate;
- and it fosters the creation of shared goods and collective ownership.

He also outlined who should be involved and how such processes can be practically implemented, emphasizing the importance of clearly defining the process boundaries and the guiding principles it should respect.

At the end of the presentation, a spontaneous and engaging Q&A session took place, likely encouraged by the in-person setting, which facilitated open discussion. Project partners had the opportunity to seek clarifications on the practical steps required to initiate participatory processes, to discuss lessons learned, and to share their own experiences and challenges related to stakeholder engagement.

To carry out the training, the session combined theoretical input, case study presentation, and interactive discussion to ensure both knowledge transfer and active engagement of participants. Presentation materials were used to introduce key concepts on participatory process design and stakeholder engagement. The Porto Casoni Masterplan served as a concrete example of successful participatory planning in the field of climate resilience. An open discussion encouraged partners to share experiences, reflect on lessons learned, and explore how such approaches could be applied in their own contexts and future initiatives.

Relevant material was shared with participants after the training. Material is also available on the project website: https://www.interreg-central.eu/projects/mission-ce-climate/?tab=media

Lessons learned:

The training highlighted the practical benefits of participatory approaches, to be used also in climate resilience projects. Key lessons included:

1. early and meaningful stakeholder engagement improves the quality and relevance of planning outcomes, and it permits to collect several information;
2. clear definition of process boundaries and guiding principles is essential for effective and transparent participation;
3. a municipality that decides to invest in participatory processes must be prepared to relinquish some of its power to engaged stakeholders;
4. sharing concrete case studies helps partners understand transferable methods and anticipate challenges;
5. interactive discussions foster learning, exchange of experiences, and identification of context-specific solutions
6. participatory processes not only enhance project outcomes but also strengthen community ownership and long-term sustainability.

Urban and spatial planning approaches:

The Porto Casoni case study is an effective example of the participatory approach used for urban planning adaptations needed to address climate hazards such as sea-level rise and storm surges, and to foster climate resilience in Lignano Sabbiadoro.

3.4. The Journey Towards Open Data and CLIMAAX Tools & Risk Analysis

Training topic:	The Journey Towards Open Data and CLIMAAX Tools & Risk Analysis
Date:	January 13th, 2026
Form:	online training
Link:	https://www.linkedin.com/feed/update/urn:li:activity:7414689169437835264
Participants:	28 participants (key stakeholders from climate data professionals, urban planners, energy sector representatives, city representatives, universities and research centres)

Description:

The expert-level training on OpenData and CLIMAAX tools provided participants with valuable knowledge and practical skills to integrate digital tools into their climate resilience strategies. The session successfully fostered collaboration among experts and facilitated the exchange of best practices in climate data usage and adaptation planning.

The first segment of the training kicked off with an overview of the development journey of the Open Data Platform. Eva Singovszká and Matej Takács shared the conceptualization process, key milestones, and the steps taken to make the platform a key player in the field of climate action. They highlighted the barriers and challenges encountered, such as technical limitations, organizational hurdles, and issues related to data accessibility. The discussion also focused on how these challenges were addressed to ensure the platform's success.

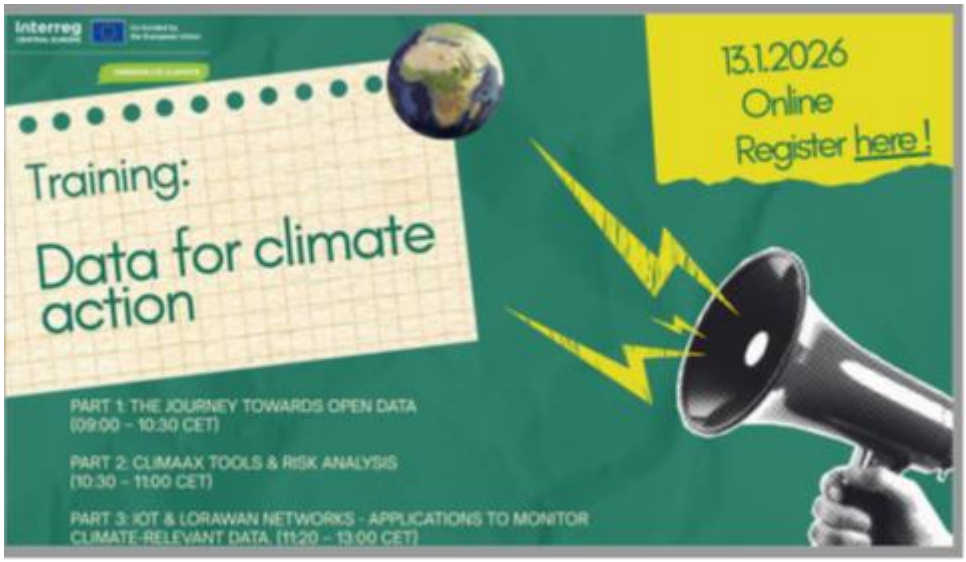
The session continued with a detailed presentation of the core datasets available on the OpenData Platform. Participants learned about environmental, climate, and geospatial data and their practical applications in climate monitoring, education, and decision-making. A discussion session followed, where participants engaged in dialogues about how to maximize the use of these datasets for climate action in their respective regions.

In the second part, Martin Kuban and Zuzana Jarošová provided a comprehensive introduction to the CLIMAAX ecosystem, detailing the various tools it offers for climate-risk analysis. The presenters outlined the types of datasets required for each tool and how these tools are integral to assessing and mitigating climate risks.

The training featured a case study of Košice, illustrating the practical application of CLIMAAX tools and OpenData in analyzing climate risks in the city. The case study highlighted how the integration of these tools supports climate-risk analysis and decision-making at the local level. Participants learned how the tools enabled Košice to monitor and assess climate impacts such as heatwaves,

air quality, and extreme weather events, providing critical data for the city's adaptation strategies.

Following the case study, a lively discussion took place, where participants shared their experiences and explored potential solutions for integrating CLIMAAX tools and OpenData into their climate risk management frameworks.



3.5. IoT & LoRaWAN Networks Applications to monitor climate-relevant data

Training topic: IoT & LoRaWAN Networks Applications to monitor climate-relevant data

Date: January 13th, 2026

Form: online training

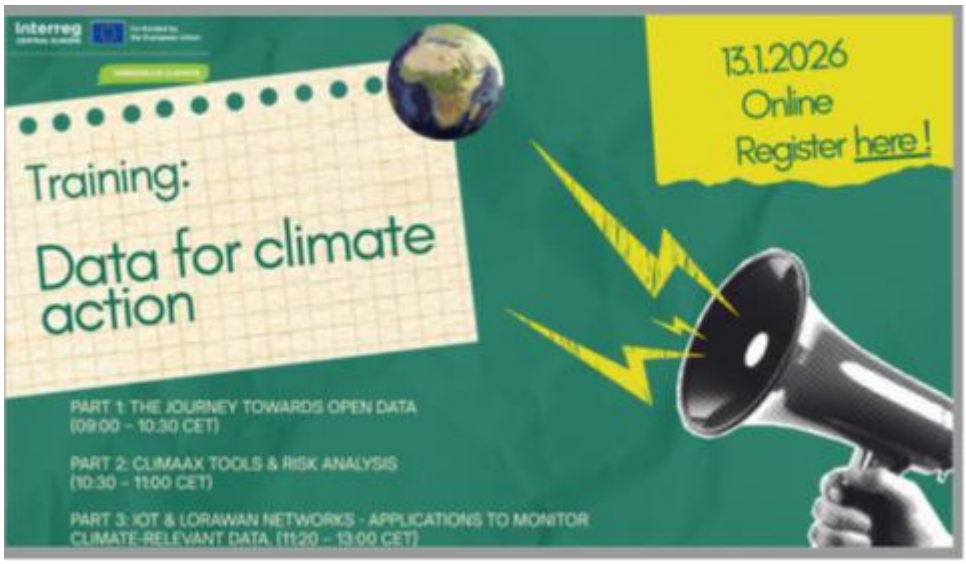
Link: https://www.linkedin.com/feed/update/urn:li:activity:7414689169437835264

Participants: 28 participants (key stakeholders from climate data professionals, urban planners, energy sector representatives, city representatives, universities and research centres)

Description:

During the training an introduction to the LoRaWAN technology and practical examples were presented by Marvin Braun. He explained how Low Power Wide Area Networks (LPWANs) can be used to develop smart and sustainable campus areas, using **SAP SE** in Walldorf as a real-world example. An overview of IoT network options is provided, comparing WAN, LAN, mobile networks, and LPWANs, with LPWANs highlighted for long-range and low-energy use cases. The training

introduced key LPWAN technologies—LoRa, Sigfox, NB-IoT, and Mioty—and compared them in terms of frequency bands, data rates, payload size, scalability, and network ownership. The training concludes that LPWANs—supported by platforms such as enerchart and implemented by **krumedia**—offer a scalable, provider-independent, and versatile foundation for data-driven campus and climate-related applications. Next presentation held by Prof. Dr. Bernhard Kölmel introduced the pilot project managed by Krumedia and the Pforzheim University. City of Pforzheim and the Northern Black Forest are presented as a "living lab" facing increasing climate stress such as urban heat islands, flooding, and drought, requiring high-resolution, localized data for informed planning. The pilot integrated a strong citizen science dimension, empowering citizens, students, and schools through DIY toolkits, workshops, and low-code/no-code data interaction tools. Several concrete use cases were demonstrated, including urban heat island mapping, flood prevention through water-level monitoring, AI-supported soil analysis, and mobility and occupancy monitoring. A 100% open-data commitment underpins transparency, public trust, and co-creation, enabling researchers, planners, and citizens to jointly develop climate solutions. Key lessons highlight the importance of robust sensor deployment, clear stakeholder roles, accessible communication, and the scalability of the approach to other municipalities.



3.6. Sustainable urban mobility;

Training topic: Sustainable urban mobility; Green urban planning; City-Driven Regenerative Nature-based solutions; Water security and groundwater management in the context of climate change.

Date: February 11th, 2026

Form: presence training

Link: https://www.interreg-central.eu/news/study-visit-and-final-live-event-in-maribor-2/

Participants: Stakeholder groups involved: project partners; Municipality of Maribor departments (mobility, municipal affairs, transport and spatial planning); RDA Podravje-Maribor; Academia (Alma Mater Europaea University; University of Maribor); Higher Vocational College for Hospitality and Tourism Maribor (VSGT Maribor); Energap Maribor and Municipality of Selnica ob Dravi members including the mayor.

Description:

A full day of the meeting was dedicated to capacity building and knowledge transfer, focusing on climate-related projects implemented in Maribor. Expert lectures provided participants with theoretical frameworks, methodological tools, and practical insights relevant for replication in other regions.

Key themes included:

- MBajk: Improving Urban Connectivity by Bicycle - Sustainable urban mobility, illustrated through the MBajk bicycle sharing system and analysis of daily mobility habits,
- Pekrski Stream Park: Planning a Green Urban Corridor - Green urban planning, with the Park ob Pekrskem potoku as a case study
- UPSURGE: City-Driven Regenerative Nature-Based Solutions - Nature-based solutions, presented through the UPSURGE project,
- From Crisis to Smart Management: Securing Groundwater for the Future - Water security and groundwater management in the context of climate change.

The lectures strengthened participants' understanding of:

- interdisciplinary climate adaptation approaches,
- stakeholder engagement and governance models,
- integration of climate data into decision-making processes.

This component clearly fulfilled the project's capacity-building objectives, enabling partners to enhance their institutional competencies and apply acquired knowledge in their local contexts.

3.7. Urban Water Management Training

Training topic: Urban water management training

Date: March 11th, 2026

Form: online training

Link: https://www.linkedin.com/feed/update/urn:li:activity:7436781175609667584

Participants: 17 participants (key stakeholders from climate data professionals, urban planners, energy sector representatives, city representatives, universities and research centres)

Description:

This training offered a more detailed look at practical climate resilience implementation by combining stakeholder coordination, technical water-management solutions, and nature-based urban planning. It was structured in three parts and showed how resilience measures can only succeed when governance, operations, and local cooperation are developed together.

The first part, led by Mr. Martin Bućan, focused on stakeholder involvement in the Mission CE Climate project. It highlighted that resilience-building on Brač was not approached as a purely technical matter, but as a coordinated effort connecting Split-Dalmatia County, technical experts from EIHP, the local utility Vodovod Brač, municipalities, and other relevant actors. The presentation emphasized the importance of breaking down institutional silos and building a shared framework for action, where practical coordination between sectors strengthens the region's

ability to respond to climate-related pressures. Citizen engagement was also presented as an important element, with workshops and sustainability-oriented activities helping to raise awareness and create broader support for long-term resilience measures.

In the second part, Mr. Ilja Drmač presented the pilot project for reducing water losses in the water supply system on the Island of Brač. The training explained that the pilot was motivated by the need to improve water supply reliability and reduce significant losses in the existing network, especially important for island conditions and the summer season, when demand is especially high. Participants learned how the pilot supported the upgrade of the water supply network through real-time monitoring and management tools, enabling quicker leak detection and more timely intervention. The presentation showed that this was not only about buying equipment, but about changing the management approach from reactive repairs to proactive, continuous monitoring. Around €70,000 was invested in advanced equipment, including 15 flow meters, 10 acoustic loggers, and one portable ultrasonic flow meter, and a separate loss-detection team was established within Vodovod Brač to ensure that the tools would be used effectively in daily practice. The training also underlined practical lessons from implementation, such as the need for close cooperation with beneficiaries, careful market-based budget planning, preparatory electrical and metal works before installation, and aligning implementation with local conditions such as traffic and the tourist season.

The third part, delivered by Dr. Martina Baučič, focused on water sensitive urban design and broadened the discussion from water-loss reduction to wider climate adaptation in urban areas. This part of the training addressed how stormwater management can be integrated into urban planning through nature-based solutions, helping cities mitigate flood risks while also creating cooler, greener, and more pleasant urban environments. In this way, the training connected technical infrastructure measures with spatial planning and demonstrated that resilience requires not only efficient water systems, but also thoughtful urban design that works with natural processes rather than against them.

4. Staff exchanges

The Steering comittee of the MISSION CE CLIMATE project has agreed that staff exchanges were not necessary, as the joint exchange of information and capacity building activities were sufficiently ensured by other forms such as study visits, co-creation sessions during presence consortium meetings and organized training sessions both in online or presence form. The decision was supported by the JS PO.

5. Workshops

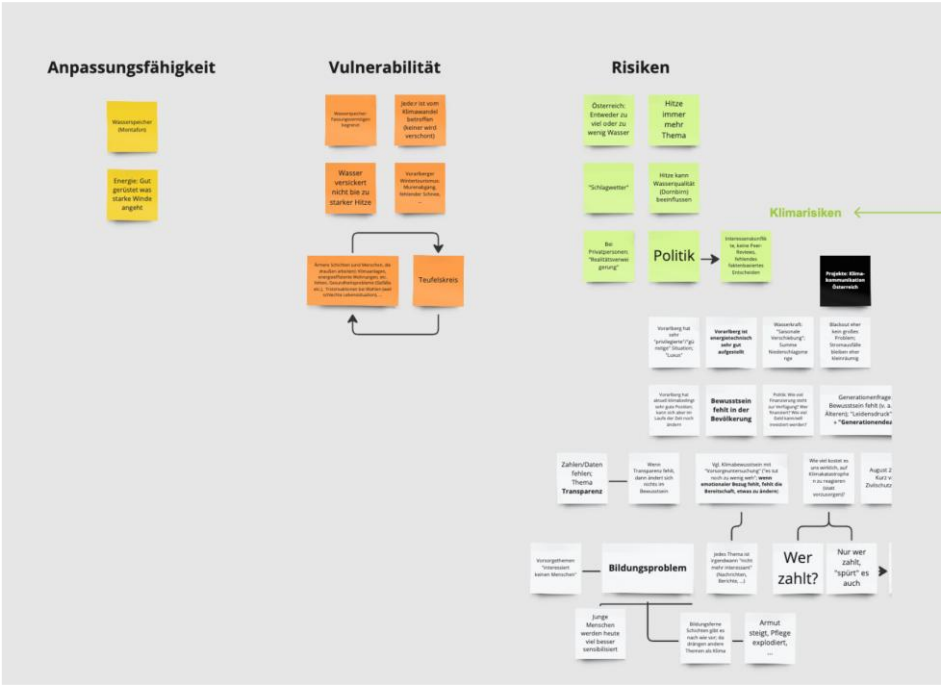
5.1. Risk Workshop

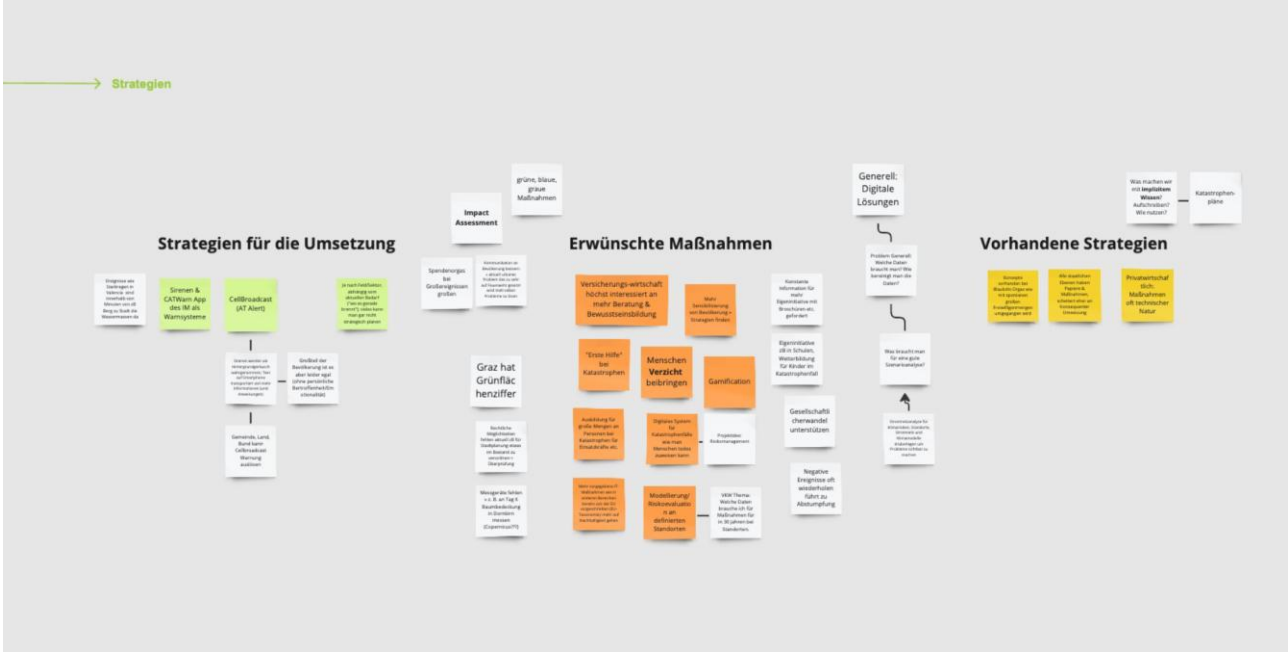
Date: January 2025

Participants: 12 participants

Description:

At the risk workshop, a group of diverse stakeholders discussed the climate risks in Vorarlberg, bringing together people from different background ranging from the energy sector to municipalities and the natural catastrophes team. It allowed to gain a more comprehensive understanding of the climate risks in Vorarlberg, which could then be used at a later stage as basis for the pilot study, but also the action plans within the Mission CE Climate Project.





5.2. Design of digital solution testing - Workshop

Date: 16th of March 2026

Format: online

Description:

In this webinar, the deliverable D.3.4.1. "Design of a digital solution for monitoring of climate change in climate change communities" was presented. Afterwards, the highlights of three different climate resilience pilot projects were shown:

- Citizen science and participation (pilot project in Pforzheim)
- Climate data management (pilot project in Dornbirn)
- Climate data management (pilot project Košice)

Lastly, a questionnaire for testing the "Design of a digital solution for monitoring of climate change in communities" was discussed. The questionnaire was refined after the meeting and in three bilateral meetings discussed with the three respective cities to learn more about the challenges and opportunities of implementing digital solutions in cities for climate monitoring.

Design of a digital solution for monitoring of climate change in communities

Martin Dobler, FHV

1

CONTEXT

Design of a digital solution for monitoring of climate change in communities

Context

- Climate change presents urgent challenges requiring innovative monitoring solutions
- Need for data-driven decision-making in climate adaptation
- Central European communities require accessible climate information
- Gap between complex climate data and actionable insights for stakeholders

Key questions

- How can dashboards enhance urban climate resilience using Quadruple/Quintuple Helix approaches?
- What are current limitations in usability, accessibility, and cocreation processes?
- Which design principles are most effective for user-centric dashboards?
- How to develop scalable frameworks for practical climate adaptation?

5

STAKEHOLDER ENGAGEMENT MODEL

Expected Impacts

- Environmental Awareness
- Evidenced-based Policy Making
- Community Engagement
- Educational Impact
- Data-driven Sustainability
- Stakeholder Collaboration
- Scalability & Replicability
- Public Safety & Risk Reduction

Target Groups

- Decision Makers
- Climate Action Professionals
- Community Leaders
- Technical Users & Data Scientists
- Engaged Citizens
- Underrepresented & Vulnerable Groups

Stakeholder Groups

- Local and Regional Authorities
- National Government Agencies
- Community Groups and NGOs
- Businesses and Private Sector
- Academic & Research Institutions
- Funding Bodies & Investors
- Technical & Service Providers
- General Public

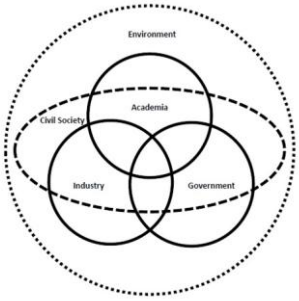
6

STAKEHOLDER ENGAGEMENT MODEL

Design of a digital solution for monitoring of climate change in communities

Stakeholder Engagment

- **Quadruple Helix Approach**: Academia, Government, Industry, Civil Society
- **Quintuple Helix**: Adds Natural Environment as fifth actor
- Co-creation with citizens at the core
- Fostering data transparency and user-centreed design



Picture: *Elias G. Carayannis - Carayannis, Elias G.; Barth, Thorsten D.; Campbell, David F. J. (2012-08-08). "The Quintuple Helix innovation model: global warming as a challenge and driver for innovation". Journal* CC BY-SA 2.0

7

STAKEHOLDER ENGAGEMENT MODEL

Participation Matrix

Implementation Approaches

- Dashboard Design
- Copernicus Climate Data Store (CDS)
- On-Site data gathering
- Citizens involvement (Citizen Science)

8

DASHBOARD DESIGN

Design of a digital solution for monitoring of climate change in communities

User-Centred Design Principles

- **Know your users**: *education, experience, interests, constraints*
- Iterative design with continuous user feedback
- Clear and informative visualisations
- Minimise information overload and cognitive complexity
- Ensure accessibility for diverse audiences

Key Design Recommendations

- Use appropriate visualisation techniques for data complexity
- Implement co-creation approaches with stakeholders
- Organise information hierarchically
- Maintain consistency and accessibility standards
- Conduct usability testing at multiple development stages

11

DASHBOARD DESIGN

Design of a digital solution for monitoring of climate change in communities

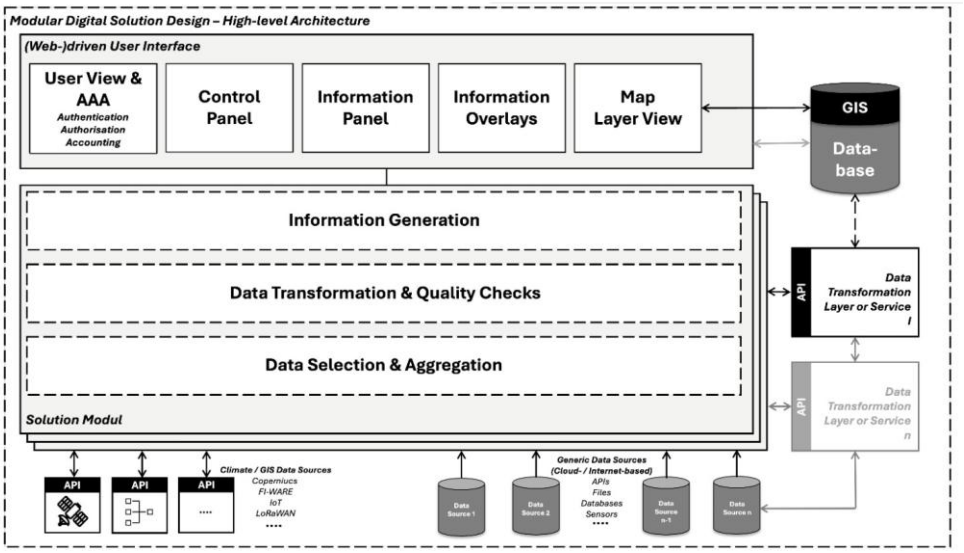
Data Quality Requirements

- **Accuracy:** Syntactic and semantic correctness
- **Completeness:** Comprehensive data coverage
- **Consistency:** Reliable across sources
- **Currentness:** Real-time and up-to-date information
- **Accessibility:** Easy to retrieve and use

12

TECHNICAL IMPLEMENTATION

Exemplary Modular Dashboard Design



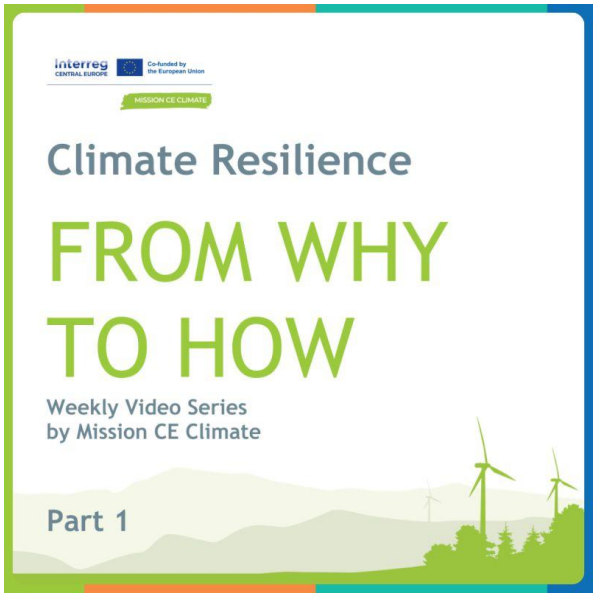
13

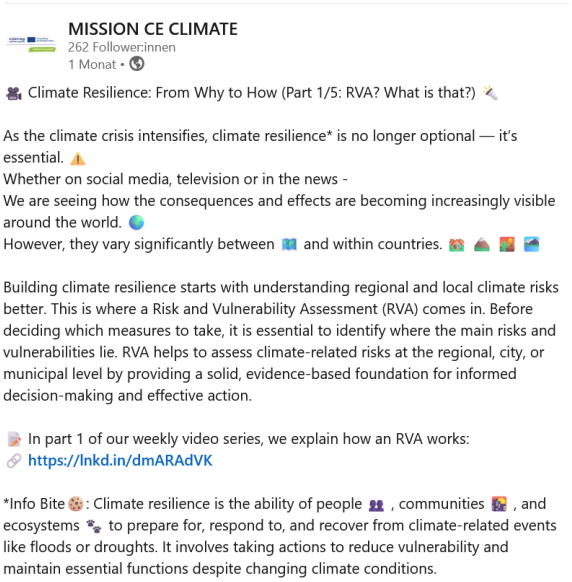
6. Videos

A video series about climate resilience was published by providing an overview about why climate resilience is relevant to how it can be implemented in municipalities or other communities.

6.1. RVA – What is that?

Topic: RVA – What is that?
Link: https://www.youtube.com/watch?v=zUpqjMT_wHE
LinkedIn: https://www.linkedin.com/feed/update/urn:li:activity:7426611194347724800





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Climate Resilience: From Why to How (Part 1/5: RVA? What is that?)

As the climate crisis intensifies, climate resilience* is no longer optional — it's essential.
Whether on social media, television or in the news -
We are seeing how the consequences and effects are becoming increasingly visible around the world.
However, they vary significantly between and within countries.

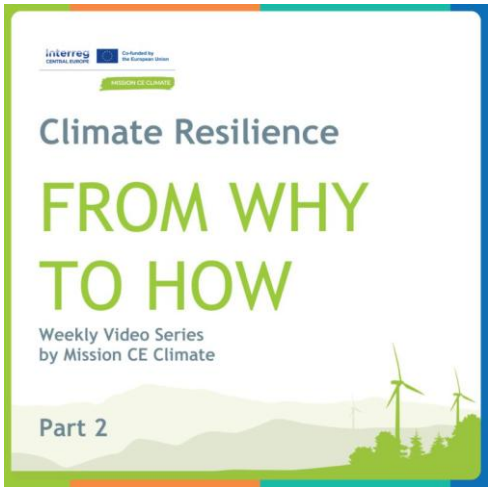
Building climate resilience starts with understanding regional and local climate risks better. This is where a Risk and Vulnerability Assessment (RVA) comes in. Before deciding which measures to take, it is essential to identify where the main risks and vulnerabilities lie. RVA helps to assess climate-related risks at the regional, city, or municipal level by providing a solid, evidence-based foundation for informed decision-making and effective action.

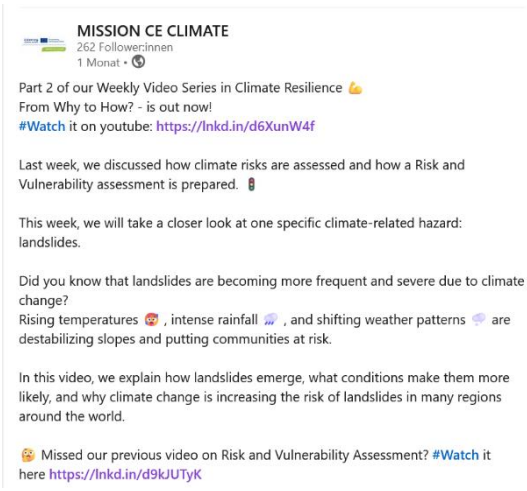
In part 1 of our weekly video series, we explain how an RVA works:
https://lnkd.in/dmARAdVK

*Info Bite: Climate resilience is the ability of people , communities , and ecosystems to prepare for, respond to, and recover from climate-related events like floods or droughts. It involves taking actions to reduce vulnerability and maintain essential functions despite changing climate conditions.

6.2. Landslides

Topic: Landslides
Link: https://www.youtube.com/watch?v=erp7OHvgoX8
LinkedIn: https://www.linkedin.com/feed/update/urn:li:activity:7429087289059766274





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Part 2 of our Weekly Video Series in Climate Resilience 💪
From Why to How? - is out now!
#Watch it on youtube: https://lnkd.in/d6XunW4f

Last week, we discussed how climate risks are assessed and how a Risk and Vulnerability assessment is prepared. 🚦

This week, we will take a closer look at one specific climate-related hazard: landslides.

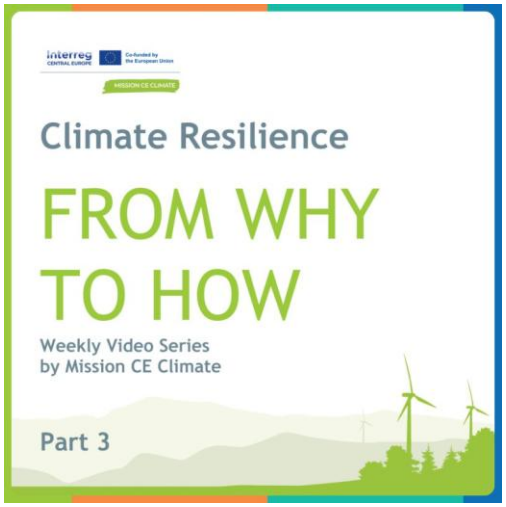
Did you know that landslides are becoming more frequent and severe due to climate change?
Rising temperatures 🥵, intense rainfall 🌧️, and shifting weather patterns 🌪️ are destabilizing slopes and putting communities at risk.

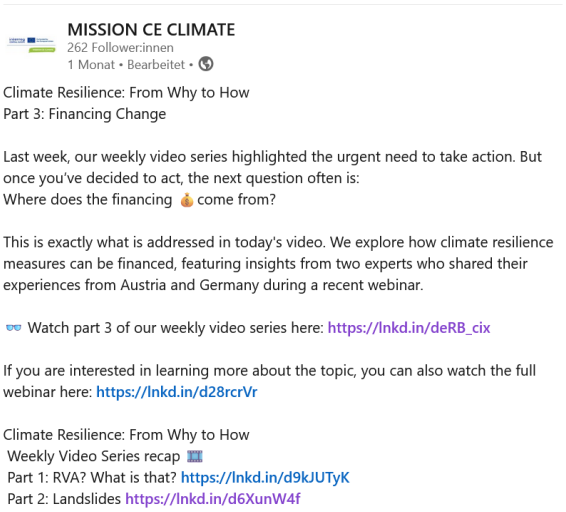
In this video, we explain how landslides emerge, what conditions make them more likely, and why climate change is increasing the risk of landslides in many regions around the world.

🤔 Missed our previous video on Risk and Vulnerability Assessment? #Watch it here https://lnkd.in/d9kJUTyK

6.3. Financing climate resilience projects

Topic: How to finance climate resilience projects
Link: https://www.youtube.com/watch?v=NGt8t_spJDU
LinkedIn: https://www.linkedin.com/feed/update/urn:li:activity:7431610108457058304





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Climate Resilience: From Why to How
Part 3: Financing Change

Last week, our weekly video series highlighted the urgent need to take action. But once you've decided to act, the next question often is:
Where does the financing 🔥 come from?

This is exactly what is addressed in today's video. We explore how climate resilience measures can be financed, featuring insights from two experts who shared their experiences from Austria and Germany during a recent webinar.

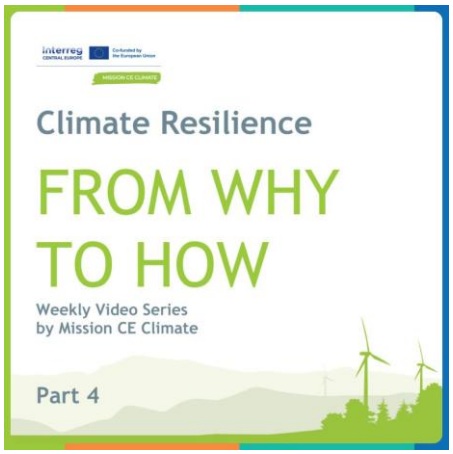
👓 Watch part 3 of our weekly video series here: https://lnkd.in/deRB_cix

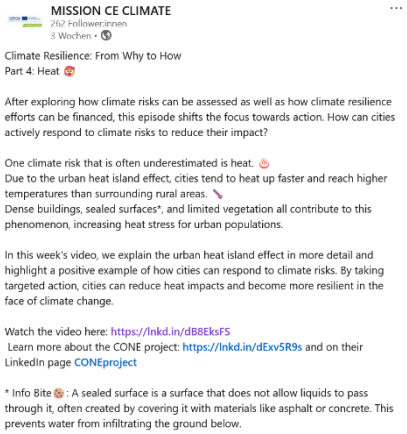
If you are interested in learning more about the topic, you can also watch the full webinar here: https://lnkd.in/d28rcrVr

Climate Resilience: From Why to How
Weekly Video Series recap 🖼️
Part 1: RVA? What is that? https://lnkd.in/d9kJUTyK
Part 2: Landslides https://lnkd.in/d6XunW4f

6.4. Urban heat island effect

Topic: Urban Heat Island Effect and CONE project
Link: https://www.youtube.com/watch?v=qBFpgeG-82A
LinkedIn: https://www.linkedin.com/posts/mission-ce-climate_climate-resilience-from-why-to-how-part-activity-7434156810095214592-Jdog?utm_source=share&utm_medium=member_desktop&rcm=ACoAACDTyNwB8UY7ofjc68KNPE6f0thMx_gau5U

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Climate Resilience: From Why to How
Part 4: Heat

After exploring how climate risks can be assessed as well as how climate resilience efforts can be financed, this episode shifts the focus towards action. How can cities actively respond to climate risks to reduce their impact?

One climate risk that is often underestimated is heat.
Due to the urban heat island effect, cities tend to heat up faster and reach higher temperatures than surrounding rural areas.
Dense buildings, sealed surfaces*, and limited vegetation all contribute to this phenomenon, increasing heat stress for urban populations.

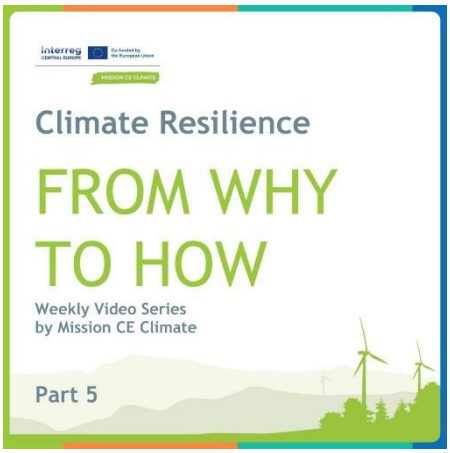
In this week's video, we explain the urban heat island effect in more detail and highlight a positive example of how cities can respond to climate risks. By taking targeted action, cities can reduce heat impacts and become more resilient in the face of climate change.

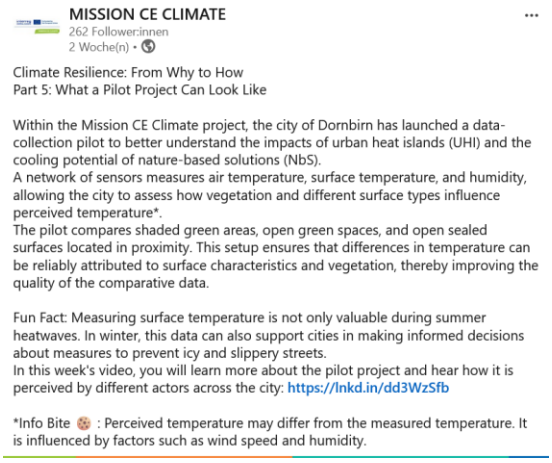
Watch the video here: https://lnkd.in/dB8EksFS
Learn more about the CONE project: https://lnkd.in/dExv5R9s and on their LinkedIn page CONEproject

* Info Bite: A sealed surface is a surface that does not allow liquids to pass through it, often created by covering it with materials like asphalt or concrete. This prevents water from infiltrating the ground below.

6.5. What a Pilot Project Can Look Like

Topic: Pilot Study in Dornbirn
Link: https://www.youtube.com/watch?v=fUWgTlkYBc0.
LinkedIn: https://www.linkedin.com/posts/climate-resilience-from-why-to-how-part-share-7431629540713553920-nBE1?utm_source=share&utm_medium=member_desktop&rcm=ACoAACDTyNwB8UY7ofjc68KNPE6f0thMx_gau5U

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Climate Resilience: From Why to How
Part 5: What a Pilot Project Can Look Like

Within the Mission CE Climate project, the city of Dornbirn has launched a data-collection pilot to better understand the impacts of urban heat islands (UHI) and the cooling potential of nature-based solutions (NbS).
A network of sensors measures air temperature, surface temperature, and humidity, allowing the city to assess how vegetation and different surface types influence perceived temperature*.
The pilot compares shaded green areas, open green spaces, and open sealed surfaces located in proximity. This setup ensures that differences in temperature can be reliably attributed to surface characteristics and vegetation, thereby improving the quality of the comparative data.

Fun Fact: Measuring surface temperature is not only valuable during summer heatwaves. In winter, this data can also support cities in making informed decisions about measures to prevent icy and slippery streets.
In this week's video, you will learn more about the pilot project and hear how it is perceived by different actors across the city: https://lnkd.in/dd3WzSfb

*Info Bite : Perceived temperature may differ from the measured temperature. It is influenced by factors such as wind speed and humidity.

D.3.3.1 Citizen tool

Interreg CENTRAL EUROPE

Co-funded by the European Union

MISSION CE CLIMATE

A citizens' guide to climate resilience

Deliverable 3.3.1 – Activity 3.1

Issued by krumedia

Document type: Report

Period July 2024

Understanding Climate Change And The Need For Adpatation

Climate change is the defining environmental challenge of the twenty-first century. Its impacts are pervasive, affecting every corner of our planet, from the icy reaches of the North Pole to the sun-kissed landscapes of the South. As temperatures rise, sea levels surge, and extreme weather events become more frequent, our homes—our sanctuaries—must evolve to withstand these challenges. This chapter delves into practical ways to transform our homes into resilient havens, emphasizing the critical role that individual actions play in fostering climate resilience.

Understanding climate change is the first step in addressing its impacts. Climate change encompasses more than just global warming; it includes rising sea levels, shrinking mountain glaciers, accelerating ice melt in Greenland, Antarctica, and the Arctic, and shifts in plant blooming times. The effects of climate change are widespread and profound, impacting freshwater availability, ecosystems, and weather patterns. For instance, glaciers and ice sheets are shrinking, contributing to sea-level rise and affecting freshwater availability. River and lake ice is breaking up earlier, disrupting ecosystems and water resources. Additionally, more frequent and intense extreme weather events—such as storms, floods, and droughts—are becoming the new norm, disrupting communities and ecosystems.

Given these changes, individual action is crucial. Climate resilience directly affects our quality of life, safety, and stability. Resilient communities can protect basic needs like food, water, and shelter even amidst environmental stressors. By adapting our homes, lifestyles, and consumption practices, we enhance our ability to withstand climate impacts. Furthermore, every individual's actions collectively contribute to global resilience. By reducing our carbon footprint, adopting sustainable practices, and promoting climate awareness, we become part of the solution.

Adaptation is key to climate resilience. It involves adjusting our behaviors, practices, and infrastructure to mitigate climate risks. For example, retrofitting homes for energy efficiency, using renewable energy sources, and implementing water-saving technologies can enhance resilience. Choosing sustainable products, reducing waste, and supporting eco-friendly practices contribute to overall resilience. Engaging with local initiatives, advocating for climate action, and participating in community resilience efforts amplify our impact.

Statistics highlight the urgency of these actions. Residential buildings account for approximately 20% of global energy consumption, and buildings consume 40% of global energy, contributing to 30% of greenhouse gas emissions. Households alone account for 19% of the EU's greenhouse gas emissions. Natural disasters cause billions of Euros in property damage annually all over the world. Urban green spaces enhance biodiversity, absorb rainwater, and provide cooling effects, playing a vital role in climate adaptation.

In this guide, practical steps for citizens to foster climate resilience are displayed. From energy-efficient upgrades and water conservation practices to emergency preparedness and nurturing climate-resilient gardens, we will cover a range of strategies to make our homes more resilient. By understanding climate change, embracing adaptation, and taking individual action, we can collectively build a more resilient and sustainable future for all. Climate resilience is not a future problem – it's a present imperative. Let's be champions of change and work towards a world where both people and nature thrive in the face of climate challenges.

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A. Adapting homes for climate resilience

Climate change is the defining environmental challenge of the twenty-first century. Its impacts span from the icy reaches of the North Pole to the sun-kissed landscapes of the South, affecting every corner of our planet. As temperatures rise, sea levels surge, and extreme weather events become more frequent, our homes must evolve to withstand these challenges.

By making conscious decisions about how we build, maintain, and live in our homes, we can significantly reduce our environmental footprint and contribute to a more sustainable future. Let this chapter guide us toward creating homes that are not only resilient to climate impacts but also support a healthier planet. 🌿🏡🌎

In this chapter, we delve into practical ways to transform our homes into resilient havens. From energy-efficient upgrades to embracing green building principles, from conserving water to planning for emergencies, and even nurturing climate-resilient gardens, we'll explore how citizens like you can play an active role in fostering climate resilience.

Enhancing Climate Resilience Through Energy Efficiency In Housing

🌿🏡💡 Embrace energy efficiency to reduce emissions, conserve resources, and build a resilient and sustainable future for all. 🌿🏡💡

Energy efficiency is a cornerstone of creating climate-resilient homes and communities. By minimizing energy waste and optimizing energy consumption, we can significantly reduce greenhouse gas emissions, conserve natural resources, and enhance the resilience of our living spaces.

This chapter will guide you through various aspects of energy efficiency, including practical tips for insulating homes, upgrading heating and cooling systems, and integrating smart appliances and electronics. By embracing energy efficiency, we can build a resilient and sustainable future, reducing emissions and conserving resources for generations to come.

Energy Efficiency in Housing and Climate Resilience

🌿🏡💡 Small changes can add up to significant energy savings over time. Implementing these practices will not only benefit your wallet but also contribute to a more sustainable future. 🌿🏡💡

Energy-efficient homes play a crucial role in enhancing overall resilience, especially in the face of climate change and extreme weather events. These homes offer numerous benefits that improve the ability of individuals and communities to withstand and recover from adverse conditions.

Reduced Vulnerability to Energy Shortages

Energy-efficient homes consume less electricity, reducing their dependence on external energy sources. During power outages caused by storms or other emergencies, these homes can rely on backup systems, such as solar panels with battery storage, to maintain essential services. This resilience ensures that occupants have access to lighting, heating, cooling, and communication even when the grid is down. By decreasing reliance on the grid, energy-efficient homes provide a buffer against energy shortages, enhancing the stability and security of

households. Furthermore, integrating renewable energy systems not only offers backup during outages but also contributes to a more sustainable energy infrastructure.

Temperature Regulation and Comfort

Proper insulation, sealed windows, and efficient heating and cooling systems help maintain comfortable indoor temperatures. In extreme heat or cold, energy-efficient homes remain habitable without excessive energy use. This means residents are less vulnerable to temperature-related health risks during heatwaves or cold snaps. Maintaining a stable and comfortable indoor environment significantly contributes to the well-being and health of the occupants, allowing them to live more comfortably and safely regardless of external weather conditions. Additionally, energy-efficient homes often feature advanced ventilation systems that ensure a constant flow of fresh air, further enhancing indoor comfort.

Financial Stability

Lower energy bills provide homeowners with more financial flexibility. Savings from energy efficiency can be redirected toward emergency preparedness, such as creating an emergency kit or reinforcing structures. Financial stability is a critical component of overall household resilience, as it allows families to better manage unexpected expenses and invest in further resilience measures. This economic benefit can make a significant difference in the long-term sustainability and security of a household. Moreover, the initial investment in energy-efficient upgrades often pays off through increased property values and reduced operating costs.

Durability and Longevity

Energy-efficient construction often involves high-quality materials and better building practices. These homes are more durable and have longer lifespans. Durability reduces the need for frequent repairs and replacements, enhancing overall resilience. Homes built to energy-efficient standards are more likely to withstand extreme weather events and other challenges, reducing maintenance costs and increasing the reliability of the living environment. Features like impact-resistant windows and reinforced structures add to the home's ability to endure severe conditions.

Health and Well-Being

Improved indoor air quality, achieved through proper ventilation and reduced pollutants, supports residents' health. Energy-efficient homes are less likely to harbour mold or dampness, which can affect respiratory health. Healthy occupants are better equipped to cope with stressors and emergencies. A healthier living environment not only improves quality of life but also reduces healthcare costs and increases the overall resilience of individuals to both environmental and personal health challenges. Energy-efficient homes also tend to use less toxic materials in construction and finishes, contributing to a safer indoor environment. Proper insulation ensures that indoor temperatures remain consistent, providing comfort to occupants throughout the year. In winter, insulation keeps homes warm by preventing heat loss, while in summer, it helps maintain a cooler indoor environment by blocking heat from entering. This stable temperature regulation makes living spaces more pleasant and reduces the strain on heating and cooling systems. Enhanced comfort is especially beneficial in extreme weather conditions, where maintaining a stable indoor environment is crucial for health and well-being

Community Resilience

When a neighborhood has a high percentage of energy-efficient homes, it collectively reduces strain on local infrastructure. During disasters, communities with resilient homes can support each other more effectively. Shared resources, such as community centers with backup power, benefit everyone. A community-wide approach to energy efficiency can amplify the benefits, creating a more robust and supportive environment for all residents. Additionally, energy-efficient communities often foster a culture of sustainability and mutual support, further strengthening communal bonds and resilience.

Environmental Impact

Energy-efficient homes contribute to a greener environment by reducing overall energy consumption. Lower energy usage translates to fewer greenhouse gas emissions, which is beneficial for the planet. This reduction in emissions helps mitigate climate change and promotes a healthier, more sustainable environment for future generations. By reducing the demand for fossil fuels, energy-efficient homes play a crucial role in the transition towards renewable energy sources and a more sustainable energy future.

Here are some of the most efficient ways to increase the energy efficiency of your home.

Home Insulation and Sealing

🌿🏠💡 Prioritize proper insulation and sealing to reduce energy consumption, lower bills, enhance comfort, and create eco-friendly, resilient homes prepared for climate challenges. 🌿🏠💡

Proper insulation and sealing are vital components of energy-efficient homes. They not only reduce energy consumption and lower utility bills but also enhance comfort, promote environmental sustainability, and contribute to long-term financial savings. By prioritizing insulation and sealing, homeowners can create more resilient and eco-friendly living spaces that are better prepared for the challenges of climate change. Implementing these measures is a crucial step towards achieving energy efficiency and reducing the overall environmental impact of our homes.

In addition, proper home insulation and sealing comes with additional benefits:

Increased Property Value
Investing in proper insulation can increase the value of a property. Energy-efficient homes are more attractive to potential buyers because they promise lower utility bills and increased comfort. Additionally, homes with good insulation are often more durable and require less maintenance, which can further enhance their market value. In an increasingly eco-conscious market, energy efficiency is a strong selling point.

Noise Reduction
Insulation also helps in reducing noise pollution inside homes. Properly insulated walls, floors, and roofs can significantly reduce the transmission of sound, creating a quieter and more peaceful indoor environment. This is particularly beneficial in urban areas or homes located near busy roads where external noise can be a disturbance.

Moisture Control
Proper insulation and sealing also help in controlling moisture levels inside the home. By preventing the entry of moisture-laden air, insulation reduces the risk of mold and mildew growth, which can cause health problems and damage the building structure. Sealing gaps and cracks further ensures that moisture does not enter the home, maintaining a dry and healthy indoor environment.

Extended Lifespan of HVAC Systems
When a home is well-insulated, the heating, ventilation, and air conditioning (HVAC) systems do not have to work as hard to maintain comfortable temperatures. This reduced workload can extend the lifespan of these systems, resulting in lower maintenance costs and fewer replacements over time. Efficient operation of HVAC systems also means reduced energy consumption and lower utility bills.

Practical Tips for Insulating Homes

- **Insulate the Roof:** The roof is a major area of heat loss in many homes. The Building Regulations recommend a minimum of 270mm of mineral wool (or similar natural insulation) for roofs. If your existing insulation is inadequate, consider topping it up or replacing it with more effective materials.

Proper roof insulation can prevent up to 25% of heat loss, making a significant impact on energy savings.

- **Insulate Walls:** External wall insulation can be more challenging and costly compared to other areas. However, insulating accessible loft spaces is easier and more affordable. Additionally, smaller measures like draught-proofing around windows, doors, and chimneys should not be overlooked. These inexpensive steps can significantly help in regulating internal temperatures and saving energy. For homes with cavity walls, insulating the cavities can be a cost-effective way to improve energy efficiency.
- **Floor Insulation:** Floors can be insulated by adding materials between floor joists. Fiberglass insulation can be unrolled and placed into joist spaces, or cellulose insulation can be blown in using an insulation blower. Insulating floors can help reduce heat loss through the ground, making the home warmer and more energy-efficient.
- **Sealing and Weatherproofing:** Sealing gaps around windows, doors, and other openings using weatherstripping and caulk is essential for preventing heat loss and drafts. Installing blinds or shades provides additional insulation for windows. Addressing gaps and crevices with backer rod, a type of foam rope, can create a tighter seal and improve overall energy efficiency. Weatherproofing also involves ensuring that doors and windows are properly fitted and that any leaks or gaps are sealed effectively.
- **Consider Replacing Windows:** If you have single-pane windows, consider energy-efficient replacements or add solar shades or tinting film. These improvements can significantly enhance energy efficiency. Modern energy-efficient windows offer better insulation, reducing heating and cooling costs while improving comfort.

Efficient Heating and Cooling Systems

🌿 🏠 💡 Prioritize optimizing heating and cooling systems to reduce energy consumption, lower bills, enhance comfort, and create eco-friendly, resilient homes prepared for climate challenges. 🌿 🏠 💡

Heating and cooling systems play a critical role in achieving efficient energy use. These systems significantly impact energy consumption, making their optimization crucial for both energy savings and environmental sustainability. Heating and cooling systems account for a substantial portion of energy consumption in various regions. In the European Union, these systems constitute around half of the total energy consumption. This high percentage highlights the significant potential for energy savings through improved efficiency in heating and cooling systems. To encourage citizens to contribute to these goals, upgrading to energy-efficient HVAC systems and programmable thermostats is highly recommended. Modern HVAC systems are designed to be more energy-efficient, reducing both energy use and costs. Programmable thermostats allow for better control over heating and cooling settings, optimizing energy use according to specific needs and occupancy patterns. These upgrades not only enhance comfort but also play a significant role in promoting sustainability and achieving climate resilience.

Smart Appliances and Electronics

🌿 🏠 💡 Optimize the energy use of smart appliances and electronics to reduce bills, lower your carbon footprint, and create a more sustainable home environment. 🌿 🏠 💡

Smart appliances and electronics have become integral parts of modern households, but they can significantly impact energy bills. Understanding their energy use and adopting more efficient practices can lead to substantial savings and environmental benefits.

Appliances and electronics are major contributors to household energy consumption. Items such as refrigerators, washing machines, dishwashers, and televisions can account for a large portion of monthly energy usage. For example, in many households, refrigerators alone can consume around 10-15% of total energy due to their continuous operation. Modern homes often have numerous electronic devices like computers, gaming consoles, and smart speakers, all of which add to the energy load. The increased reliance on home offices and entertainment systems, particularly during the COVID-19 pandemic, has further highlighted the need for energy-efficient solutions in the household sector.

The use of energy-efficient appliances is one of the most effective ways to reduce the energy impact of appliances and electronics. Energy-efficient appliances are designed to use less electricity without compromising performance. Similarly, energy-efficient dishwashers and dryers also provide significant savings by utilizing advanced technologies that reduce power consumption. By choosing appliances with high energy efficiency ratings, households can substantially lower their energy bills and carbon footprints.

In addition to choosing energy-efficient models, it's crucial to turn off devices when they are not in use. Many electronics continue to draw power even when turned off, a phenomenon known as "phantom load." This standby power can account for up to 10% of household energy use. Simple actions like unplugging devices, using power strips to easily switch off multiple devices at once, and enabling power-saving modes can effectively reduce this unnecessary energy consumption.

Home Energy Management Systems (HEMS)

Investing in home energy management systems (HEMS) can provide a comprehensive approach to managing household energy use. HEMS integrate with smart appliances to monitor and control energy consumption, offering insights and recommendations to further enhance efficiency. By being mindful of the impact of appliances and electronics on energy bills and adopting energy-efficient models and practices, households can achieve significant cost savings and contribute to environmental sustainability.

Example: Lighting Upgrades

🌿 🏠 💡 Upgrading to LED bulbs is a simple yet effective way to enhance energy efficiency, reduce electricity bills, and benefit the environment. 🌿 🏠 💡

Lighting upgrades are a straightforward yet impactful way to enhance energy efficiency and reduce electricity bills. One of the most significant changes in this domain has been the shift from incandescent bulbs to LED bulbs, which offer numerous advantages over their traditional counterparts.

LED bulbs are far more energy-efficient than incandescent bulbs. Incandescent bulbs convert only about 10% of the energy they consume into light, with the remaining 90% wasted as heat. In contrast, LED bulbs use energy much more efficiently, converting a greater proportion of energy into light and producing very little heat. This efficiency translates into significant energy savings; LED bulbs use up to 80% less energy than incandescent bulbs for the same amount of light, making them an excellent choice for reducing energy consumption.

Another major advantage of LED bulbs is their longevity. While incandescent bulbs typically last for around 1,000 hours, LED bulbs can last for 25,000 hours or more. This extended lifespan means that LED bulbs need to be replaced far less frequently, resulting in lower maintenance costs and reduced environmental impact due to fewer bulbs being discarded.

In addition to their energy efficiency and long lifespan, LED bulbs also offer superior performance. They are available in a wide range of color temperatures and brightness levels, allowing consumers to choose lighting that suits their needs and preferences. LED bulbs also provide instant full brightness when switched on, unlike some other energy-efficient lighting options that can take time to warm up.

Further Practical Tips to Enhance Energy Efficiency in Your Home:

- **Look for Energy Star or Equivalent Certifications:** These labels ensure that the product meets high energy efficiency standards.
- **Utilize Smart Features:** Smart appliances can significantly reduce energy use by optimizing their operation.
- **Adopt Energy-Saving Habits:** Turn off and unplug devices when not in use, and make use of energy-saving settings and features.
- **Regular Maintenance:** Keeping appliances in good working order, such as cleaning refrigerator coils and checking seals, ensures they operate efficiently.
- **Wash Clothes in Cold Water:** Use cold water whenever possible for laundry. Heating water accounts for a significant portion of energy consumption in washing machines. Using cold water can reduce energy use and save money. Additionally, modern detergents are formulated to clean effectively in cold water, making this an easy and effective energy-saving practice.
- **Clean or Replace Filters Regularly:** Dirty filters make HVAC systems work harder and consume more energy. Keeping filters clean maintains optimal efficiency and extends the life of your heating and cooling systems. Regular maintenance of HVAC systems ensures they operate efficiently, providing better air quality and comfort.
- **Use Your Microwave Instead of the Stove:** Microwaves are more energy-efficient for cooking small meals. Reserve stove usage for larger cooking tasks to reduce energy consumption. Microwaves also cook food faster, saving both time and energy.
- **Defrost Refrigerator and Freezer:** Regularly defrost your appliances to prevent excessive ice buildup. Efficiently running appliances save energy and improve performance. Keeping your refrigerator and freezer coils clean can also help them run more efficiently.
- **Control Blinds and Shades:** Close blinds, shades, and drapes on sunny sides during warmer months to keep your home cool. Open them during cooler months to utilize natural sunlight for heating, reducing energy use. This passive solar heating and cooling technique can significantly enhance the energy efficiency of your home.
- **Avoid Peeking in the Oven While Baking:** Each time you open the oven, it loses heat. Minimize energy waste by avoiding unnecessary peeks and keeping the oven door closed during cooking. Using a timer and interior light to check on your food can help maintain the oven's temperature.
- **Use Natural Light When Possible:** Turn off artificial lights during daylight hours and utilize natural sunlight to brighten your home. This simple practice can significantly reduce energy consumption and create a more pleasant indoor environment.
- **Set Thermostat Temperatures Wisely:** Set your thermostat to 25°C in summer and 20°C in winter. Every degree of extra heating or cooling increases energy usage. Adjusting your thermostat wisely can lead to substantial energy savings. Consider using programmable thermostats to automatically adjust temperatures based on your schedule, optimizing comfort and efficiency.
- **Optimize Refrigerator and Freezer Usage:** Keep your refrigerator and freezer as full as possible, using water bottles if needed. Overfilling reduces airflow and makes appliances work harder, increasing energy use. Keeping them well-organized also helps improve efficiency by reducing the time the door stays open.
- **Run Dishwashers and Washers/Dryers at Night:** Nighttime usage keeps the house cooler and reduces strain on the power grid during peak hours. Turn off heated dry on your dishwasher and air dry instead to save energy. Using energy-efficient appliances and running them during off-peak hours can significantly reduce your household's energy footprint.

- **Adjust Bathroom and Kitchen Ventilation Fans:** Don't leave ventilation fans running longer than necessary, as they replace indoor air with outside air. Use them efficiently to save energy. Ensuring that your home is properly ventilated without overusing fans can improve air quality and reduce energy costs.

Implementing these practices will not only benefit your wallet but also contribute to a more sustainable future. Small changes can add up to significant energy savings over time, making your home more energy-efficient and environmentally friendly.

Renewable Energy

🌿 🏠 💡 Invest in renewable energy technologies and support green energy providers to reduce carbon emissions, achieve energy independence, and contribute to a sustainable future. 🌿 🏠 💡

Renewable energy is a cornerstone of sustainable living, offering a path to reduce carbon footprints and achieve energy independence. Solar panels, wind turbines, green energy providers, and cooperatives are leading the way in this transformation, providing diverse options for households and communities to harness clean energy.

Solar Panels
Solar panels are one of the most accessible and popular renewable energy technologies for residential use. By converting sunlight directly into electricity, solar panels provide a reliable and sustainable source of energy.

Wind Turbines
Wind turbines, although often associated with large-scale wind farms, can also be implemented on a smaller scale for individual homes or communities. The "Samsø Island" project in Denmark demonstrates community-led wind energy success. The island transitioned to 100% renewable energy through a combination of wind, solar, and biomass projects. Local residents own shares in the wind turbines, ensuring that the financial benefits stay within the community. This project highlights how community engagement and ownership can drive the transition to renewable energy, providing economic and social benefits alongside environmental ones.

Green Energy Providers and Cooperatives
Green energy providers and cooperatives are instrumental in expanding access to renewable energy. These organizations often offer electricity generated from renewable sources such as wind, solar, and hydro, allowing consumers to choose greener energy options.

Enhancing Climate Resilience Through Water Conservation

As we navigate the challenges of a changing climate, our choices regarding water consumption are crucial. Water-efficient fixtures are essential for reducing water waste and promoting sustainability. These fixtures ensure that the amount of water used matches the actual need, thereby conserving resources. Fixtures such as low-flow showerheads, water-saving faucets, and dual-flush toilets significantly contribute to water conservation. Water conservation contributes to overall resilience, especially during droughts or water supply disruptions. Efficient water use reduces the strain on local water resources and infrastructure, ensuring a more sustainable and reliable supply of water for household needs. Implementing greywater recycling systems can also significantly enhance water efficiency, providing an alternative water source for landscaping and other non-potable uses.

Additionally, graywater systems can be used to recycle water from sinks or showers for non-potable uses like irrigation, further optimizing water use. Rainwater harvesting systems help address water scarcity during dry periods and reduce reliance on municipal water sources. Smart meters and sensors provide real-time feedback, helping users monitor and reduce their water consumption. The combined environmental and financial benefits of these fixtures are profound, protecting ecosystems and leading to significant savings on water and energy bills.

Incorporating water-efficient fixtures into our homes and communities is a critical step toward conserving water resources, reducing our environmental footprint, and promoting sustainability for future generations. These measures address global water scarcity and ensure long-term water sustainability amid climate change and population growth.

Water-Efficient Fixtures

💧 🌿 Choose water-efficient fixtures to conserve water resources, reduce your environmental footprint, and promote sustainability for future generations. Let's make every drop count! 💧 🌿

Understanding water efficiency involves minimizing water wastage by assessing the amount of water needed for specific purposes and comparing it with the actual water used or delivered. In many countries, residential water use constitutes around 16% of total freshwater withdrawals, emphasizing the importance of conservation efforts. Efficient water use benefits our environment by conserving precious resources and also contributes to climate change mitigation by reducing energy consumption and greenhouse gas emissions.

Common Water-Efficient Fixtures

Energy-efficient homes often incorporate water-saving features, such as low-flow fixtures and rainwater harvesting systems. Common water-efficient fixtures play a significant role in achieving water efficiency:

- Low-flow showerheads are designed to reduce water flow while maintaining satisfactory performance. These fixtures can cut water usage by up to 50%, translating into significant savings. Some showerheads use atomization technology to create a mist, using 70% less water than traditional showerheads.
- Water-saving faucets are designed to limit water flow without compromising functionality.
- Dual-flush toilets offer different flush options for liquid waste (low volume) and solid waste (higher volume), reducing water usage by up to 68% compared to conventional toilets.
- Gray water systems recycle water from sinks or showers for non-potable uses like toilet flushing or irrigation, providing a sustainable way to reuse water within the household.
- **Smart meters and sensors** provide real-time feedback to users, encouraging mindful water use. These devices help identify leaks and monitor water consumption patterns, empowering homeowners to make informed decisions about their water usage. The “Flume” smart water monitor, for instance, attaches to a home’s water meter and provides real-time data via a smartphone app, helping users detect leaks and monitor usage.

The benefits of water-efficient fixtures are multifaceted. Environmentally, they significantly reduce water waste, easing the strain on local water sources. By conserving water, we contribute directly to environmental well-being and help protect ecosystems.

Graywater Recycling

💧 🌿 🌎 Embrace graywater recycling to reduce water waste, lower bills, and support environmental sustainability. Let's turn this resource into a force for good! 💧 🌿 🌎

In our quest for water conservation and environmental stewardship, graywater recycling emerges as a powerful tool. Graywater refers to the lightly used water from showers, bathtubs, sinks, and washing machines in our homes. Unlike blackwater, which comes from toilets or washing diapers and contains feces, graywater contains traces of grease, hair, dirt, food, and some cleaning products but lacks significant pathogenic contaminants. Instead of spiraling down the drain and into sewers, graywater can be repurposed in various ways, presenting an opportunity to optimize water use in our daily lives.

By reusing graywater, we can slash water waste by up to 40%. This is particularly critical as climate change intensifies droughts, pushing regions like California to impose strict water use limits. Graywater systems ensure outdoor water availability even during these restrictions, thereby supporting sustainable landscaping and gardening practices. Reducing water use through graywater recycling directly translates to lower water bills, offering financial savings for both households and businesses. For instance, a household in an arid region implementing a graywater system can significantly reduce its annual water expenses. Moreover, recycling graywater reduces the load on sewage treatment plants and minimizes pollution. Given that graywater typically contains fewer contaminants compared to blackwater, it is a more eco-friendly choice, contributing to the overall reduction of pollutants entering natural water bodies.

Effective Uses of Graywater

Graywater can be repurposed effectively for various uses, predominantly in irrigation. It is ideal for watering trees, shrubs, flowers, and native grasses. These plants can thrive with the nutrients found in graywater, reducing the need for additional fertilizers. It can also be used for garden edibles, provided the water only touches the soil and not the edible parts of the plants. This precaution helps prevent any potential contamination of the produce. To ensure the safety and efficacy of graywater recycling, it is essential to avoid harmful substances such as bleach or excessive salt in household products. Opt for biodegradable and plant-based cleaning products to keep graywater safe for use in gardens.

Graywater Collection and Systems

Homeowners can collect graywater from showers and sinks in buckets and manually distribute it to plants. Additionally, using a graywater diverter valve, water from the washing machine can be redirected to the garden, offering a straightforward and cost-effective recycling method. More sophisticated systems can be installed by professionals, including graywater irrigation systems with separate pipes for graywater and potable water, ensuring that the recycled water is used efficiently for irrigation. Constructed wetlands treat graywater through plant roots and soil, offering an eco-friendly and aesthetically pleasing solution for larger properties. Subsurface drip irrigation delivers graywater directly to plant roots underground, minimizing water loss due to evaporation and ensuring that plants receive adequate hydration.

Practical Tips to Enhance Water Conservation at Home:

Conserving water at home is not only environmentally responsible but also helps lower utility costs. Here are practical tips to reduce water consumption:

- **Turning Off Faucets:** One effective measure is to turn off the faucet while brushing your teeth or shaving, which can save approximately 760 liters of water per month. Rather than allowing the water to run continuously, simply wet your toothbrush and turn off the tap until needed again.
- **Taking Shorter Showers:** Taking shorter showers can substantially reduce water usage. Aim to limit showers to five minutes or less, as prolonged showers can consume approximately 7.6 liters of water per minute. Shorter showers can maintain personal hygiene while conserving water.
- **Flushing Toilets Wisely:** Another significant approach is to flush the toilet only when necessary. Avoid using the toilet as a disposal for non-sanitary waste, and refrain from courtesy flushes. For those with dual-flush toilets, use the smaller flush option for liquid waste to minimize water usage. Additionally, reducing the volume of water per flush can be achieved by placing a water-filled plastic

bottle or a brick in the toilet tank, which decreases water consumption without compromising functionality.

- **Addressing Leaks:** Addressing leaks promptly is essential, as a dripping faucet or leaking toilet can waste substantial amounts of water daily. Regular inspections and timely repairs of leaks are necessary to prevent unnecessary water loss.
- **Collecting Rainwater:** Collecting rainwater can provide a valuable resource for outdoor purposes. Installing a rain barrel allows for the collection of rainwater, which can then be used for watering plants, washing vehicles, or cleaning outdoor surfaces.
- **Watering Plants Judiciously:** Watering plants judiciously is another effective conservation strategy. It is advisable to water plants early in the morning or late in the evening to reduce evaporation. Utilizing a soaker hose or drip irrigation system ensures that water is delivered directly to plant roots, optimizing efficiency. Additionally, reusing cooking water is a simple yet beneficial practice. After boiling vegetables or pasta, allow the water to cool and use it to water plants, as it contains nutrients that are beneficial to the garden.
- **Upgrading to Water-Efficient Fixtures:** Upgrading to water-efficient fixtures can significantly contribute to water conservation efforts. Installing low-flow showerheads, water-saving faucets, and dual-flush toilets can markedly reduce water usage. Furthermore, considering the implementation of graywater recycling systems for non-potable uses can further enhance water conservation.

Enhancing Climate Resilience Through Climate Adaptation In The Garden

Creating climate-resilient and wildlife-friendly gardens is an essential step in addressing the environmental challenges posed by climate change. These gardens not only enhance the beauty and functionality of our outdoor spaces but also contribute significantly to environmental sustainability and biodiversity conservation. As we face increasing temperatures, unpredictable weather patterns, and a decline in wildlife populations, our gardens can become sanctuaries of resilience and ecological balance.

Climate-resilient gardens are designed to withstand and adapt to changing climate conditions. This involves implementing sustainable practices such as no-till gardening, choosing native and drought-resistant plants, and incorporating water-saving techniques like rainwater harvesting. These methods help to sequester carbon, reduce water usage, and maintain healthy soil, all of which are crucial for creating a garden that can thrive despite environmental stresses.

In addition to climate resilience, fostering wildlife-friendly gardens is vital for supporting biodiversity. By providing essential resources such as food, water, shelter, and safe habitats, we can attract and sustain a variety of wildlife species, from pollinators like bees and butterflies to birds and small mammals. Simple actions like planting native species, installing birdbaths and insect hotels, and avoiding chemical pesticides can transform our gardens into vibrant ecosystems that promote ecological balance and enhance our connection to nature.

Through these practices, we can create gardens that not only beautify our surroundings but also play a critical role in combating climate change and supporting wildlife. Let's explore how we can design and maintain gardens that are resilient to climate impacts and welcoming to wildlife, contributing to a sustainable and thriving environment for future generations.

Climate-resilient gardens

🌿🏡💡 Remember that a climate-resilient garden not only benefits your immediate surroundings but also contributes to global efforts in combating climate change. By nurturing your soil, supporting biodiversity, and making conscious choices, you can create a beautiful and sustainable outdoor space. 🌿🌎💡

Creating a climate-resilient garden involves thoughtful planning and sustainable practices. Here are some strategies to help you build a garden that thrives in a changing climate:

Sequester Carbon with No-Till Gardening

No-till gardening is a trend that promotes healthy soil and mitigates climate change. Avoid disturbing the soil by tilling or digging. Instead, create no-dig garden beds by mowing or cutting down existing vegetation low to the ground. This approach preserves soil structure, reduces weed seed germination, and keeps stored carbon in the ground. By maintaining the integrity of the soil, you not only support healthier plant growth but also contribute to the global effort of carbon sequestration, which helps mitigate the effects of climate change.

Choose Native and Pollinator-Friendly Plants

Replacing traditional lawns with native plants and those that attract pollinators is a key strategy for building a resilient garden. Native plants are adapted to local conditions, require less water, and support biodiversity. You'll notice an increase in bees, butterflies, and other beneficial insects that play crucial roles in pollination and pest control. This shift towards a more natural and sustainable landscape not only enhances the beauty of your garden but also fosters a healthier ecosystem. Native plants often have deeper root systems that help stabilize the soil and improve water retention.

Collect Rainwater

Installing rain barrels or cisterns to collect rainwater is an effective way to conserve resources and reduce reliance on municipal water sources. Using collected rainwater for irrigation during dry periods ensures that your plants receive the moisture they need without straining local water supplies. This practice not only supports water conservation but also helps your garden thrive during periods of drought. Rainwater is often softer and free of the salts and chemicals found in tap water, which can benefit plant health.

Reduce Plastic Waste

Opting for sustainable materials in your garden and avoiding single-use plastics is essential for minimizing environmental impact. Choose reusable or biodegradable options whenever possible. By reducing plastic waste, you contribute to a healthier environment and set a positive example for sustainable gardening practices. Consider using tools and containers made from recycled or natural materials and avoid plastic mulches in favor of organic alternatives like straw or wood chips.

Support Soil Health

Adding organic matter to the soil improves its structure and fertility, promoting robust plant growth. Using cover crops protects soil from erosion and enhances nutrient content, while composting kitchen scraps enriches the soil naturally. Healthy soil is the foundation of a resilient garden, supporting plant health and productivity over the long term. Practices such as crop rotation and avoiding synthetic fertilizers can also contribute to maintaining soil health.

Plant Trees and Shrubs for Shade and Wind Protection

Trees and shrubs provide essential shade, reduce soil evaporation, and act as windbreaks. Proper placement of these plants can create microclimates that benefit other plants, making your garden more resilient to extreme weather conditions. Additionally, trees and shrubs enhance the aesthetic appeal of your garden and provide habitat for wildlife. They can also help reduce heating and cooling costs for nearby buildings by providing natural insulation.

Diversify Your Plant Selection

A diverse garden is more resilient to pests, diseases, and extreme weather. Mixing different species and varieties creates a balanced ecosystem, reducing the risk of significant damage from any single threat. Plant diversity also ensures that your garden remains productive and beautiful throughout the year. Diverse plantings can support a wider range of beneficial insects and microorganisms, contributing to overall garden health.

Mulch Beds to Conserve Moisture

Applying organic mulch around plants helps retain soil moisture, suppress weeds, and regulate temperature. Mulching also improves soil health over time by adding organic matter as it decomposes. This simple practice can significantly enhance the resilience and sustainability of your garden. Mulches such as wood chips, straw, or compost not only protect the soil but also provide a habitat for beneficial organisms.

Choose Perennials Over Annuals

Perennial plants, which come back year after year, reduce the need for replanting and establish deeper root systems that contribute to long-term soil health. By incorporating more perennials into your garden, you create a stable and sustainable landscape that requires less maintenance and supports ongoing ecological balance. Perennials can also provide continuous cover and reduce soil erosion compared to annuals that need replanting each season.

Practice Companion Planting

Pairing compatible plants together to enhance growth and deter pests is a time-tested gardening technique. For example, planting marigolds near tomatoes can help repel nematodes, benefiting both plants. Companion

planting leverages natural relationships between plants to create a healthier and more productive garden. It can also improve pollination and yield by attracting beneficial insects.

Creating a climate-resilient garden involves integrating these sustainable practices to ensure your garden thrives in the face of changing climate conditions. By adopting no-till gardening, choosing native and pollinator-friendly plants, collecting rainwater, reducing plastic waste, supporting soil health, planting trees and shrubs, diversifying plant selection, mulching beds, choosing perennials, and practicing companion planting, you can build a garden that is not only beautiful and productive but also environmentally sustainable and resilient to climate change.

Wildlife-friendly gardens

🌿🏡💡 Create a wildlife-friendly garden to support biodiversity, promote ecological balance, and enjoy the presence of wildlife, enhancing your well-being and contributing to global conservation efforts. 🌿🌎💡

Creating a wildlife-friendly garden is a rewarding and impactful way to support biodiversity and enjoy the presence of nature right in your backyard. This process involves several thoughtful strategies to provide essential resources and habitats for various wildlife species, ultimately fostering a thriving ecosystem.

Provide Food Sources

To support a variety of pollinators, it is crucial to plant a diverse array of flowering plants that bloom at different times of the year. This ensures a continuous supply of nectar for bees, butterflies, and other beneficial insects, which are vital for pollination and the overall health of the environment. Including native shrubs and trees that produce berries and nuts can provide essential food sources for birds and small mammals throughout the year. These plants not only enhance the aesthetic appeal of your garden but also play a significant role in sustaining local wildlife populations. For example, oak trees support hundreds of species of caterpillars, which in turn feed numerous bird species, demonstrating the interconnectedness of native plant species and local wildlife.

Offer Water

Water is a vital resource for all wildlife. Installing a birdbath or a small pond can offer drinking and bathing water for birds and other creatures. It is important to ensure that the water source is safe and accessible, with shallow edges or stepping stones to accommodate smaller animals. A well-maintained water feature can become a focal point in your garden, attracting a diverse range of species, from birds and amphibians to insects. Incorporating aquatic plants can further enhance the habitat by providing shelter and breeding grounds for amphibians and insects, thus creating a balanced ecosystem. Regularly cleaning and replenishing the water is essential to prevent the spread of disease and ensure a healthy environment for the wildlife.

Create Habitats

Creating suitable habitats is essential for attracting and sustaining wildlife. Leaving some areas of your garden wild, with piles of leaves, logs, or rocks, can provide shelter and breeding sites for insects, amphibians, and small mammals. These areas mimic natural habitats and offer crucial resources that manicured gardens often lack. Additionally, installing birdhouses, bat boxes, and insect hotels can offer nesting sites for a variety of species. These structures should be placed in appropriate locations to maximize their utility and ensure the safety of the inhabitants. For example, birdhouses should be placed at a height that deters predators, and bat boxes should be positioned in sunny locations to provide the warmth bats need. Creating habitats that cater to the specific needs of different species can significantly increase the biodiversity of your garden.

Ensure Shelter and Safety

Providing safe nesting sites and cover is crucial for protecting wildlife from predators and harsh weather conditions. Planting dense hedges and thorny bushes can offer secure nesting sites for birds and small animals.

These plants not only provide protection but also serve as food sources and breeding grounds. Maintaining some areas of grass at a longer length can provide cover for ground-nesting insects and small creatures, enhancing the overall habitat quality of your garden. Additionally, creating layered vegetation, with ground cover, shrubs, and trees, can provide various levels of shelter and food, supporting a wider range of species. Ensuring that there are safe pathways and corridors for wildlife to move through your garden can help animals escape predators and find resources more easily.

Avoid Chemicals

Using organic gardening practices is fundamental to protecting the wildlife you aim to attract. Avoiding pesticides and herbicides helps maintain a healthy ecosystem where beneficial insects and other wildlife can thrive. Opt for natural pest control methods, such as encouraging predator species and using organic repellents, to keep your garden free from harmful chemicals. For instance, introducing ladybugs to control aphids or planting companion plants that deter pests can be effective strategies. Organic fertilizers, such as compost and manure, can enhance soil health without the negative impacts associated with synthetic chemicals. This approach not only benefits wildlife but also improves the overall health and resilience of your garden ecosystem.

Connect with Nature

Creating green corridors with climbing plants on fences or trellises can facilitate the safe movement of wildlife across your garden. This practice not only enhances the visual appeal of your garden but also supports the broader ecosystem by providing continuous habitat links. When planning your garden, consider the overall landscape and how your garden fits into the local environment, ensuring that it contributes positively to the surrounding ecosystem. For example, connecting your garden with nearby parks or natural areas can create larger habitats for wildlife and support greater biodiversity. Creating green roofs and walls can also provide additional habitat and connectivity in urban environments, where space for traditional gardens may be limited.

By implementing these strategies, you can create a wildlife-friendly garden that supports biodiversity, promotes ecological balance, and offers the joy of observing wildlife up close. These practices not only benefit wildlife but also enrich your gardening experience, making your garden a haven for both nature and yourself. The increased presence of birds, butterflies, and other wildlife can bring a sense of peace and connection to the natural world, enhancing your well-being and fostering a deeper appreciation for the environment. As more individuals adopt wildlife-friendly gardening practices, the cumulative impact on biodiversity and ecosystem health can be substantial, contributing to global conservation efforts.

Enhancing Climate Resilience Through Disaster Preparedness

🌿🏠💡 Take proactive steps today to enhance disaster preparedness and resilience—assemble emergency kits, develop comprehensive plans, implement structural adaptations, and invest in energy backup systems to create safer, more resilient communities ready to withstand and recover from climate change impacts. 🌿🏠💡

As climate change intensifies, the frequency and severity of natural disasters such as floods, storms, and heatwaves are increasing. Preparing for these events is critical to safeguard lives and property. Effective disaster preparedness involves assembling emergency kits, developing comprehensive emergency plans, and implementing structural adaptations to withstand extreme weather conditions.

Emergency Kits and Plans

An essential step in disaster preparedness is creating an emergency kit. This kit should include supplies that will sustain your family for at least 72 hours. Key items include non-perishable food, water (at least one gallon

per person per day), medications, a first aid kit, flashlights, batteries, a manual can opener, and essential documents (such as insurance policies, identification, and bank records). Additionally, personal hygiene items, blankets, and a multi-tool can be incredibly useful. It's advisable to periodically review and update the kit to ensure all items are in good condition and that the contents meet your family's current needs.

Developing a comprehensive emergency plan is equally important. This plan should outline evacuation routes, communication strategies, and procedures for different types of emergencies. Ensure that all family members are aware of the plan and practice it regularly. Designate a meeting place outside of your immediate area in case local evacuation is necessary and identify an out-of-town contact who can act as a communication liaison. Including considerations for pets and specific needs of family members, such as medical conditions or disabilities, is crucial for a complete plan.

Structural Adaptations for Extreme Weather

Structural adaptations can significantly enhance the resilience of homes to extreme weather. For instance, installing storm shutters or impact-resistant windows can protect against high winds and flying debris during hurricanes. Elevating the home or retrofitting it with flood barriers can reduce the risk of flood damage. In regions prone to wildfires, using fire-resistant building materials and creating defensible space around the property by clearing flammable vegetation can be lifesaving.

Another important consideration is the roof. Ensuring that your roof is made of durable materials that can withstand high winds, and securing it with hurricane straps, can prevent extensive damage during storms. Proper insulation and ventilation also help maintain indoor temperatures during heatwaves and cold spells, making homes more comfortable and energy-efficient.

Energy Backup Systems

In the face of extreme weather events, energy backup systems are vital for maintaining power and ensuring the functionality of essential household systems. Various backup power options, such as solar panels with battery storage, generators, and wind turbines, offer reliable energy solutions during power outages.

Discuss Backup Power Options

Solar panels paired with battery storage systems provide a sustainable and efficient backup power option. These systems store excess energy generated during sunny periods, which can then be used during power outages or when solar generation is low. This setup not only ensures a continuous power supply but also reduces dependency on the grid and lowers electricity bills.

Traditional generators, powered by gasoline, diesel, or propane, are another option. They can provide immediate power during outages but require regular maintenance and fuel storage. In contrast, wind turbines can be an effective alternative in areas with consistent wind patterns. These systems convert wind energy into electricity, offering a renewable source of power during emergencies.

Role During Extreme Weather Events

Backup power systems play a crucial role during extreme weather events by maintaining critical household functions. They keep essential appliances running, such as refrigerators, medical equipment, and communication devices, ensuring safety and comfort during emergencies. For example, during a severe winter storm, a backup power system can prevent pipes from freezing by powering heating systems, and during a heatwave, it can keep cooling systems operational to prevent heat-related illnesses. Moreover, backup power systems contribute to community resilience. Homes equipped with these systems are less likely to experience prolonged power outages, reducing the strain on emergency services and utility repair crews. In the aftermath of a disaster, having a reliable power source can expedite recovery efforts and support overall community stability.

Resilience Planning and Emergency Preparedness

Creating a resilient home and community requires proactive measures and detailed planning. Enhancing home resilience to climate change impacts and developing a family emergency plan are critical components of preparedness. Additionally, engaging with community resilience initiatives and utilizing disaster preparedness resources can strengthen collective readiness.

Tips for Making Homes More Resilient to Climate Change Impacts

To make homes more resilient to climate change impacts, consider implementing several practical measures. For flood-prone areas, elevate utilities such as water heaters and electrical panels above potential flood levels. Installing sump pumps with battery backup can help manage water intrusion. In storm-prone regions, securing outdoor furniture and installing sturdy garage doors can prevent damage from high winds. During heatwaves, improving home insulation and installing energy-efficient windows can maintain cooler indoor temperatures. Planting trees strategically around the home can provide shade and reduce cooling costs. In areas susceptible to wildfires, creating a defensible space by removing flammable materials and maintaining a fire-resistant landscape can protect the property.

Creating a Family Emergency Plan

A comprehensive family emergency plan is vital for effective disaster response. Start by identifying the types of disasters that are most likely to occur in your area and tailor your plan accordingly. Establish clear communication strategies, including a designated out-of-town contact who can facilitate communication if local networks are down.

Outline evacuation routes and identify multiple meeting places: one near your home and another outside your neighborhood. Ensure all family members, including children, understand the plan and practice it regularly. Include provisions for pets, special needs of family members, and ensure everyone knows how to shut off utilities if necessary.

Community Resilience Initiatives and Disaster Preparedness Resources

Community resilience initiatives play a pivotal role in disaster preparedness. These programs often provide valuable resources and support for individual and collective readiness. Engage with local government and community organizations to stay informed about available resources, such as sandbags for flood prevention, emergency shelters, and evacuation assistance.

Participate in community training programs, such as Community Emergency Response Teams (CERT), which provide education and hands-on training in disaster response. These programs enhance individual skills and foster a sense of collective responsibility, ensuring a coordinated and effective response during emergencies.

B. Adopting Sustainable Consumption Practices

Nurturing a Greener Tomorrow through Sustainable Consumption

In our rapidly changing world, where climate resilience is paramount, every individual's choices matter. As European citizens, we hold the power to shape our collective destiny by adopting sustainable consumption practices. These practices extend beyond mere lifestyle adjustments; they are our contribution to safeguarding the planet for future generations.

Why Sustainable Consumption Matters: The Numbers Speak

The European Commission's Joint Research Centre (JRC) has meticulously measured 16 different environmental impacts of EU consumption. Shockingly, for five critical areas—climate change, particulate matter, resource use, freshwater eutrophication, and human toxicity-cancer—the average EU citizen's consumption exceeds planetary boundaries. Our choices ripple across the globe, affecting ecosystems, biodiversity, and the delicate balance of nature.

Three significant contributors to our environmental footprint are food, housing, and mobility. Our plates bear the heaviest load, with the environmental footprint associated with food choices being substantial. Housing, particularly the energy used for heating, significantly impacts the planet. Our reliance on private cars and the kilometers we travel leave an indelible mark on the environment. Between 2010 and 2015, the environmental footprint in these areas increased by 6%, driven by a 10% surge in kilometers travelled and a 29% increase in the number of appliances owned. Households alone account for 19% of the EU's greenhouse gas emissions. We cannot afford complacency; our actions today shape the world we inherit tomorrow.

Empowering Change: A Call to Action

As we embark on this journey toward sustainable consumption, let us recognize that our choices are not isolated. They resonate across borders, ecosystems, and generations. By embracing mindful food choices, rethinking mobility, and minimizing waste, we become stewards of a greener, more resilient Earth. Together, as European citizens, we can turn the tide—one conscious decision at a time. Let this chapter guide us toward a future where sustainability is not just a buzzword but a way of life.

Sustainable Food Consumption

🌿🍎💡 Embrace sustainable eating habits – choose organic and local foods, buy in bulk, plan meals to reduce food waste, and eat low on the food chain. This way you can reduce your carbon footprint, support local food systems, and contribute to a healthier planet for future generations. 🌿🍎💡

Reducing our carbon footprint is essential for a sustainable future. By adopting simple and effective lifestyle changes, citizens can significantly minimize their impact on the environment. Here are several strategies to help achieve this goal:

Eat Low on the Food Chain

One of the most impactful ways to reduce your carbon footprint is by adopting a diet that emphasizes fruits, vegetables, grains, and beans. Livestock farming, particularly for meat and dairy products, is a significant contributor to greenhouse gas emissions due to methane production and deforestation for grazing land. By

reducing your consumption of meat and dairy, you can lower your carbon footprint substantially. Studies have shown that by cutting meat and dairy from your diet, you can reduce your carbon footprint by up to 4 kilogrammes per day. This dietary shift not only benefits the environment but also supports personal health by encouraging the intake of nutrient-rich plant-based foods.

Choose Organic and Local Foods

The transportation of food over long distances consumes a considerable amount of fossil fuels, contributing to greenhouse gas emissions. By choosing locally grown and seasonal produce, you can significantly reduce the carbon emissions associated with food transport. Organic farming practices also play a crucial role in sustainability as they typically use fewer synthetic fertilizers and pesticides, leading to healthier soils and reduced environmental impact. Supporting local farmers' markets and community-supported agriculture (CSA) programs can help you access fresh, organic produce while supporting local economies and reducing your carbon footprint.

Buy Food in Bulk

Purchasing food in bulk is another effective way to reduce your environmental impact. Using your own reusable containers when buying bulk foodstuffs minimizes packaging waste and decreases the reliance on single-use plastics, which are major contributors to pollution and environmental degradation. Bulk buying not only helps in reducing waste but also often proves to be more economical. Many stores now offer bulk sections where you can purchase grains, nuts, dried fruits, and other staples without the excessive packaging that typically accompanies smaller quantities. This practice supports a more sustainable lifestyle by cutting down on plastic waste and reducing the overall carbon footprint of your grocery shopping.

Plan Meals and Reduce Food Waste

Meal planning is a practical approach to minimizing food waste, which is a significant issue in many households. By planning your meals ahead of time, you can buy only what you need and avoid over-purchasing. This not only helps reduce waste but also saves money. Freezing leftovers and using them for future meals is another way to ensure that food does not go to waste. Composting food scraps is an eco-friendly method to recycle nutrients back into the soil, reducing the amount of organic waste that ends up in landfills where it can produce methane, a potent greenhouse gas. Composting also enriches garden soil, promoting healthier plant growth and reducing the need for chemical fertilizers.

Incorporating these practices into your daily routine can lead to significant reductions in your carbon footprint. By eating low on the food chain, choosing organic and local foods, buying in bulk, and planning meals to reduce food waste, you contribute to a more sustainable and environmentally friendly lifestyle. Each small change, when adopted collectively by many, can lead to substantial positive impacts on the environment, helping to combat climate change and promote a healthier planet for future generations. Adopting these strategies not only benefits the environment but also enhances personal well-being and fosters a sense of community through supporting local food systems.

Sustinable Mobility

🌿 🚲 🌎 Transition to greener transportation alternatives to create a more sustainable future for generations to come. 🌿 🚲 🌎

In an era characterized by escalating environmental concerns and climate change, the need for sustainable and eco-friendly transportation has never been more urgent.

The adoption of green transportation modes significantly lowers carbon emissions and reduces air pollution. Electric vehicles and other sustainable options release fewer pollutants, helping mitigate the detrimental effects of climate change and improving air quality in urban areas. Reduced emissions lead to lower levels of smog

and particulate matter, which are harmful to human health. By transitioning to greener transportation, cities can create healthier environments for their residents. For instance, the widespread adoption of electric buses in cities like Shenzhen, China, has resulted in substantial reductions in urban air pollution.

Green transportation modes are generally more energy-efficient compared to their conventional counterparts. Electric vehicles, for example, convert a higher percentage of stored energy into actual propulsion, leading to reduced energy consumption and fossil fuel dependency. This increased efficiency translates to lower overall energy use and a smaller environmental footprint. Additionally, the integration of renewable energy sources into the electricity grid can further enhance the sustainability of electric transportation. Innovations in energy storage and smart grid technologies are also contributing to the more efficient use of energy in transportation.

Let's explore some modes of eco-friendly transportation and the extensive benefits they offer:

Electric Vehicles (EVs)

Electric vehicles (EVs) have gained remarkable popularity as a viable alternative to traditional gasoline-powered cars. They run entirely on electricity, producing zero tailpipe emissions and significantly reducing air pollution. The continued advancements in battery technology are making EVs more affordable and capable of traveling longer distances on a single charge. For instance, modern EVs can now travel over 300 kilometers on a full charge, addressing the range anxiety that has historically deterred some potential users. These improvements make EVs a promising choice for eco-conscious commuters. Moreover, the integration of renewable energy sources, such as solar and wind power, into the electricity grid further reduces the overall carbon footprint of EVs. Additionally, government incentives and policies aimed at promoting electric vehicles, such as tax credits and subsidies, are accelerating their adoption.

Public Transportation

Public transportation systems, including buses, trains, and subways, are essential components of sustainable mobility. By encouraging the use of shared transport, we can minimize the number of individual vehicles on the road, thus reducing congestion and emissions. Well-planned public transit networks provide an efficient, cost-effective, and eco-friendly means of commuting. Cities that have invested in extensive public transport systems, such as Tokyo and London, have seen significant reductions in traffic congestion and improvements in air quality. The electrification of buses and the implementation of hybrid and electric trains further enhance the environmental benefits of public transportation. These initiatives not only reduce greenhouse gas emissions but also lower noise pollution, creating more livable urban environments.

Cycling and Walking

Active modes of transportation like cycling and walking are not only beneficial for personal health but also for the environment. These modes produce zero emissions and require minimal infrastructure, contributing to reduced congestion and improved air quality. Cities that invest in well-designed bike lanes and pedestrian pathways promote a healthier lifestyle while decreasing reliance on fossil fuel-based transportation. For example, Copenhagen and Amsterdam have developed extensive cycling infrastructure, leading to high rates of bicycle use and significant reductions in urban emissions. Initiatives such as bike-sharing programs and pedestrian-friendly urban planning can further encourage cycling and walking. By prioritizing active transportation, urban areas can reduce traffic congestion, decrease pollution levels, and enhance public health.

Carpooling and Ride-Sharing

Carpooling and ride-sharing initiatives encourage the sharing of rides among multiple passengers traveling in the same direction. By reducing the number of vehicles on the road, these practices decrease greenhouse gas emissions, ease traffic congestion, and save participants money on fuel and maintenance costs. Ride-sharing platforms like Uber and Lyft, along with carpooling apps, facilitate the organization of shared rides, making it easier for individuals to participate in these eco-friendly transportation options. These initiatives not only benefit the environment but also foster a sense of community among users. Furthermore, companies can incentivize carpooling among employees through programs that offer preferential parking or reduced travel costs.

Consumption and waste reduction

🌿🛒💡 Embrace sustainable shopping: choose eco-friendly products, support ethical brands, and adopt mindful practices to reduce your environmental footprint and promote a market that values sustainability and ethics. 🌿🛒💡

Sustainable shopping is a critical component of reducing our environmental footprint. By making conscious choices, consumers can significantly contribute to environmental conservation and support ethical practices within the retail industry. Here are several strategies to help promote sustainability through shopping habits:

Choosing Eco-Friendly Products

Opting for eco-friendly products is an essential step towards sustainable shopping. These products are typically made from renewable resources, have minimal environmental impact during their lifecycle, and are often biodegradable or recyclable. Look for certifications such as Fair Trade, USDA Organic, and Energy Star, which indicate that products meet specific environmental and ethical standards. Selecting items with minimal packaging or those packaged in recyclable materials further reduces waste and promotes sustainability.

Supporting Ethical Brands and Businesses

Supporting brands and businesses that prioritize sustainability and ethical practices can drive positive change in the industry. Ethical brands often focus on fair labor practices, environmental stewardship, and community support. Consumers can research companies' sustainability reports or certifications like B Corp, which assesses the overall social and environmental performance of businesses. By directing spending towards such brands, consumers can help foster a market that values ethical and sustainable production.

Avoiding Fast Fashion

Fast fashion is characterized by cheap, trendy clothing that quickly goes out of style, leading to high turnover and significant waste. These discarded items contribute to landfills where they decompose and release methane, a potent greenhouse gas. To reduce fashion-related carbon footprints, consumers should opt for vintage or recycled clothing. Thrift stores, consignment shops, and online platforms for second-hand clothing are excellent alternatives that extend the life of garments and reduce the demand for new, resource-intensive clothing production.

Washing Clothing in Cold Water

Washing clothes in cold water is an effective way to save energy compared to hot water washing. Heating water for laundry accounts for a significant portion of household energy use. Modern detergents are designed to work efficiently in cold water, making it possible to maintain cleanliness without the additional energy consumption. This simple change can reduce household energy bills and decrease the overall environmental impact of laundry practices.

Additional Strategies for Sustainable Shopping

Reduce Single-Use Plastics

Reducing reliance on single-use plastics is crucial for sustainable shopping. Consumers should bring their own reusable bags, containers, and water bottles when shopping. Many stores now offer incentives for customers who use their own bags, further encouraging this practice. Additionally, choosing products that are not packaged in plastic, or opting for items packaged in recyclable or biodegradable materials, can significantly reduce plastic waste.

Buy Locally Produced Goods

Purchasing locally produced goods supports local economies and reduces the carbon footprint associated with transportation. Local products often require less packaging and shorter supply chains, contributing to overall sustainability. Farmers' markets, local co-ops, and community-supported agriculture (CSA) programs are excellent sources for fresh, local produce and goods.

Invest in Quality Over Quantity

Investing in high-quality products that are durable and long-lasting reduces the need for frequent replacements, thus minimizing waste. Whether it's clothing, electronics, or household items, choosing well-made products can save money in the long run and lessen the environmental impact. Quality items often come with better warranties and repair options, extending their usability even further.

Utilize Digital Receipts

Opting for digital receipts instead of printed ones helps reduce paper waste. Many retailers offer the option to email receipts, which not only cuts down on paper use but also makes it easier for consumers to keep track of their purchases without clutter. This small change can contribute to significant reductions in paper waste over time.

Participate in Recycling Programs

Participating in recycling programs ensures that materials like paper, plastic, glass, and metals are reused instead of ending up in landfills. Many retailers offer recycling programs for specific products, such as electronics or batteries. Consumers can also take advantage of municipal recycling services to responsibly dispose of recyclable materials.

C. Building a Resilient Community

Community Resilience

Creating resilient and sustainable communities is essential in today's rapidly changing world. By fostering strong social connections, promoting community engagement, and developing green spaces, we can build environments that are adaptable, supportive, and environmentally conscious.

Social connections form the backbone of resilient communities. Establishing robust neighborhood networks and support systems provides mutual aid, enhances collective problem-solving, and nurtures a sense of belonging. Through regular interactions and collaborative efforts, residents can build trust and solidarity, ensuring that everyone is prepared and supported during times of crisis.

Active community engagement plays a crucial role in sustainability efforts. Involvement in local sustainability projects and volunteering activities not only addresses environmental issues but also strengthens the social fabric. These initiatives encourage residents to work together towards common goals, promoting a sense of responsibility and collective action.

Promoting green spaces within urban environments is another critical component of building resilient communities. Green spaces enhance environmental quality, support biodiversity, and improve the health and well-being of residents. Community gardens, urban greening projects, and the strategic planting of native species create sustainable, healthy, and vibrant living spaces, contributing to a balanced and ecologically sound urban environment.

Social connections

🌿 🏠 💡 Strengthen social connections by building neighborhood networks, sharing resources, and fostering education to create resilient, supportive, and adaptable communities that thrive in the face of adversity. 🌿 🏠 💡

Creating a resilient community relies heavily on the strength and interconnectedness of social connections. These relationships provide the foundation for mutual support, collective problem-solving, and a shared sense of belonging. Strengthening social connections through neighborhood networks and support systems, as well as through education and resource sharing, is essential for building a robust and adaptive community.

Neighborhood Networks and Support Systems

Establishing and nurturing neighborhood networks is a cornerstone of community resilience. These networks foster a sense of camaraderie and trust among residents, which is crucial during times of crisis. Regular neighborhood gatherings, such as block parties, potlucks, and local events, help build and maintain these connections. These gatherings provide opportunities for residents to get to know one another, share experiences, and collaborate on community projects.

Support systems within neighborhoods can take various forms, including neighborhood watch programs, volunteer groups, and local assistance networks. Such systems ensure that vulnerable members of the community, such as the elderly or those with disabilities, have access to necessary resources and support. For example, during emergencies, a well-organized support network can facilitate the distribution of food, water, and medical supplies, ensuring that everyone receives the help they need.

Furthermore, technology can play a vital role in enhancing neighborhood networks. Online platforms and social media groups enable residents to communicate quickly and efficiently, share information, and coordinate efforts. These digital tools can be particularly useful for organizing community initiatives, alerting members to potential hazards, and mobilizing volunteers.

Education and Sharing Resources

Education and the sharing of resources are integral to fostering a resilient community. By educating residents about local risks, emergency preparedness, and sustainable practices, communities can better anticipate and respond to challenges. Workshops, seminars, and training sessions on topics such as disaster preparedness, first aid, and sustainable living practices can empower residents with the knowledge and skills needed to handle emergencies and contribute to the community's well-being.

Resource sharing is another critical aspect of building social connections. Community resource centers or libraries can provide access to tools, equipment, and educational materials that might otherwise be inaccessible to some residents. These centers can also serve as hubs for information dissemination and skill-sharing, where individuals can teach and learn from each other.

Additionally, initiatives like community gardens and tool-sharing programs encourage collaboration and resource optimization. Community gardens not only provide fresh produce but also serve as gathering spots where residents can work together, share gardening tips, and strengthen their bonds. Tool-sharing programs reduce the need for each household to own rarely-used tools, promoting a culture of sharing and cooperation.

Collaborative consumption, a concept where community members share access to goods and services, further strengthens social ties and resource efficiency. Carpooling, shared childcare, and cooperative buying groups are examples of how communities can pool resources to achieve common goals. These practices not only foster a sense of unity but also reduce individual costs and environmental impact.

Community engagement

🌿 🏡 💡 Foster community engagement by participating in local sustainability initiatives, volunteering, and advocacy to build a resilient, inclusive, and sustainable community. 🌿 🏡 💡

Active community engagement is vital for fostering a resilient and sustainable community. By participating in local sustainability initiatives and engaging in volunteering and advocacy, residents can contribute to the well-being of their community, promote environmental stewardship, and build a sense of collective responsibility and pride.

Participating in Local Sustainability Initiatives

Engaging in local sustainability initiatives is an effective way for community members to work together towards common environmental goals. These initiatives often focus on issues such as reducing waste, conserving energy, promoting renewable energy sources, and protecting natural habitats. Community gardens, recycling programs, and local clean-up drives are examples of sustainability initiatives that can have a significant positive impact on the environment.

Participation in these initiatives not only helps to achieve specific sustainability goals but also strengthens the social fabric of the community. Working alongside neighbors on common projects fosters relationships, builds trust, and creates a sense of belonging. Additionally, these activities provide educational opportunities, raising awareness about environmental issues and teaching practical skills that residents can apply in their daily lives.

Local governments and organizations play a crucial role in supporting and promoting sustainability initiatives. They can provide resources, funding, and expertise to help communities implement effective programs. Furthermore, public events such as workshops, fairs, and exhibitions can inspire and educate residents about sustainable practices and encourage broader community participation.

Volunteering and Advocacy

Volunteering is a powerful way to contribute to the resilience and sustainability of a community. By dedicating time and effort to local causes, volunteers can support essential services, enhance community resources, and address pressing social and environmental issues. Opportunities for volunteering are diverse and can include activities such as tutoring, mentoring, providing support at food banks, participating in environmental conservation projects, and assisting in disaster preparedness and response efforts.

Advocacy is another critical aspect of community engagement. By advocating for policies and practices that promote sustainability and resilience, community members can influence decision-making processes and drive systemic change. Advocacy can take many forms, from participating in public meetings and engaging with local officials to organizing campaigns and using social media to raise awareness about important issues.

Effective advocacy requires collaboration and communication. Forming or joining local advocacy groups allows individuals to pool their knowledge, resources, and influence, making their efforts more impactful. These groups can work on a variety of issues, such as promoting renewable energy, improving public transportation, and protecting green spaces.

Engaging in both volunteering and advocacy empowers residents to take an active role in shaping the future of their community. It fosters a sense of agency and responsibility, encouraging individuals to contribute to the common good and work towards long-term sustainability.

Community Gardens and Urban Greening

Community gardens are valuable assets for urban areas, offering a myriad of benefits to both residents and the environment. These shared spaces provide opportunities for people to grow their own food, which promotes food security and encourages healthy eating habits. Additionally, community gardens serve as social hubs where residents can connect, share knowledge, and build a sense of community.

Urban greening, which includes the establishment of parks, green roofs, and green walls, contributes significantly to the improvement of air quality and reduction of urban heat islands. Green spaces act as natural air filters, absorbing pollutants and producing oxygen, thus enhancing the overall air quality in cities. Furthermore, the presence of greenery in urban settings can reduce temperatures, providing a cooler and more comfortable environment during hot weather.

The benefits of urban greening extend beyond environmental impacts. Green spaces offer recreational opportunities, promoting physical activity and mental well-being. Studies have shown that access to green areas can reduce stress, improve mood, and enhance overall quality of life. For children, these spaces provide safe areas to play and explore, contributing to their physical and cognitive development.

For more information and good practices related to cclimate resilience, consult the following websites

	www.interreg-central.eu/projects/mission-ce-climate/ www.climatehub.si

MISSION CE CLIMATE project

Climate Resilient Communities of Central Europe

Resilience to climate change can only be achieved when you look at all parts of the puzzle. Cross-sectoral approaches are needed but silo-thinking is still hard to overcome in central Europe. The MISSION CE CLIMATE project helps regions to better coordinate their responses to climate change. The partners activate citizens in pilot regions to contribute to newly introduced community climate missions and develop a climate resilience strategy 2030 including locally adapted action plans.

Central Europe faces many climate change challenges like the rest of the world. The main aim of the MISSION CE CLIMATE project is to overcome the disjointed sectoral responses to climate change by introducing a coordinated, cross-sectoral approach that puts local/regional authorities at the centre of the governance and management of the climate resilience process. The overall objective is to support communities in Central Europe to become resilient to climate change and to enable them to respond in a coordinated way to the impacts caused by climate change. The project will build sustainable systems (community climate missions) and community capacities (integrated strategy, local action plans, and solutions).

The project attempts to implement a concept conceived by the European Commission in the context of the “Climate Resilient Europe Mission". The project's intended outcomes are:

1. Establishment of climate resilience systems in partner communities (Community Climate Missions) supported by a joint 2030 Climate Resilience Strategy (definition of actions, business models, financing mechanisms) and locally tailored action plans (project portfolio approach);

2. Enhancing community capacity to adapt to climate change with new skills and tools;

3. Activated citizens contributing to community climate resilience through increased awareness and capacity (tools, etc.);

4. Solutions developed through pilot projects that respond to community adaptation challenges

For more information and advice on climate adaptation in your area, consult your local climate mission:

Climate mission Brac

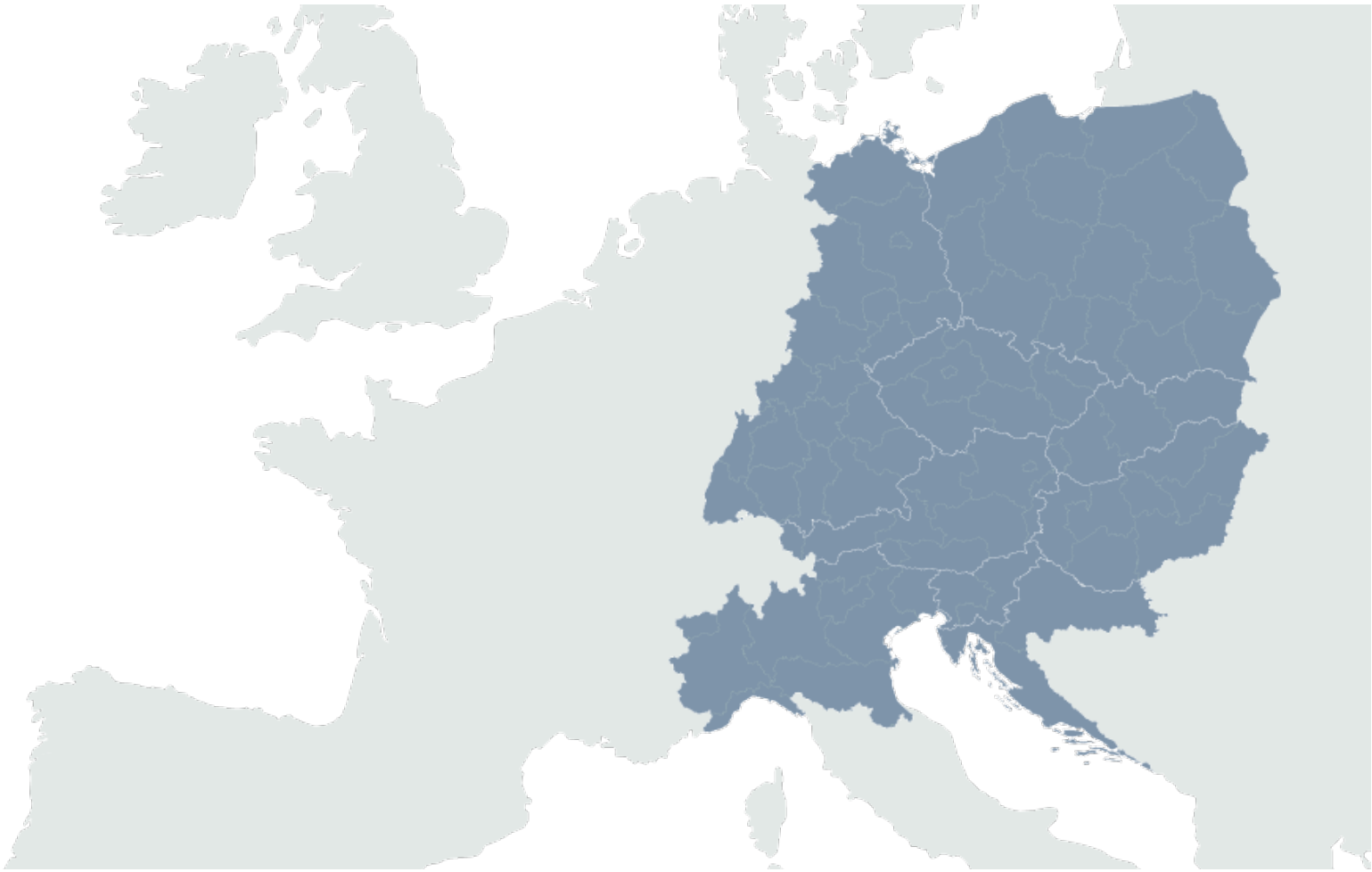
Climate mission Dornbirn

Climate mission Kosiče

Climate mission Maribor

Climate mission Lignano

Climate mission Pforzheim



D.3.4.1 Design of a digital solution for monitoring of climate change in communities

Interreg CENTRAL EUROPE

Co-funded by the European Union

MISSION CE CLIMATE

Design of a digital solution for monitoring of climate change in communities

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A. INTRODUCTION & SUMMARY

Context

With climate change posing significant challenges to communities worldwide, the current trends in climate change research extend the development of green solutions to the promotion, design, and uptake of resilient measures. For communities in Central Europe extreme weather events have become commonplace, especially flooding and heat waves. The accelerating impacts of climate change require communities to enhance their resilience through timely access to reliable information and adaptive solutions. This report presents the design of a digital solution for monitoring climate change in communities, with a focus on a modular dashboard that integrates diverse data sources and addresses the needs of both citizens and experts.

Designing resilience measures for above mentioned events requires effective data-driven decision-making to enable rapid response and targeted impact. This document addresses this need by presenting a framework for designing and integrating data-driven solutions that enable resilient communities to climate change in the region. Building on the Quadruple Helix and Co-Creation approaches, a methodology is outlined for developing and evaluating dashboards that address key stakeholder needs, particularly those of municipalities and their service providers. By reviewing existing work and identifying key criteria for dashboard development and integration (UX/UI, data quality, AI/ML adoption, business models), this paper provides a structured approach to assessing and tailoring dashboards for specific community contexts. The findings highlight best practices for selected municipalities in Central Europe, demonstrating the potential of our framework to enhance resilience to climate change through effective data-driven decision making.

Summary & Objective

The objective of this deliverable is to develop a concept of a digital solution rather than the implementation of the tool itself. The proposed concept leverages Earth Observation data (e.g., Copernicus), local sensor networks, and citizen science contributions—collected via IoT infrastructures such as LoRaWAN—to provide accurate, localised, and real-time climate indicators. A dual-dashboard approach ensures that citizens receive accessible and engaging tools for awareness-raising and informed decision-making, while experts gain advanced features for natural hazard management, scenario analysis, and climate risk assessment.
The design emphasises participatory approaches, aligning with community-specific user needs through a participation matrix and defined use cases. Its modular architecture supports scalability, adaptability to different contexts, and interoperability with existing climate data systems.

The technical implementation discusses data integration strategies, interface design principles (UI/UX considerations), and system performance requirements to ensure usability and sustainability. Practical examples and good practices are highlighted to demonstrate potential benefits, while a promotion and dissemination strategy is outlined

to foster community engagement and long-term adoption.A methodology for best practices of digital solutions within the Mission CE Climate's context, including the project's case studies of digital solutions and assessment templates concludes this report.

This deliverable provides an in-depth exploration of the diverse requirements involved in developing such solutions. It begins by outlining the purpose and context, emphasizing the pressing climate challenges facing Central Europe, the relevance of quadruple and quintuple helix frameworks, the importance of citizen involvement, and the landscape of existing climate-information services. It then addresses requirements derived from regional climate models, including technical aspects such as the role of UI/UX in creating dashboards that are both practical and engaging. Building on this foundation, the document introduced several design approaches, focusing on modular dashboard development, overarching design objectives, a participation matrix connecting data granularity to levels of citizen engagement, and a technical overview of potential enabling technologies.

The user-needs analysis identified key stakeholder and user groups, highlighted climate indicators essential for resilience, and summarised insights from the consortium survey. The study also reviewed selected publicly accessible EU data sources and compiled good practices contributed by consortium partners. Taken together, these findings show that creating effective modular dashboards demands not only technological innovation but also cross-sector collaboration and ongoing community participation to genuinely advance climate-resilient futures.

Approach & Methodoloy

The document adopts a design- and user-centred methodology that combines conceptual framework development, requirements analysis, and modular technical design to create digital dashboards for climate-resilient communities. It starts by framing the problem in terms of Central Europe's climate risks and then positions the work within quadruple and quintuple helix approaches, emphasising co-creation with citizens, public authorities, academia, and industry. On this basis, it defines key questions, reviews existing climate information services and regional climate model requirements, and derives functional, data, and UI/UX requirements for dashboards. A modular architecture is then proposed, including a participation matrix that links data granularity and functionality to different user groups and engagement levels, as well as an outline of data integration and processing pipelines combining Earth observation data, local sensors, and citizen science. Exemplary technological tools are presented and compared.

Building on these conceptual and technical foundations, the methodology uses a user needs analysis and real-world examples to iteratively refine and validate the approach. Stakeholder and target groups are identified, relevant climate indicators and additional information needs are specified, and use cases are collected from project partners to capture practical requirements and constraints. The methodology is operationalised through the collection of best practice templates applied to three municipal examples (Pforzheim, Košice, Dornbirn), where each case documents the local context, digital solution, technology stack, implementation details, impacts, and use cases. Insights from

these cases are then synthesised into design principles and assessment criteria that can be reused to replicate modular climate dashboards for other communities.

Outline

Overall, the document explains the need for digital, data-driven tools to strengthen community resilience against climate-related hazards such as floods and heatwaves in Central Europe. It presents the deliverable's objective as the design of a concept (as opposed to a technical description of a full implementation) for a modular dashboard that integrates Earth observation data, local sensors, and citizen science, targeting both citizens and experts through dashboard approaches.

In total, this document consists of seven parts; part A consists of an introduction, part B sets the context towards climate resilience, part C focuses on dashboard design, and part D looks at existing tools and initiatives of digital solutions. Parts E, F, and G describe good practices.

In the section on the contribution of digital solutions and the dashboard design (part B, page 9), the document outlines the overall purpose and context, including the climate challenges, the relevance of quadruple and quintuple helix frameworks, and the role of citizen participation. It then sets out requirements derived from regional climate models, key questions to be addressed, and the landscape of existing climate information services, followed by a modular design approach with design goals, a participation matrix, and a technical overview of data integration and processing architectures (chapter 2, page 23).

In the user-needs part (chapter 3, page 31), the document describes how to identify stakeholder and target groups, defines climate indicators and complementary climate information needed for dashboards, and summarises user needs and use cases gathered from the project consortium (based on survery across project partners), extending them with relevant approaches towards awareness-raising for citizens. In the section on existing tools and initiatives (chapter 4, page 42), it reviews relevant digital tools and supporting initiatives, highlighting resources such as Copernicus and other Earth observation data services, as well as enabling technologies like FIWARE.

Afterwards, the document describes three good practices: Pforzheim, Košice, and Dornbirn.

In the Pforzheim good practice chapters (part E, page 48), the document provides general information about the city's context, describes the local digital solution and target groups, and outlines expected impacts, technical implementation, and an implementation overview illustrated with screenshots. It then details a broad set of concrete use cases, ranging from school air monitoring and citizen-led soil and flood monitoring to urban heat mapping, smart logistics, AI-based analysis, infrastructure management, and smart building energy management.

In the Košice good practice chapters (part F, page 74), the document likewise presents general information, describes the digital solution, its target groups, and patterns of stakeholder collaboration, and assesses qualitative and quantitative impacts. It also

specifies technical implementation details including data sources and data types, provides an implementation overview with screenshots, and elaborates use cases such as educational dashboards, community engagement via linked apps, and strategic use by school management and municipal governance through open data portals.

In the Dornbirn good practice chapters (part G, page 86), the document offers general information and a description of the digital solution, including the technology stack, monitored climate indicators, geographical coverage, target groups, and expected impacts. It further outlines implementation aspects, presents illustrative screenshots, and lists use cases that demonstrate how modular climate dashboards support local climate monitoring and decision-making.

In the concluding part, the document ends with references and an appendix containing a best-practice template for documenting and assessing digital solutions within the project's context.

B. THE CONTRIBUTION OF DIGITAL SOLUTIONS IN ENHANCING CLIMATE RESILIENCE IN COMMUNITIES

As the world struggles with the escalating impacts of climate change, the need for robust climate resilience strategies has become increasingly evident. Central Europe, with its unique blend of developed urban centres, rich agricultural lands, and diverse ecosystems, is particularly vulnerable to the adverse effects of climate change. This region faces numerous challenges, including more frequent and severe weather events, changing precipitation patterns, sea level rise, and rising temperatures. These changes threaten not only the environment but also the socio-economic stability of Central European communities. The economic costs of these impacts are substantial: according to a study by the European Environment Agency, between 1980 and 2022, weather- and climate-related extremes caused economic losses of assets estimated at EUR 650 billion in the EU Member States (European Environment Agency, 2023). Without adequate resilience measures, these costs are expected to rise significantly, placing further strain on national and local economies and potentially exacerbating social inequalities. Together with these impacts, climate change threatens Central Europe's diverse ecosystems, disrupting species distribution and increasing vulnerability to invasive species; the degradation of wetlands and forests diminishes natural flood buffering and biodiversity, increasing the risk of flooding in downstream communities. The malfunction of these ecosystems not only diminishes their ability to provide critical services but also undermines the cultural and recreational value they offer to local communities.

Given the diverse and interconnected impacts of climate change on Central Europe, the development and implementation of comprehensive climate resilience strategies are essential. These strategies must be multifaceted, encompassing a range of measures aimed at reducing vulnerability, enhancing adaptive capacity, and building resilience across different sectors and governance levels. One key component of such strategies is the integration of climate considerations into urban planning and development (designing and retrofitting infrastructure to withstand extreme weather events, implementing Nature-based Solutions such as green roofs and permeable pavements to manage stormwater, and enhancing green spaces to mitigate urban heat islands and provide cooling benefits). In the agricultural sector, resilience strategies may include adopting climate-smart agricultural practices (i.e. crop diversification, conservation tillage, and improved irrigation techniques). Furthermore, protecting and restoring natural ecosystems is a crucial aspect of climate resilience. This includes measures to conserve biodiversity, restore degraded habitats, and enhance the connectivity of natural landscapes to facilitate species migration and adaptation: reforestation and afforestation initiatives can sequester carbon, improve soil and water quality, and provide critical habitat for wildlife, contributing to both climate mitigation and adaptation goals.

Effective climate resilience strategies also require robust policy frameworks and active community engagement. Governments at all levels must prioritise climate resilience in their policy agendas, allocating resources, and providing incentives for resilience-building initiatives. This includes developing and enforcing regulations that promote sustainable land use, reduce greenhouse gas emissions, and enhance disaster preparedness and response capabilities. Community involvement is equally important. Building climate

resilience is not just the responsibility of governments and experts; it requires the active participation of local communities, businesses, and civil society organizations. Public awareness campaigns, educational programs, and participatory planning processes can empower communities to understand their vulnerabilities, identify resilience-building opportunities, and take proactive measures to protect themselves and their livelihoods.

Therefore, developing and implementing effective climate resilience strategies is imperative to safeguard these communities and ensure their sustainable development. The path to resilience requires collaborative efforts, innovative solutions, and a long-term commitment to safeguarding the environment and the well-being of present and future generations. Digital solutions, especially (modular) dashboards, can help in implementing these strategies.

Digital solutions play a role in enhancing climate resilience by providing communities with the tools to better anticipate, monitor, and respond to climate-related risks. Advanced data analytics, satellite monitoring, and climate modelling enable more accurate forecasting of extreme weather events, allowing local authorities and residents to take timely preventive actions. Early warning systems powered by digital technologies can disseminate real-time alerts through mobile applications, social media platforms, or community-based communication networks, ensuring that vulnerable populations receive critical information quickly. At the same time, digital platforms facilitate the integration of diverse datasets (such as land use, hydrological conditions, and socio-economic indicators) into comprehensive risk assessments that inform evidence-based decision-making at both municipal and regional scales. By making climate information more accessible and actionable, digital tools strengthen preparedness and reduce the long-term costs of climate impacts.

The integration of citizen science can further help in implementing resilience strategies by not only harnessing data but also contributing to the mindset in a region or community. Similarly, participatory digital platforms allow communities to engage directly in resilience planning, share local knowledge, and co-design adaptive measures that suit their specific needs. These solutions not only improve technical capacity but also foster inclusive governance, empowering citizens to actively shape climate resilience strategies and ensuring that no group is left behind in the face of growing climate challenges.

C. DASHBOARD DESIGN

1. Purpose and Context

Due to global warming and climate change, communities around the world face increasing challenges not only in mitigating but also in adapting to climate change. In its Synthesis Report for Policymakers of the Sixth Assessment Report (2023), the Intergovernmental Panel on Climate Change (IPCC) summarizes key findings on the current and projected impacts of climate change in various sectors and regions (Calvin et al., 2023). The extent of these impacts depends on the pathways of climate-resistant development which integrate greenhouse gas (GHG) mitigation and adaption strategies to address climate change consequences. (Calvin et al., 2023). Monitoring, assessing, and implementing climate-resilient development transitions are crucial for reducing greenhouse gas emissions while strengthening social, economic, and ecological resilience in communities (Calvin et al., 2023).

One of the key measures for effective climate adaptation strategies is building community knowledge through capacity development and accessible information services, such as climate services (Biesbroek et al., 2010; Calvin et al., 2023). Climate services play an important role in providing localized and user-oriented climate information, which improves climate literacy and supports informed decision making. However, for these services to be truly effective, they must be appropriately designed to ensure that climate information is accessible, actionable, and tailored to the specific needs of users (Riach & Glaser, 2024).

As an effective way to translate climate data into actionable insights, climate dashboards can serve as an information platform to support decision-making and other user purposes. Effective dashboard design is essential to ensure that climate information is user-friendly, actionable, and aligned with stakeholder needs. Well-designed dashboards not only facilitate the communication and application of climate data but also empower individuals and organizations to make evidence-based decisions, which consequently enhance adaptation planning and implementation (Brasseur & Gallardo, 2016).

This work examines how effective dashboard design enhances climate resilience in communities. By integrating climate data, supporting evidence-based decision-making, and aligning with key criteria such as UX/UI design, data quality, AI/ML integration, and sustainable business models, the framework should help to better support communities in their climate adaptation efforts. These criteria will be framed within the Quadruple Helix Model, ensuring active and effective integration of the four key actors: academia, industry, government, and civil society. The framework aims to promote agile software development, based on collaborative and user-centred dashboard design, to effectively meet stakeholder needs.

Digital tools play a pivotal role in meeting these needs by transforming climate data into actionable insights. Dashboard serve as critical enablers by integrating diverse data sources—including Earth Observation Systems (EOS), IoT sensors, and local datasets—and presenting them through user-friendly interfaces. These tools empower stakeholders to

assess vulnerabilities, design adaptive measures, and coordinate crisis responses effectively (Giuliani et al., 2017; Lehmann et al., 2021; Schumann et al., 2018).

Dashboards can be powerful tools in a climate resilient development of communities. They enable data-driven decision making and can help in understanding climate change and the resulting risks in a comprehensive way. Some important characteristics of climate change related dashboard are the following:

- Real-time data integration: For example, the *Heatalyzer* monitors live temperature data, offering communities actionable insights into heatwave conditions (Capol et al., 2024).
- Early warning systems: Real-time alerts facilitate proactive disaster preparedness (Giuliani et al., 2017; Schumann et al., 2018).
- Resilience planning: GIS-based dashboards can map vulnerabilities, assess risks, and simulate resilience strategies tailored to specific regions (Giuliani et al., 2017; Paranunzio & Marra, 2024).
- Community engagement: Participatory dashboards leverage citizen-generated data, ensuring local relevance and fostering collaboration (Lock et al., 2020).
- Making informed decisions: By aggregating climate and socio-economic data, dashboards support evidence-based policies and efficient resource allocation (Aguiar et al., 2024; Contreras et al., 2022; Lehmann et al., 2021).

By combining advanced analytics, participatory design, and real-time data processing, dashboards bridge the gap between complex climate information and practical solutions.

1.1. Quadruple and Quintuple Helix Approaches

Traditional models of innovation have largely focused on interactions between academia, industry, and government, known as the Triple Helix model. This approach has long been regarded as a foundation for knowledge production and technological advancement. However, as modern innovation systems have become more complex and decentralized, the need for greater public engagement and real-time data access has led to the emergence of the Quadruple Helix model. The Quadruple Helix (QH) model expands the Triple Helix framework by integrating civil society alongside the three other dimension. The QH framework highlights the growing role of civil society as an essential actor in innovation, particularly in addressing social, environmental, and economic challenges (Roman et al., 2020; Stephens, 2025). Rather than viewing innovation as a top-down process driven by governments and businesses, the QH model envisions a more participatory approach, where the public collaborates directly with research institutions, policymakers, and the private sector in a so-called co-creation process (Stephens, 2025).

At the policy level, the QH framework has been widely adopted within European innovation strategies, with the European Union (EU) placing the QH model at the forefront of its innovation agenda, particularly within Research and Innovation Strategies for Smart Specialization (RIS3) (Roman et al., 2020).

The implementation of the QH model varies across different contexts. In urban settings, cities are often the epicentres of innovation, where interactions between stakeholders

are facilitated through digital tools, participatory platforms, and community-driven initiatives. Co-creation in cities has been particularly effective in tackling complex social and environmental challenges by fostering direct engagement between governments, businesses, and civil society (Roman et al., 2020; Stephens, 2025).

Due to the density, as well as the frequency and variety of activities, urban regions are predestined for QH co-creation processes. In contrast, its implementation in regional innovation strategies has been more challenging. A major issue in regional implementation is that governments and industries often dominate innovation processes, leaving limited room for meaningful community participation. This is particularly problematic in climate adaptation planning, where local knowledge and real-time data integration are crucial for developing effective regional responses to climate change. In this regard, climate dashboards could serve as a potential solution, allowing regional policymakers and civil society to access real-time environmental data, climate risk projections, and localized mitigation strategies. By making data more accessible and transparent, these platforms can strengthen evidence-based decision-making in regional innovation strategies.

Although the QH model presents a compelling framework for sustainable innovation, its implementation faces several barriers that need to be addressed. One of the primary challenges is defining the role of civil society in innovation processes, as the literature is not giving clearly defined indicators to the concept of co-creation (Stephens, 2025).

Institutional resistance presents another significant barrier. Many public and private sector actors struggle to integrate bottom-up participation into established governance structures. Without fostering accessible collaboration spaces to ensure meaningful participation, co-creation risks becoming a top-down process, contradicting the very essence of the QH model (Stephens, 2025).

Creating digital participation platforms, such as climate dashboards, can enhance to tackle this problem. By ensuring transparency and facilitating citizen-driven innovation, climate dashboards can serve as platforms for multi-stakeholder collaboration between government, academia, industry, and civil society. Furthermore, as climate adaptation and innovation continue to evolve, leveraging the Quadruple Helix approach with real-time climate monitoring tools could significantly enhance the effectiveness of sustainability initiatives worldwide.

1.2. Key Questions to be Addressed

Based on the needs of data-driven decision-making and the potential to enhance climate resilience in Central European communities, as outlined in sections 1.1. Quadruple and Quintuple Helix Approach and 3. User Needs, this work proposes a Dashboard Design Framework that integrates the Quadruple Helix approach. It aligns the needs, roles, and engagement strategies of academia, government, industry, and civil society with key software development principles—including data quality, user experience (UX), user interface (UI), artificial intelligence (AI) and machine learning (ML), and sustainable business models (BM).

By fostering data transparency and co-creation, the framework is aiming for a user-centred approach that empowers informed decision-making. To achieve this, we define the following main key question:

- How can dashboards be designed to enhance urban climate resilience in Central European communities based on a Quadruple/Quintuple Helix approach?
- What are the current limitations of existing dashboards for urban climate resilience in terms of usability, information accessibility, and business model approaches, including co-creation processes with civil society?
- What design principles and development approaches (e.g., visualization techniques, participatory methods, and machine learning) are most effective for creating user-centric dashboards tailored to diverse stakeholder needs?
- How can a scalable dashboard framework be developed and evaluated to ensure its practical applicability in supporting data-driven decision-making for climate adaptation?

1.3. Existing Climate Change Information Services

Climate change presents one of the most urgent global challenges, requiring innovative solutions to monitor, assess, and respond to its impacts. The increasing availability of environmental data has led to the development of climate dashboards—sophisticated digital platforms designed to provide insights into climate trends, risks, and policy strategies. These dashboards serve as crucial tools for researchers, policymakers, businesses, and communities to make informed decisions and take proactive measures in climate adaptation and mitigation.

By consolidating large datasets, climate dashboards enhance the accessibility and usability of climate-related information. They integrate various data sources, including satellite imagery, meteorological observations, and climate models, transforming raw data into meaningful visualizations. Many dashboards cater to specific regions or topics, ranging from global climate monitoring to localized adaptation strategies.

As climate change poses increasingly complex challenges, the need for robust, data-driven dashboards has grown significantly. These platforms serve as essential tools for monitoring, analysing, and planning climate change adaptation and mitigation strategies. Below, we explore prominent climate dashboards, highlighting their features, operational areas, data visualization methods, and target audiences.

Table 1 provides a comparative overview of nine climate dashboards designed for monitoring and adaptation. Overall, these platforms share several common features, such as interactive visualization tools and data analysis capabilities, while differing in geographic focus and user interface design.

For instance, the European Environment Agency's Climate-ADAPT Platform (European Environment Agency, 2025) and Copernicus Climate Change Service (Copernicus, 2025) both offer extensive resources for data-driven decision making and policy support in Europe. These platforms are characterized by their interactive visualizations and tools for

assessing vulnerabilities, making them particularly useful for local and regional governments.

Similarly, the platforms European Climate Assessment & Dataset (ECAD, 2025) and ZAMG Climate Data Hub (ZAMG, 2025) emphasize detailed climate trend analyses and localized data, targeting researchers and policymakers with visually rich interfaces.

In contrast, ClimateEU (Marchi et al., 2020) offers Europe-wide climate data that can be queried to support impact assessments and adaptation planning.

At a broader scale, global platforms like the European Space Agency's Climate Change Initiative (ESA, 2025) and NOAA Climate Dashboard (NOAA, 2025) focus on delivering worldwide climate indicators through satellite data and highly interactive tools, respectively. Additionally, the World Resources Institute's Climate Watch Europe (WRI, 2025) combines policy visualization with greenhouse gas tracking to monitor national climate targets.

Overall, the table highlights how these dashboards incorporate similar core functions, such as data aggregation and interactive user interfaces, while tailoring their features to suit specific regional needs and use cases. The selection of the most suitable platform for individual purposes differs due to diverse user needs and can range from localized adaptation strategies to global climate research.

Table 1: Overview of Different Climate Services and Dashboards

Platform	Features	Scope	User Interaction	Use Cases	Accessibility	Access
European Environment Agency – Climate-ADAPT Platform	Adaptation resources; Vulnerability tools	Europe (Regional level)	Interactive visualizations	Local & regional; policy	Open-source; Direct access	EEA Adaptation Dashboard
Copernicus Climate Change Service (C3S)	Extensive datasets; Analysis tools	Europe; Global support	Intuitive customization	Research; Policy	Open-source; Direct access	Copernicus Atlas
European Climate Assessment & Dataset (ECA&D)	Extreme weather analysis; Trend visualization	Europe	Visual-rich interface	Policymaking	Open-source; Direct access	ECA&D Dashboard
Geosphere Austria	Climate database; Downloadable datasets	Austria	Intuitive	Local adaptation Climate research	Selection of climate; indicators via datasets	Geosphere Austria
ClimateEU	Queryable data; Historical & projection data	Europe	User-friendly	Impact assessment; Adaptation planning	Downloadable software	ClimateEU
World Resources Institute – Climate Watch Europe	GHG tracking; Policy visualization	Europe	Interactive visuals	Policy evaluation; Policymaking	Selection of country data	Climate Watch Europe
European Space Agency – Climate Change Initiative (CCI)	Satellite data; Global climate trends	Global	Basic interface	Research; Modeling	Open-source; Direct access	ESA CCI Dashboard
NOAA Climate Dashboard	Global indicators; Climate metrics	Global	Highly interactive	Public awareness; Research; Policy	Selection of different data	NOAA Climate Dashboard

1.4. Regional Climate Model Requirements

In the following we give an overview of common prerequisites for modelling requirements of climate models to be used in digital solutions.

Support via Risk and Vulnerability Assessments
We suggest that to efficiently include the region-specific requirements regarding climatic and socioeconomic conditions, it is of high importance of conducting a risk and vulnerability assessment at regional level and adapt the integration of data types into the climate resilience dashboard. This allows the design of dashboards that meet communities' needs. However, this brings an increase in complexity in the process of dashboard development, as it requires an adaptable and interactive dashboard approach. We argue that this increase in complexity is worth being considered as useful in terms of a significant increase in value for the users, leading to enhance climate resilience on community-level.

Climate Data Resolution
The resolution needed is dependent on the climate model approach (global or regional model), with regional climate models requiring a much higher grid resolution when it comes to earth observation data for example. Higher resolution, however, comes with higher computational costs. One efficient way to improve resolution for improved details at reasonable costs is dynamical downscaling, which is taking a global model with lateral boundary conditions and sea surface conditions from a global climate model, and applying a regional climate model at higher resolution for the specific area defined.

Use of model projections
Climate model projections are projections of how the Earth´s climate may change in different assumed scenarios. These can be helpful in different climate-related forecasting applications. As model projections are the highlight the applicability of models.

Data quality
Data quality plays a critical role in the effectiveness of climate resilience dashboards, which rely on high-quality, real-time data for decision-making. Ensuring accurate, complete, and consistent data allows municipalities and stakeholders to develop targeted adaptation and mitigation strategies. This section outlines the key dimensions of data quality, associated challenges, and methods for ensuring high data integrity.

According to ISO/IEC 25012[1], data quality is defined as "the capability of data to satisfy stated and implied needs when used under specified conditions".

Several dimensions contribute to high-quality data, which can be categorized into two perspectives: inherent data quality and system-dependent data quality. Inherent data quality refers to characteristics intrinsic to the data itself, independent of any system processing or management. It includes accuracy (syntactic as well as semantic), completeness, consistency, credibility, and currentness. On the other hand, system-dependent data quality refers to the extent to which data quality is achieved and

[1] https://www.iso.org/standard/35736.html

maintained within a (computer) system. This includes availability, portability, and recoverability. Some dimensions rely both on the inherent properties of the data and the system managing it. These include accessibility, compliance, confidentiality, efficiency, precision, traceability, and understandability. (Batini & Scannapieca, 2006; Fenner et al., 2021; Otto & Österle, 2016; Vetrò et al., 2016; Vuckovic & Schmidt, 2023).

Ensuring high data quality is crucial for effective decision-making, particularly in contexts such as climate resilience dashboards, where real-time, accurate data plays a vital role. Several strategies can be employed to maintain data integrity, including validation techniques, quality assessment frameworks, and metadata management. One fundamental approach to ensuring data quality is validation and error detection. Quality control frameworks, such as the CrowdQC+ package, have been developed to filter and remove faulty data from crowdsourced sources. These methodologies utilize statistical techniques to identify anomalies and inconsistencies in datasets before they are used for analysis (Fenner et al., 2021).

Another critical aspect of maintaining data quality is assessing the reliability of sources. Studies have shown that crowdsourced meteorological data, while valuable, often contain errors that must be corrected before use. Methods such as cross-referencing with authoritative sources, as demonstrated in research on personal weather stations (PWS), can enhance data accuracy by comparing collected data with validated meteorological records. (Vetrò et al., 2016).

UX/UI

To effectively support climate resilient development in communities via climate services, a user-centred design approach is essential (Calvo et al., 2022; Morelli et al., 2021). Following Hansen´s User Engineering Principles, the first principle is to ‘know the user’ (Hansen, 1971). This requires building a profile of intended users that help making design decisions. The profile should include education, experience, interests, available time, and any specific constraints relevant to the problem at hand (Hansen, 1971; Young et al., 2021).

The design of the dashboard should be data- and task-dependent. A key requirement is to evaluate different design variants to assess their effectiveness and quality (Reinwald et al., 2023). Visualizations must be clear and informative, enhancing users' knowledge and supporting task completion and informed decision-making (Grainger et al., 2016). Due to the diversity of user needs, it is of great importance to adapt the interface and visualisation techniques in the dashboard design process to the target audiences (Contreras et al., 2022).

A user-centred design approach helps in achieving adaptation in an efficient and effective way. User-centred design is an iterative process, in which user feedback is integrated throughout the entire design process (Calvo et al., 2022; Contreras et al., 2022; Morelli et al., 2021). A user-centred approach ensures optimized data visualizations (including shape, size, and colour adjustments for clarity), minimised information overload (limiting information categories to the essential ones), and reduced cognitive and graphical complexity. Such a co-design approach ensures that climate data visualizations are accessible, clear, and usable for diverse target audiences, including policymakers,

international organizations, media, communities, and citizens (Calvo et al., 2022; Terrado et al., 2022). A user-centred design process, including co-designing of climate services such as dashboards for improving climate resilience, enables the integration of all sectors described in the Quadruple Helix Approach (see section 1.1.: Quadruple and Quintuple Helix Approach).

To achieve this, participatory approaches such as interviews, workshops, learning labs, and user forums should be used. Ideally, stakeholders are involved from the beginning and throughout all stages of visualization co-development (Terrado et al., 2022). A co-design approach ensures that climate data visualizations are accessible, clear, and usable for diverse target audiences, including policymakers, international organisations, media, communities, and citizens (Morelli et al., 2021).

Going beyond co-design efforts, it is also required to continuously evaluate usability to identify potential gaps between user needs and the way information is presented. Identifying usability gaps requires comparing end-user needs with the dashboard's purpose, information structure, and visual format to ensure clarity and effectiveness (Raaphorst et al., 2020).

To integrate these principles, the following recommendations can help as a guidance in designing and implementing a successful dashboard:

- **Using the right Visualisation Techniques**: The selection of appropriate visualization techniques is a crucial factor in the development of climate dashboards. Data visualization should enable effective decision making by reducing complexity and extracting information from the raw data. This requires visualization techniques with an appropriate level of complexity to optimize the effectiveness of decision support and interpretation of information, and can be achieved by analysing characteristics of the end-users (Contreras et al., 2022).

- **User-Centred Design and Co-Creation Approach**: Ensure that the dashboard is designed iteratively with continuous user involvement, considering diverse user needs, skills, and accessibility requirements (Calvo et al., 2022; Hansen, 1971; Morelli et al., 2021; Terrado et al., 2022).

- **Ensure Clarity**: Present climate data in a structured format with clear terminology, intuitive navigation, and well-labelled visual elements to enhance comprehension (Grainger et al., 2016; Terrado et al., 2022).

- **Use Visuals Appropriately:** Choose visualisation types based on data characteristics and user tasks and apply colour, size, and shape in a way that reduces complexity without overwhelming the user (Morelli et al., 2021; Terrado et al., 2022).

- **Organize Information Hierarchically**: Implement a logical layout that prioritizes key insights while providing additional details progressively (Calvo et al., 2022; Hansen, 1971).
- **Avoid Cognitive Overload and Distractions**: Limiting the number of categories displayed at once, as well as using consistent terminology and graphical elements

helps to minimise confusion. Adapting terminology and language to the context of the user and providing a help documentation should also be considered (Terrado et al., 2022).

- **Maintain Consistency and Accessibility**: Use uniform design elements, colour palettes, and reference icons throughout the dashboard and chose them in colour-blind-friendly schemes and assistive technologies (Terrado et al., 2022).

- **Test for Usability and Effectiveness**: Conduct user testing at multiple stages of development to refine interactions, assess comprehension, and enhance decision-support capabilities based on real-world feedback. Ideally, this process should be iterative to ensure continuous improvement (Calvo et al., 2022; Terrado et al., 2022).

Use of AI and ML

Dashboards with integrated Artificial Intelligence (AI) and Machine Learning (ML) provide transformative benefits for climate adaptation. They not only help in visualising data but also serve as powerful tools for risk analysis and management, allowing real-time monitoring and proactive decision making that improve urban resilience (Mehryar et al., 2024; Štěpán Machovský, 2023).

AI techniques are useful for assessing climate risks, estimating exposure, and supporting decision-making. By processing large historical and real-time environmental datasets, these systems improve risk management and guide urban policy decisions (Mehryar et al., 2024). Furthermore, integrating ML into dashboards allows for interactive data analysis. For example, one-click solutions and embedded Jupyter Notebooks enable both non-expert and expert users to explore and visualize complex datasets in real time (Štěpán Machovský, 2023).

ML models can also predict extreme events, such as lightning occurrence, using commonly available meteorological parameters. A nowcasting approach based on MeteoSwiss data provides lightning warnings up to 30 minutes in advance (Mostajabi et al., 2019). Furthermore, ML algorithms detect unusual patterns in environmental data that act as early warning signals for potential risks, while clustering techniques group similar risk profiles to support targeted interventions and decision-making in climate adaptation (Bochenek & Ustrnul, 2022).

However, challenges remain. As described in the section on data quality, data quality is a major issue, as sensor degradation and fragmented sources can lead to unreliable or outdated data. Moreover, high technical requirements, such as significant computational resources and smooth integration into existing data flows, increase cost and complexity. Robust data governance, ML-based validation, and advanced computing infrastructures are needed to address these problems (Shalu & Gurjeet Singh, 2023).

Looking ahead, risk-based decision support and data-driven analysis are expected to advance further, continuously optimizing dashboards. This progress will lead to more efficient decision making and improved climate adaptation strategies (Ramya & Singh, 2024).

Business Models for Climate Resilience Dashboard Development

In today's economy, business models are critical for organizations to create, deliver, and capture value. A business model describes how a firm's internal processes create value through services or production and capture value through marketing strategies and increased sales. These processes are vulnerable to external changes, including market shifts, regulatory adjustments, and environmental changes (DiBella, 2020).

Climate services are defined as the production, translation, and delivery of useful climate data, information, and knowledge (Larosa & Mysiak, 2020; National Academies Press, 2001). These are used by decision-makers, which includes all users of the provided climate services with a broad spectrum of different needs (National Academies Press, 2001). Climate services encompass climate records, extreme event catalogues, reanalyses, forecasts, projections, and indices used in vulnerability and risk assessments, as well as linkages to the sectors affected by climate indicators (e.g. energy demand depending on temperature) (Larosa & Mysiak, 2020; National Academies Press, 2001).

To effectively develop and offer climate resilience dashboards, serving as a key component of climate services, specific requirements for business models must be met:

- **User-centred activities and elements**: Climate services must adapt to the needs and culture of their users by recognizing diverse potential users and their specific requirements (Brasseur & Gallardo, 2016).

- **Co-creation process**: A co-creation approach is a key component of climate services BMs. Collaboration among various stakeholders, including enables the exchange of knowledge and competencies, as well as the development of user-friendly services (Brasseur & Gallardo, 2016; Larosa & Mysiak, 2020). This collaboration can occur both offline through workshops and conferences and online through web-based products (Larosa & Mysiak, 2020).

- **Value Network**: An interaction space in which climate services operate can be essential for up-scaling climate services successfully. Using subscriptions to create an online-based infrastructure is one of the most common ways to build partnerships and organizations. Value networks have a huge effect on the innovation process and can create mutual learning opportunities (Larosa & Mysiak, 2020).

- **Financial Structure**: Balancing financial aspects is essential for the long-term viability of climate services. Public providers mainly focus on value proposition and value network, while private firms focus on financial compensation and the value-driven character of their services. As a third provider´s group to be mentioned, research institutions very often receive external research fundings, aiming for structured research projects with legal rules that are not aligning with the corporates request on receiving retribution (Brasseur & Gallardo, 2016; Larosa & Mysiak, 2020; Swart et al., 2017).

Specific Business Models for Climate Resilience Dashboards

One concrete application of climate services is the development of climate dashboards. To ensure effective delivery and user engagement, following the key requirements identified in this section, key components of an effective BM include the following:

- **Tailor-made Services**: Climate dashboards should provide tailor-made services to meet the specific needs of public and private actors. This customization enhances the utility and relevance of the information provided (Brasseur & Gallardo, 2016; Larosa & Mysiak, 2020).
- **Data Integration**: Climate dashboards should integrate various data sources such as the Copernicus Climate Change Service (C3S) and the Climate Data Store to provide free access to data and post-processed information (Larosa & Mysiak, 2020).
- **Targeted Sectors**: Focus on sectors such as energy, water management, and disaster risk reduction, where co-creation and tailor-made approaches are more effective (Larosa & Mysiak, 2020; National Academies Press, 2001).
- **User-Centric Design**: A user-centric approach is essential for a cost-effective and comprehensive linking of knowledge and its use for decision-making and other purposes. This includes mutual information exchange and feedback, communication and accessibility of information, and continuing evaluation and assessment by users and providers (Brasseur & Gallardo, 2016; Larosa & Mysiak, 2020).
- **Hybrid Approach**: Climate services can be private, public, or hybrid goods (Larosa & Mysiak, 2020; Perrels, 2020; Swart et al., 2017). This has consequences for evaluating the propagation of value added from climate services because the cost coverage and price observation differs across these types of goods (Perrels, 2020). It is requested to aim for a hybrid model, with the main objective to design climate services as public goods, mainly funded by taxes and with free access to any citizens. The hybrid model, however, allows financial retribution, but only for specific needs that are requested for exclusive uses (Larosa & Mysiak, 2020).
- **Transparency**: Lack of information on climate risk exposure for certain should be avoided through climate services data transparency (Perrels, 2020).
- **Community Resilience**: It is important to build a sustainable European climate service community that includes users, providers, intermediaries, innovators, and researchers to make the market more sustainable. This requires forums where trust can be built and the credibility and quality of services can be demonstrated (Street, 2016).
- **IT Infrastructure**: Building a solid IT infrastructure is crucial to support data flow and address the challenges associated with big data (Hanelt et al., 2021).

By considering these aspects, business models for climate services can effectively contribute to climate change adaptation while ensuring sustainable value creation. The development of climate services should be viewed as a continuous process, adapting to the changing needs of users and technological advancements, as well as to the changing climate affecting the users' needs.

2. Modular (Dashboard) Design Approach

2.1. Design & Goals

A modular dashboard design approach in climate resilience enables communities to monitor, analyse, and respond to climate risks through integrated, adaptable systems composed of distinct, reusable modules.

Modular dashboards are built from self-contained, reusable components, allowing developers to mix, match, and customize elements such as sidebars, charts, and data tables according to specific needs. This modular structure promotes scalability, flexibility, and maintainability; enabling updates, upgrades, or the addition of new features without disrupting the overall system. Modules can be reused across multiple dashboards and projects, facilitating parallel development and efficient collaboration. In contrast, non-modular dashboards are designed as unified, monolithic systems where the interface and functionality are tightly integrated. Altering or expanding these dashboards often requires significant redevelopment, as changes are less isolated and typically affect the entire system. Non-modular dashboards are less adaptable and more difficult to customise, with limited reusability and reduced long-term efficiency. As a result, modular dashboards are considered better for adaptability, maintenance, and futureproofing, while non-modular dashboards may offer simplicity but lack the versatility required for evolving user needs.

Modular dashboards are structured as collections of self-contained components (modules) such as data visualisations, near-real-time indicators, scenario models, or alert systems. Each module is dedicated to a key functionality, for example:

- Geo-intelligence for mapping hazards
- Climate outlook and trend visualization
- Monitoring & evaluation tools
- Citizen feedback or reporting portals

This approach allows for customisation according to local needs, rapid iteration, and future scalability. It also supports interoperability by enabling the integration of new data sources and modules without disrupting the overall system.

An effective modular dashboard architecture depends on establishing a logical structure that clearly distinguishes between global dashboards and those tailored to local or community-specific contexts. The inclusion of intuitive navigation and well-organised hierarchical elements ensures that users—both citizens seeking alerts and experts managing data models—can readily access the tools and information most relevant to their needs. Thoughtful grouping and precise labelling make modules such as hazard visualisation, adaptation catalogues, and project trackers easy to identify and use. Additionally, robust filtering and customisation options enable users to focus on the metrics, risks, or locations most pertinent to their objectives.

Development best practices include clean folder hierarchies, reusable UI components, and clear separation of logic and style. Continuous user feedback loops and co-creation with stakeholders ensure ongoing relevance and utility.

Modularity equips dashboards with the ability to respond swiftly to evolving climate events and shifting stakeholder needs. Integrated modules, such as those for scenario analysis and investment planning, enable targeted decision-making, while features like project trackers enable communities to effectively monitor and advance climate adaptation initiatives. Insights from case studies using both urban and rural dashboards illustrate how these platforms can enhance overall community resilience, facilitate informed policymaking, and foster robust collaboration among diverse stakeholders.

2.2. Modular Dashboard Design – Participation Matrix

The matrix presented below outlines the relationship between citizen involvement and data availability, segmented into nine distinct categories. It illustrates the relationship between citizen involvement and the amount of data available in a community or organizational context. This framework aims to clarify the varying impacts of different levels of citizen involvement and data availability on data governance and community engagement.

Each category represents a specific combination of citizen engagement and the extent of data accessibility, ranging from minimal interaction to comprehensive participation and co-creation. It is divided into a 3x3 grid with two axes. The vertical axis represents the Amount of Data, ranging from Low at the bottom, through Medium in the middle, to High at the top. The horizontal axis represents Citizen Involvement, progressing from Low on the left, through Medium in the center, to High on the right.

How to use the matrix
This matrix serves as a framework to assess and plan the relationship between data availability and citizen involvement in any data governance or community engagement initiative. The matrix can be used in the following steps:

- **Step 1: Assessment** - Identify the current state of the project or community by locating which cell best describes the existing interaction level between citizen involvement and data volume. This helps clarify current capabilities and engagement.
- **Step 2: Goal Setting** - Use the matrix to define desired progress. For example, a community currently at 'Data Sharing' (medium data, low citizen involvement) may aim to move towards 'Data Collaborator' or 'Co-Creation' by increasing citizen participation.
- **Step 3: Strategy Development** - Tailor strategies to increase data collection methods, citizen engagement activities, or both. The matrix highlights the trade-off and opportunity zones for improving transparency, collaboration, and governance.
- **Step 4: Monitoring Progress** - Track advancement over time by mapping changes in citizen involvement and data availability; use this to refine engagement methods and data initiatives.
- **Step 5: Encouraging Inclusivity** - The matrix can be used to design solutions enabling balancing of data richness with active citizen participation to foster trust, accountability, and shared ownership of data-driven decisions.

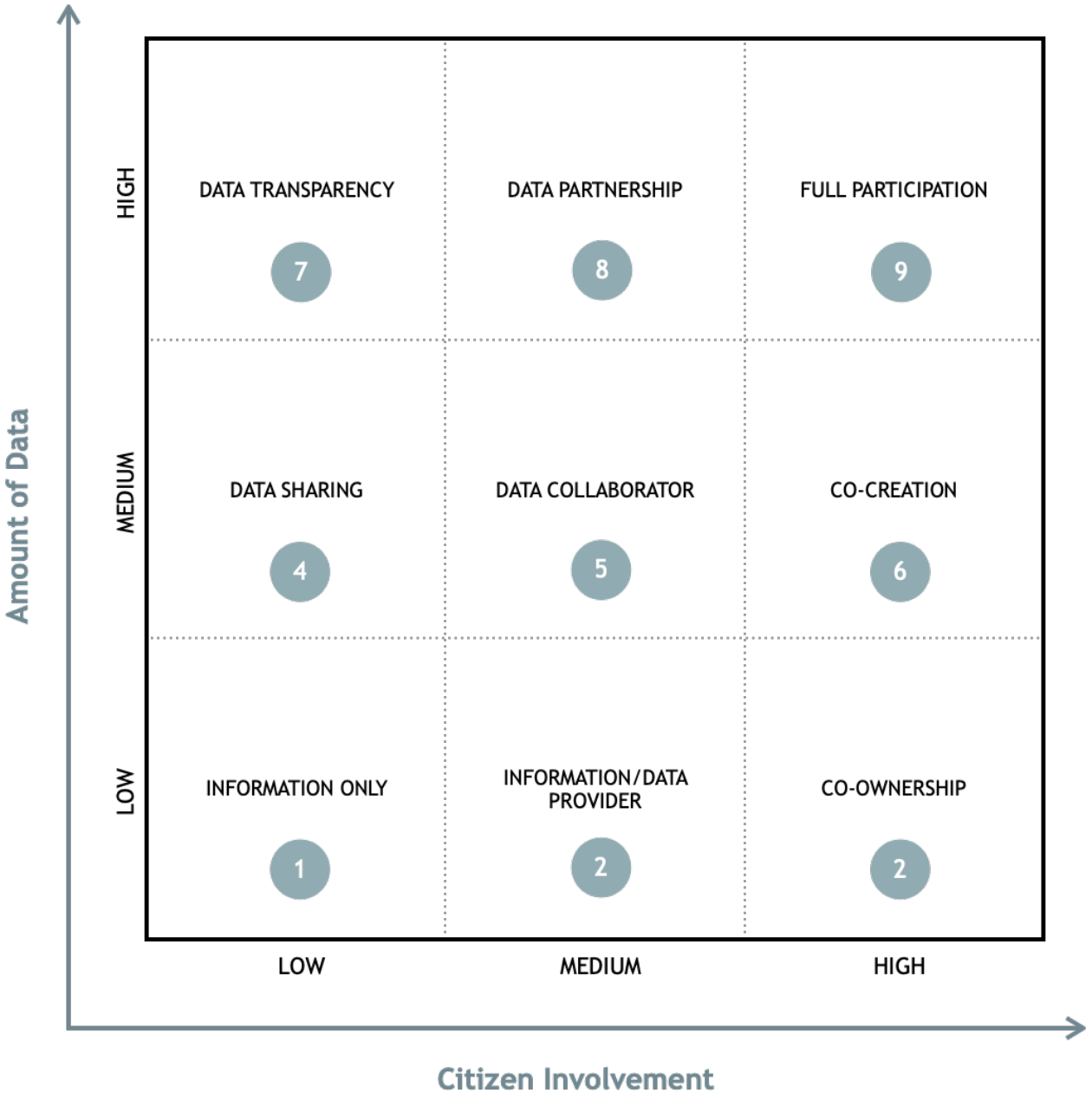


Figure 1: Participation Matrix for Use Case Derivation

Participation Matrix Quadrant Details

1. Information Only - Low Data, Low Citizen Involvement

In this quadrant, citizens have minimal involvement and access to very limited data. They primarily receive basic information without interactive engagement or access to dynamic dashboards. For example, a municipality might send a newsletter informing residents about upcoming climate workshops or show basic climate data like average live temperatures. The goal here is awareness and not active participation. However, this approach is considered the least ideal because it offers minimal citizen engagement and insufficient data for addressing the complexity of climate challenges. Within the Mission CE Climate context, this passive information delivery contradicts the project's priority of

fostering active local participation and community empowerment in climate adaptation strategies.
Related projects:

- ENES-CE Initiative; project, which raised awareness on energy efficiency and CO_2 reduction but with minimal interaction from citizens.
- Climate-ADAPT

2. Information/Data Provider - Low Data, Medium Citizen Involvement
Here, citizens have a moderate level of involvement and access to limited data. They contribute to data collection or provide information but lack significant control or ownership of the data. An example could be local governments asking residents to report extreme weather events, such as flood occurrences or heatwaves, via simple online forms. The data collected is controlled centrally, typically by government agencies, to support adaptation planning. This quadrant marks a transition from solely receiving information to active citizen contributions, though without full collaborative control.

3. Co-Ownership - Low Data, High Citizen Involvement
Citizens in this quadrant have high involvement and share ownership over the available data, despite the data volume being limited. They take on significant responsibility and decision-making roles related to data. For example, a small community managing a local flood defense system collects real-time precipitation and water level data and collectively decides how to mitigate flood risks using this locally governed information. This quadrant symbolizes empowerment through shared control, fostering stronger community trust and climate resilience.

4. Data Sharing - Medium Data, Low Citizen Involvement
This quadrant is characterized by citizens having access to a moderate amount of data but with primarily passive involvement. While citizens can view and download climate-related datasets, such as open data portals offering projections or historic flood data, their role is often limited to information consumption rather than active analysis or decision-making. This setting supports transparency but lacks deeper citizen engagement in planning or adaptation processes.

5. Data Collaborator - Medium Data, Medium Citizen Involvement
Citizens actively collaborate with data providers, engaging more deeply with a moderate volume of data. They assist in data collection, share insights, and jointly use the data for community benefit. An example includes citizens measuring urban heat islands using distributed temperature sensors and sharing results with city planners, who then use this data to develop mitigation strategies like creating urban green spaces. Projects like the Municipality of Koper Pilot exemplify this quadrant, where citizens play an active role in data gathering and collaborative use. This stage enhances shared responsibility and knowledge co-production.

Related projects:

- Municipality of Koper – Pilot; actively involved citizens in gathering climate-related data.

6. Co-Creation - Medium Data, High Citizen Involvement
In this quadrant, citizens are deeply involved in both creating and using a moderate amount of data. They partner closely with data providers, researchers, and policymakers to co-create climate solutions and interventions. For instance, in a city-wide initiative, citizens and planners collaborate on urban green infrastructure designs using data on water management and flood risk to develop features like rain gardens. This level emphasizes joint problem-solving, innovation, and localized adaptation strategies reflecting community priorities.

7. Data Transparency - High Data, Low Citizen Involvement
This quadrant has high data availability ensuring broad transparency, but citizen involvement remains low. The public can freely access comprehensive datasets, such as dashboards showcasing regional climate resilience metrics, CO_2 emissions, and detailed risk maps. Although transparency is high, citizen participation in interpreting the data or influencing strategy decisions is limited. This model serves as a baseline for openness but does not fully leverage citizen input for adaptive governance.

8. Data Partnership - High Data, Medium Citizen Involvement
Citizens engage actively with a large volume of data, working in close partnership with data providers and decision-makers. They contribute to data analysis, share insights, and influence data use in policymaking. For example, in a regional resilience platform, citizens collaborate with policymakers to analyze flood risk datasets and co-develop infrastructure projects like flood defenses. This quadrant fosters shared governance, allowing citizens a tangible role in shaping climate strategies and enhancing trust through partnership.

9. Full Participation - High Data, High Citizen Involvement
The ideal quadrant combines full citizen engagement with comprehensive data availability, creating a highly participatory, data-rich environment. For example, in a Smart City climate project, citizens participate in real-time data collection via IoT sensors and are actively involved in analyzing data on energy use, transportation, and climate impacts. They help guide planning, monitoring, and management decisions, ensuring solutions are grounded in community needs. This approach is the best practice because it integrates extensive data resources with meaningful citizen empowerment, fostering innovation, cross-sector collaboration, and adaptive capacity.

Related projects:
Copenhagen's CPH 2025 Climate Plan and Climate Adapted Cities, where strong citizen involvement complements broad data access to drive climate adaptation.

- The CPH 2025 Climate Plan + Climate Adapted Cities (Copenhagen); not 100% full participation but citizens were/are highly involved.

2.3. Modular Dashboard Design – Technical Descripiton

Whilst a detailed technical description must be discussed and agreed upon together with relevant experts or software providers, we give a short overview of a streamlined, classic software development process for a modular dashboard as well as list key technologies which are relevant to its development.

Software Process
The process normally consists of phases for (a) *Planning & Requirement Analysis*, (b) *Design & Software Architecture*, (c) *Development*, (c) *Testing*, (d) *Deployment*. This process is iterative and might use agile software development approaches in each of the phases. Certain phases might be repeated if the need arises or are concluded with a (e) *Maintenance* phase. It is advisable to plan to integration into the project management of a dashboard project, as the deployment / rollout of the solution might need to be accompanied by integration, marketing, or similar measures, especially if the dashboard is intended to be used for citizen science.

A software design process for a modular dashboard usually begins with planning and requirement analysis, where the project's goals, user needs, data sources such as IoT and citizen science sensors, and technical feasibility are defined. This phase sets the foundation by clarifying functionalities like real-time data visualisation and stakeholder roles. Next, the design phase develops a high-level and detailed architectural plan focused on a modular structure, defining reusable UI components, data flows, system interfaces, and integration points. Prototypes or wireframes are created to visualise the user interface and workflows, incorporating security and performance criteria. During development, backend services and frontend modules are implemented independently to promote scalability and reuse, with integration of real-time data ingestion using streaming protocols such as MQTT. User authentication and access control are also established. Testing follows, including unit testing of modules, integration testing of the full system, and user acceptance testing with target groups to ensure data accuracy and usability. The deployment phase involves releasing the dashboard on production infrastructure, often using containerisation and orchestration tools for modular updates and scalability. Finally, maintenance and improvement continue post-deployment, utilising agile methods to incorporate user feedback, add features, and adapt to evolving requirements, thus ensuring a sustainable, flexible, and user-centred modular dashboard aligned with climate resilience goals.

List of potential key technologies
In general, key technologies are to be chosen for frontend and backend development, as well as data storage. Specifically, key technology choices pertaining to IoT and sensor data integration, data processing and analytics, as well as use case specific technologies are relevant to modular dashboard design. Together, these technologies form the foundation for flexible, scalable, and user-centred modular dashboards that effectively integrate IoT and citizen science sensor data to support climate resilience monitoring and community engagement.

Key technologies used for a modular dashboard design, especially when integrating IoT and citizen science sensors as data sources, include the following:

Frontend Technologies

- *Modular UI Frameworks and Libraries:* React, Angular, and Vue.js are popular choices for building modular components, such as reusable cards, charts, tables, navbars, and widgets. They enable scalable, maintainable, and customizable user interfaces.
- *Component-Based Architecture:* Dashboards are constructed from self-contained, reusable components with clear separation of presentation and logic. Techniques like React hooks or Angular services manage shared logic cleanly.
- *Utility-First CSS Frameworks:* TailwindCSS or Bootstrap facilitate consistent styling with minimal effort, supporting responsive and adaptive design for multiple devices.

Backend and Data Integration

- *APIs and Web Services:* RESTful APIs or GraphQL endpoints enable real-time or batch communication with data sources, including IoT platforms or sensor networks.
- *Data Streaming and Messaging:* MQTT, WebSockets, or Kafka are commonly used to stream real-time sensor data from IoT devices into the dashboard backend for processing and visualization.

IoT and Sensor Data Integration

- *IoT Protocols:* LoRaWAN, NB-IoT, Zigbee, and MQTT protocols support low-power, long-range sensor networks gathering environmental, climate, or citizen-contributed data.
- *Sensor Networks and Gateways:* Local sensor stations, citizen science devices, or smart meters collect data shared via IoT gateways to centralized or cloud-based data platforms.
- *Data Aggregation Platforms*: Cloud services like Microsoft Azure IoT Hub, AWS IoT Core, or Google Cloud IoT provide scalable ingestion, storage, and processing infrastructure.

Data Processing & Analytics

- *Databases:* Time-series databases (e.g., InfluxDB, TimescaleDB), NoSQL (e.g., MongoDB), and relational databases (e.g., PostgreSQL) store sensor and citizen science data for efficient querying.
- *Data Visualisation and BI Tools:* Libraries such as D3.js, Chart.js, or integrated tools like Power BI and Tableau visualise climate data dynamically.
- *AI/ML Components:* Machine learning models for anomaly detection, forecasting, or scenario modelling are increasingly integrated to enhance decision support.

Additional Technologies

- *Citizen Science Platforms and APIs:* Tools and protocols supporting citizen data contributions, validation, and quality assurance integrate with dashboards.
- Security and Authentication: OAuth, JWT, and role-based access control protect sensitive data and ensure authorized usage.
- *Modular Architecture Patterns:* Microservices or serverless functions often implement modular backend services corresponding to frontend modules for scalability and maintainability.

2.4. Data Integration and Processing Architecture for Modular Climate Dashboards

Figure 2 provides a high-level architecture diagram tailored for a modular digital dashboard design, specifically aligned with the integration and processing needs of climate data within city infrastructures. It demonstrates a layered, component-based solution that supports scalability and interoperability, ideal for evaluation by city ICT departments aiming to test the feasibility of integrating such solutions within existing municipal ICT environments. This architecture is intentionally modular and technology-agnostic, designed to lower integration barriers for city IT teams. Each layer and service can be leveraged independently or integrated stepwise, enabling cities to adopt dashboard capabilities that fit their specific legacy systems, security standards, and scalability requirements. This flexibility supports gradual adoption and pilot testing within the constraints and requirements of municipal digital ecosystems.

At the top, the architecture features a (web-)driven user interface encompassing modules like User View & AAA (Authentication, Authorisation, Accounting), Control Panel, Information Panel, Information Overlays, and a Map Layer View. These UI components enable flexible user access, administrative control, and comprehensive data visualisation.

Beneath the interface, the architecture is divided into multiple modules with each module having a minimum of three layers, including:

- Information Generation: For processing and creating actionable insights from raw and transformed data.
- Data Transformation & Quality Checks: Central to ensuring data accuracy and reliability, this layer encompasses all transformations, corrections, and validations before integration.
- Data Selection & Aggregation: Responsible for sourcing, filtering, and combining data from multiple inputs.

Data may be sourced from various origins (APIs, databases, files, sensors), which are flexible and scalable to fit city-specific data landscapes. These data sources feed into the modular solution, which is capable of integrating with external transformation services via well-defined APIs. The Map Layer View is directly integrated with an ArcGIS-backed database, providing essential spatial analysis and visualization for climate-related urban data. This connection illustrates the architecture’s readiness to dovetail with commonly used city geospatial systems, reinforcing practical feasibility for municipal IT departments. To enhance adaptability and future-proofing, the framework adopts API-based integration for data transformation services, ensuring the modular dashboard can extend to new data sources and analytical functionalities as needed, supporting IT departments' goal of seamless integration with evolving urban data landscapes.

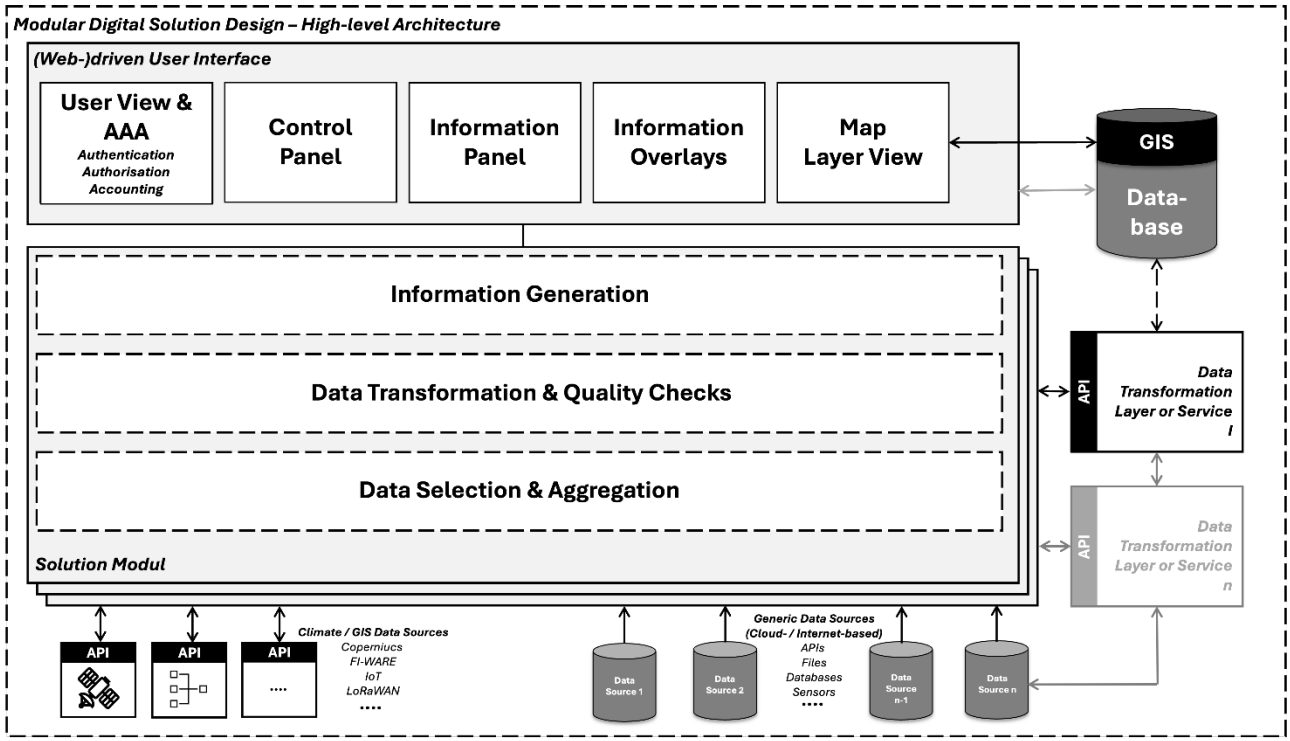
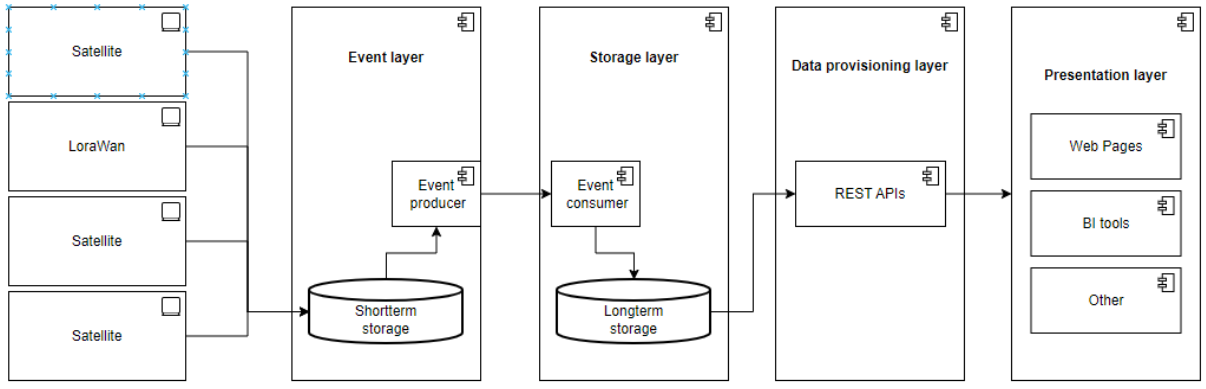


Figure 2: Modular Digital Solutions Design

2.4.1. Example for a Data Integration and Processing Architecture for Modular Climate Dashboards



3. User Needs

Collecting user needs for a modular climate resilience dashboard should begin with a thorough stakeholder assessment, identifying all relevant internal and external parties who will use or influence the platform. Involving stakeholders from the outset is helpful to ensure that requirements are comprehensive and aligned with real-world practices.

The Delphi method is widely recognised as robust approach for determining user needs or translating them into IT requirements, as it systematically gathers expert feedback through multiple iterative rounds of anonymous questionnaires, promoting consensus and

reducing bias. The Delphi (see Figure 3) method is a structured, multi-stage survey process used to gather and refine expert opinions for estimating future events or circumstances, particularly in risk management. It begins by creating a catalogue of questions or statements that experts review during the first round, typically through questionnaires or working documents. After each round, expert feedback and comments are incorporated and the updated catalogue is redistributed for further refinement and discussion. This iterative feedback allows experts to reconsider their responses in light of anonymous group input, gradually building consensus. One of the main advantages of the Delphi method is its ability to avoid misjudgements caused by groupthink or the dominance of outspoken individuals in direct discussions, thanks to the anonymity and structured approach. However, a notable disadvantage is that the process can be cumbersome, often requiring many rounds to reach a consensus, and demands statistical expertise when the estimation of probabilities is involved. Overall, the Delphi method is highly effective for complex scenarios requiring unbiased, collective expert judgment, though the time and effort involved may make it less practical for rapid decision contexts.

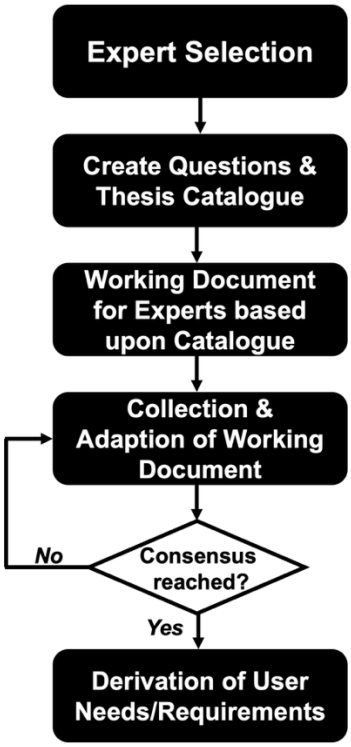


Figure 3: Delphi-Method Overview

Since it is important to note that the Delphi method can be time-consuming due to its iterative nature, making it less suitable when rapid development is required. In such cases, more straightforward methods should be considered, such as targeted questionnaires, collaborative workshops, bilateral discussions, or expert interviews.

Overall, the user needs collection process typically starts within a single institution or core project team, using initial assessment tools to gather preliminary needs and identify user expectations. Subsequently, it should be extended to incorporate input from all involved stakeholders, including external partners, community representatives, and technical experts, ensuring that a diverse range of perspectives is incorporated into the

final requirements definition. Each step builds on the previous one, using stakeholder feedback to refine and validate the user needs.

A brief overview of the user needs collection process includes the following: begin by *mapping and consulting stakeholders*; *select appropriate methods for engaging* them (consider Delphi technique for depth and consensus), or simpler questionnaires and workshops for speed; *synthesise findings*; and *iteratively refine requirements in collaboration with all key user groups*. This extended and participatory approach ensures the dashboard's technical features and functional capabilities are optimally matched to the evolving needs of its users and stakeholders.

3.1. Stakeholder & Target Groups

Stakeholder groups and target audiences for a modular dashboard supporting resilience and sustainability management encompass a broad spectrum, reflecting the multi-layered nature of climate adaptation and sustainable development initiatives.

The following list is intended as a guideline and starting point for stakeholder group and target group identification; concrete groups must always be defined based upon specific dashboard development. It might also be helpful to use the dashboard matrix from chapter 2 to assess especially citizen target / stakeholder groups.

Stakeholder Groups

- ***Local and Regional Authorities***: City governments, municipal climate teams, county administrations, and regional planning agencies responsible for policy-making, emergency response, adaptation planning, and reporting. These groups are of special focus for analysis of their climate related resilience, contingency, or even risk strategies.

- ***National Government Agencies:*** Ministries and departments focused on environment, sustainability, climate action, disaster management, and infrastructure at the state or federal level. These groups are of special focus for analysis of their climate related resilience, contingency, or even risk strategies.

- ***Community Groups and NGOs:*** Non-profits, environmental organizations, advocacy groups, and local resilience committees driving grassroots projects, public awareness, and community engagement.

- ***Businesses and Private Sector:*** Local entrepreneurs, corporations involved in green innovation, infrastructure, utilities, tourism, and sectors impacted by climate risk, contributing data and implementing adaptation measures.

- ***Academic and Research Institutions:*** Universities and scientific organisations that supply climate data, model projections, and conduct assessments, also facilitating citizen science initiatives.

- ***Funding Bodies and Investors:*** Regional, national, and international organisations, banks, and philanthropic entities supporting climate adaptation, innovation, and sustainability projects.

- ***Technical and Service Providers:*** IT companies, consultants, and platform vendors delivering dashboard software, IoT integration, and analytical tools.

- ***General Public:*** Residents, local community members, and vulnerable populations, especially those directly impacted by climate and environmental changes, as both data recipients and contributors through citizen science platforms.

Special Case – Stakeholder groups on a European Union level
On the European Union level, key stakeholder groups that support technological climate resilience strategies are broad and highly interconnected, reflecting the complexity and cross-sectoral nature of adaptation initiatives.

When designing a dashboard, one might consider analysis of the following movements or groups:

- ***European Commission Directorates-General (DGs)***: Especially DG CLIMA (Climate Action), DG ENV (Environment), DG RTD (Research & Innovation), DG REGIO (Regional & Urban Policy), and DG CNECT (Communications Networks, Content & Technology), which set policy, fund research, and drive digital infrastructure for resilience.

- ***European Environment Agency (EEA)***: Provides climate data, monitors progress, offers assessment platforms (e.g., Climate-ADAPT), and supports knowledge sharing at the union level.

- ***Joint Research Centre (JRC)***: Supplies scientific and technical support, develops risk and impact models, and creates harmonized datasets and standards for resilience strategies.

- ***Copernicus Programme***: The EU's Earth Observation programme provides real-time and historical climate and environmental data essential for resilience dashboards and digital decision support tools.
- ***European Investment Bank (EIB) & Horizon Europe***: Funding bodies supporting technological innovation, pilot projects, and large-scale deployment of digital solutions for climate adaptation.

- ***Eurostat***: Delivers harmonised statistical data and climate-relevant indicators across EU countries, which can be integrated into digital dashboards for monitoring resilience.

- ***EU Mission on Adaptation to Climate Change***: Engages regions and communities in experimentation, innovation packages, and 'twinning' programmes for scaling up climate resilience solutions with technology.

- ***Transnational and Regional Networks***: Bodies such as ICLEI Europe, Covenant of Mayors for Climate & Energy, Regions4Climate project, Pathways2Resilience, and REGILIENCE deliver best practices, capacity building, and coordination between cities and regions on digital innovation for adaptation.

- ***Pan-European Research Infrastructures***: Projects like ARSINOE, IMPETUS, and TransformAr supply models, data platforms, living labs, and digital toolkits for cross-border cooperation and replication of technological solutions.

- ***Stakeholder Advisory Platforms:*** Multi-actor forums, citizen engagement bodies, and professional networks (such as the European Urban Resilience Forum, EURESFO) validate, disseminate, and improve technological solutions for climate resilience.

Target Groups

Target groups for (modular) dashboards might include, but are not limited to:

- ***Decision Makers:*** Municipal managers, elected officials, program coordinators, and agency staff who oversee climate adaptation, sustainability projects, and allocate resources.

- ***Climate Action Professionals:*** Experts responsible for designing, implementing, and monitoring resilience and sustainability measures (includes planners, engineers, and emergency management personnel) – these professionals might be employees of a wide range of institutions, usually they are part of municipalities or civil engineering organisations.

- ***Community Leaders:*** Influencers, local organisers, and advocates who model adaptive behaviours and organise local initiatives.

- ***Technical Users and Data Scientists:*** Those utilising the dashboard for analytics, scenario modelling, and ongoing monitoring (includes academic researchers, municipal data teams, technical service providers, and others).

- ***Engaged Citizens:*** Individuals actively participating in climate action (e.g., citizen science, feedback, co-creation) and users leveraging dashboard tools for personal or community benefit.

- ***Underrepresented and Vulnerable Groups:*** Communities facing greater climate risks—elderly, low-income, minority groups—whose needs and voices must be prioritised in resilience planning. These groups might be especially important since underrepresented or vulnerable groups are usually impacted the most by a changing climate and its effects.

3.2. Climate Indicators

A broad range of indicators exist which might be displayed in dashboard or for which individuals modules could be developed and integrated into a dashboard. The categories in the following resemble *potential* categories for climate resilience indicators suitable for dashboard visualisation, including both simple sensor-based and complex composite examples for each.

A simple sensor-based indicator is usually based on one sensor or group of sensors which measure the same indicator, e.g., average of temperature sensors.

A composite-based indicator takes into account multiple data sources and combines the data into one derived indicator, e.g., perceived temperature by combining temperature and wind chill factors.

Also note, that the following indicators are relevant for Central Europe. In other regions, other indicator types might be more suitable (e.g., coastal and water level Indicators for non-landlocked countries).
A more extensive and full list of indicators might be obtained from Climate-Adapt[2] or ETC/CCA Technical Papers[3].

Exemplary Indicator Categories & Indicators

Category: **Climate Hazard Indicators**

Examples:
- Daily Maximum Temperature: Real-time readings from local temperature sensors.
- Heatwave Days (Composite): Count of periods exceeding high temperature thresholds for several consecutive days, combining multiple temperature sensors.

Category: **Hydrological Indicators**

Examples:
- Total Precipitation: Accumulated rain or snow data from precipitation gauges.
- Flood Recurrence (Composite): Ensemble index estimating 50-year flood recurrence by combining river discharge sensors, rainfall intensity records, and soil moisture data.

Category: **Drought and Water Stress Indicators**

Examples:
- Consecutive Dry Days: Measurement of longest periods with no significant rainfall, calculated from multiple precipitation sensors.

[2] https://climate-adapt.eea.europa.eu/en/knowledge/mre

[3] *Example*: https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/tp_3-2018

- Magnitude of Meteorological Droughts (Composite): Severity index based on standardised precipitation and soil moisture datasets, integrating several sensor sources.

Category: **Fire Risk and Forest Health Indicators**

Examples:
- High Fire Danger Days: Number of days with elevated Fire Weather Index, using temperature, humidity, wind, and rainfall sensor data.
- Fire Weather Index (Composite): Combined output using meteorological sensor readings for temperature, precipitation, wind speed, and humidity.

Category: **Ecosystem and Land Cover Indicators**

Examples:
- Mean Soil Moisture: Measurements from distributed soil moisture probes to indicate water availability.
- Aridity Actual (Composite): Ratio of evapotranspiration to precipitation using soil moisture sensors, weather stations, and remote sensing data.

Category: **Human Impact and Health Indicators**

Examples:
- Frost Days: Number of days with temperatures below zero from weather stations.
- High UTCI Days (Composite): Days when the Universal Thermal Climate Index (UTCI) exceeds heat stress thresholds, calculated from air temperature, humidity, wind speed, and radiant temperature sensors.

Category: **Resource/Energy Use Indicators**

Examples:
- Heating Degree Days: Days requiring heating based on temperature sensor readings.
- Cooling Degree Days (Composite): Cumulative metric tracking demand for cooling, integrating air temperature records and building energy data.

Category: **Adaptation Response Indicators**
Examples:
- Green Infrastructure Coverage: Area or count data from GIS mapping and field sensors monitoring new green installations.
- Community Participation Rate (Composite): Percentage of residents actively engaged in climate adaptation activities, derived from citizen science app data, participation forms, and event sensors.

3.3. Further Climate Information for Dashboards

Besides indicator, dashboards might also be used to display relevant information, depending on the target group. Citizen and end-user focused dashboards might present a static tips & tricks section or derived recommendations based upon current indicator statistics.

Other climate information modules for such dashboards might cover a wide range of relevant topics critical for resilience and sustainability. They typically include climate projections that present expected changes in temperature, precipitation, and extreme events over future periods, often downscaled to regional or local levels for practical use. These dashboards can provide alerts and early-warning systems designed to inform users about imminent climate hazards, helping communities prepare and respond effectively. Additionally, many dashboards incorporate actionable recommendations tailored to everyday decisions, such as advising users to take shaded paths when moving from point A to B or reminding them to stay hydrated on hot days, thereby promoting climate-adaptive behaviours. Beyond data and alerts, these platforms often highlight climate action projects and local events underway in the region, raising awareness and fostering community engagement. Together, these elements might create an interactive, informative toolset that supports both informed decision-making and active participation in climate resilience efforts across diverse user groups.

3.4. User Needs: Use Cases Among Project Consortium

As an exemplary use case study, we performed a survey among the Mission CE Climate project partners and their stakeholders to generate an idea what partners might consider to be relevant for their dashboard development.

Questions of the survey included:

1. *Which environmental indicators are the most important for your field of expertise? Select by relevance (1 = not relevant; 5 = highly relevant)*
2. *Any other information or indicators that you suggest for the dashboard?*
3. *What climate-related information is most valuable for citizens from your perspective? Please select by relevance (1 = not relevant, 5 = highly relevant).*
4. *How should citizens interact with the dashboard? Please select one or more options*
5. *What else should the dashboard include to support your field of work?*
6. *Do you have any examples of good citizen engagement for dashboards?*
7. *What is your field of expertise?*

For Question 1 "*Which environmental indicators are the most important for your field of expertise? Select by relevance (1 = not relevant; 5 = highly relevant)*" the raw indicators were rated as follows:

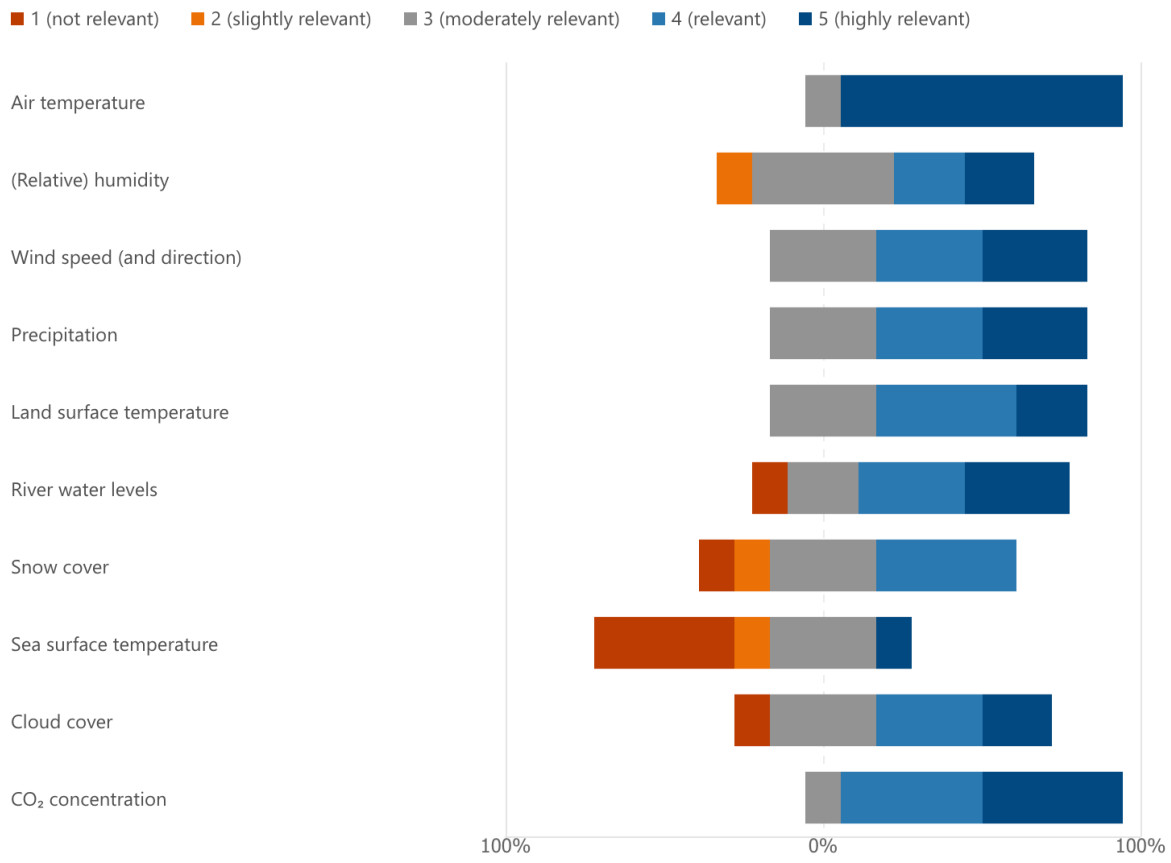


Figure 4: Exemplary consortium response to the question "Which environmental indicators are the most important for your field of expertise? Select by relevance (1 = not relevant; 5 = highly relevant)?"

For Question 3 "*What climate-related information is most valuable for citizens from your perspective? Please select by relevance (1 = not relevant, 5 = highly relevant)*" information categories for citizens was rated as follows:

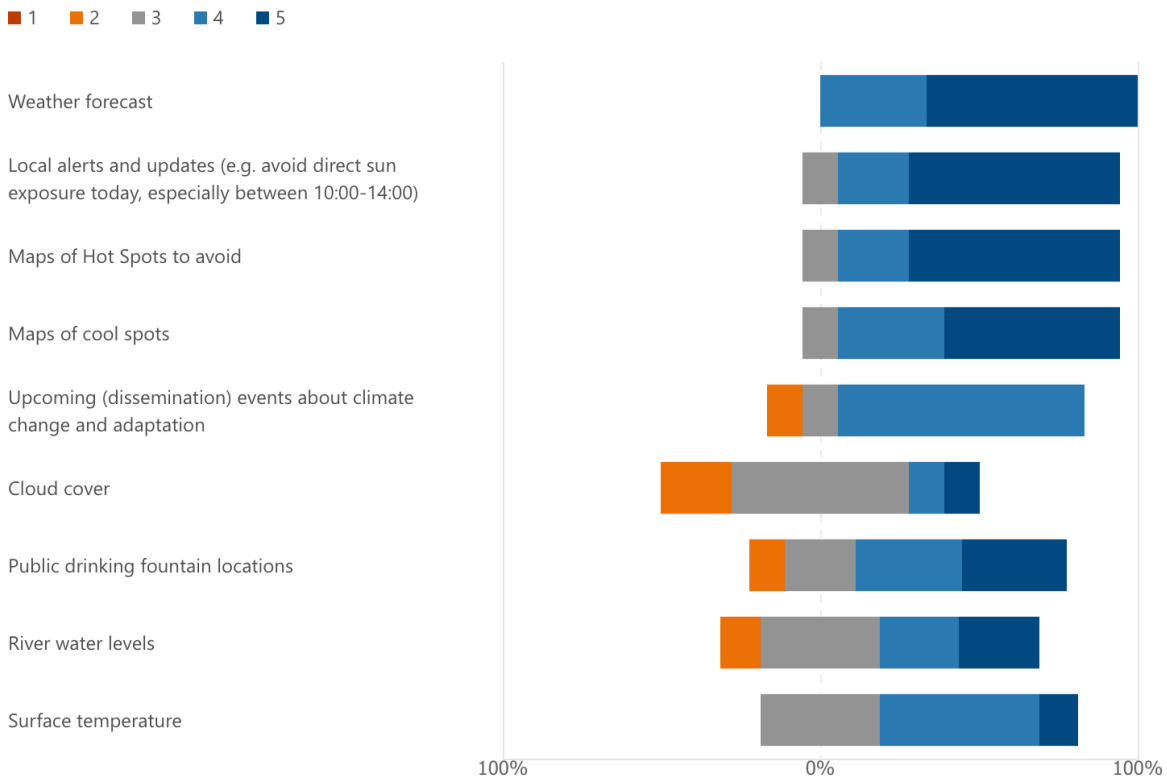


Figure 5: Exemplary response to the question "What climate-related information is most valuable for citizens from your perspective? Please select by relevance (1 = not relevant, 5 = highly relevant)."

For Question 5 citizen interaction with the dashboard was rated as follows:

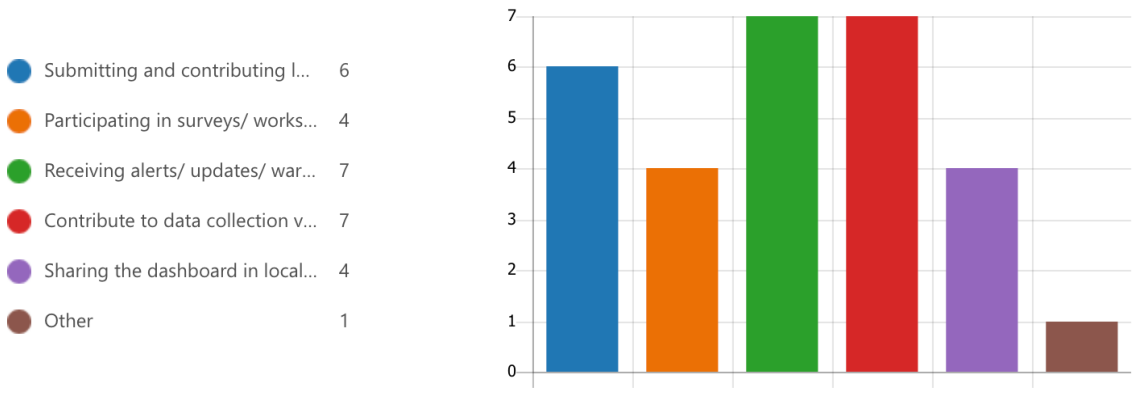


Figure 6: Exemplary response to the question "How should citizens interact with the dashboard? Please select one or more options"

3.4.1. Awareness Raising / Citizens Information

Designing effective awareness-raising programmes using modular climate resilience dashboards involves several key methods. Programmes typically start with stakeholder engagement and assessment of needs, ensuring that the dashboard content and features address target audiences' specific concerns and information gaps. Modular design allows dashboards to be tailored for different user groups—for example, providing high-level visualisations and actionable tips for citizens while offering in-depth data and monitoring tools for professionals and policymakers. Iterative co-design with stakeholders, including feedback loops and participatory workshops, enhances dashboard usability and relevance. Outreach strategies frequently combine dashboard launches with communication campaigns, interactive workshops, and digital storytelling to contextualise data and translate insights into practical community action. Additionally, embedding citizen science modules invites community contributions to climate monitoring, fostering ownership and boosting grassroots awareness. Programme success is further supported through ongoing evaluation and updates, informed by usage analytics and community input, to keep the dashboard content relevant and the engagement sustained over time. Adequate marketing and information campaigns may support the efforts.

Further information can be found in:

European Commission. (2021). *Resilience Dashboard for the social and economic, green, digital, and geopolitical dimensions*. https://commission.europa.eu/system/files/2021-11/dashboard_report_20211129_en.pdf

https://library.wmo.int/records/item/69061-2024-state-of-climate-services-five-year-progress-report-2019-2024

D. Existing Tools & Initiatives for Digital Solutions

4. Existing Tools & Supporting Initiatives

A plethora of tools, i.e., software solutions, exist to support the development of dashboards. Similarly, (technological) initiatives towards base technologies from the European Commission may aid the development of digital solutions. In the following, we give a brief overview over these tools and initiatives.

4.1. Existing tools

Several types of software tools and libraries are available to support the development of climate resilience dashboards, each catering to different development contexts and user needs. Open-source libraries, such as OpenClimateGIS and the tools provided by the Copernicus Climate Data Store, offer developers customizable frameworks and programmatic access to climate data for flexible and transparent solution building. Closed source, commercial solutions like those from Jupiter Intelligence provide integrated, enterprise-level platforms with ready-to-use climate analytics and user-friendly interfaces, typically tailored for business or governmental use (Jupiter, 2025). Some tools, such as the CLIMADA-App, bridge the gap by providing open-source modelling with a desktop user interface for ease of use by less technical users, while platforms like the CLIMAAX toolbox combine web-based environments for interactive visualization and offline downloadable components for advanced, standalone usage (American Planning Association, 2025; CLIMAAX, 2025; EIOPA, 2025; Jupiter, 2025).

The landscape thus includes both libraries for flexible, code-driven development and complete tools with graphical frontends requiring minimal programming experience. Web-based software facilitates collaboration and broad accessibility, allowing multiple users to access, visualize, and update climate data in real time, whereas standalone software is suitable for offline, high-performance processing or private data environments. This diversity ensures that climate resilience dashboard development can be tailored for varying technical expertise, security requirements, and use cases—from community-level awareness raising to large-scale professional climate risk assessment (American Planning Association, 2025; CLIMAAX, 2025; EIOPA, 2025; Jupiter, 2025).

When developing digital solutions, especially dashboards from scratch, one may use a dedicated developer (compare e.g., Dornbirn pilot dashboard provider weavs[4]). If a digital solution, which is established from scratch should be based upon common dashboard tools, one may use the following table in Figure 7. Please note, that these tools might not be climate resilience specific but rather generic data processing and dashboard tools.

[4] Citymonitor - Die Urbane Datenplattform für Smart Cities: https://www.city-monitor.com/

Tool	Power BI (Microsoft)	Grafana	Tableau	Kibana	Domo	Metabase	Looker (Google)	Redash	Plotly	Qlik Sense
Dashboard availability for end consumer	Requires Pro or Premium license for sharing; free users can view shared content (no account needed to view shared reports; link)	Free and paid versions; no account needed for public dashboards	Requires license; free public version available	Free and paid versions; no account needed for public dashboards	Requires license; no free public version	Free and paid versions; no account needed for public dashboards	Requires license; no free public version	Free and paid versions; no account needed for public dashboards	Free and paid versions; no account needed for public dashboards	Requires license; no free public version
Server location	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant	Multiple global locations; GDPR compliant
API connectability	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration	Extensive API support; easy integration
User friendliness (project team)	Moderate learning curve; familiar to Office users, though	Moderate learning curve	Moderate learning curve	Moderate learning curve	Moderate learning curve	Moderate learning curve	Moderate learning curve	Moderate learning curve	Moderate learning curve	Moderate learning curve
Data visualization options	Area charts (Basic, Stacked) Bar and column charts Cards (Multi-row, Single number) Combo charts Decomposition tree Doughnut charts Funnel charts Gauge charts Key influencers KPIs Line charts Maps (Basic, Filled, ArcGIS) Matrix Pie charts R script visuals Ribbon charts Scatter and bubble charts Slicers Stacked area charts Table Treemap Waterfall charts Custom visuals from AppSource	Bar charts Line charts Pie charts Heatmaps Histograms Graphs Tables Single stat panels Gauge panels Text panels Custom plugins and panels	Bar charts Line charts Pie charts Maps Scatter plots Gantt charts Bubble charts Histograms Bullet graphs Heat maps Highlight tables Treemaps Box plots Waterfall charts Word clouds Custom visuals	Bar charts Line charts Pie charts Area charts Data tables Heatmaps Maps Tag clouds Timelion (time series) Vega visualizations Custom plugins	Bar charts Line charts Pie charts Maps Scatter plots Histograms Bullet graphs Heat maps Treemaps Box plots Waterfall charts Word clouds Custom visuals	Bar charts Line charts Pie charts Area charts Tables Maps Scatter plots Heatmaps Custom visual	Bar charts Line charts Pie charts Area charts Tables Maps Scatter plots Heatmaps Treemaps Box plots Waterfall charts Custom visuals	Bar charts Line charts Pie charts Area charts Tables Maps Scatter plots Heatmaps Custom visuals	Bar charts Line charts Pie charts Area charts Tables Maps Scatter plots Heatmaps Treemaps Box plots Waterfall charts 3D charts Custom visuals	Bar charts Line charts Pie charts Area charts Tables Maps Scatter plots Heatmaps Treemaps Box plots Waterfall charts Custom visuals
Time intervals of data refresh	Up to 48 times/day (every 30 mins); live data options (will be disabled in 2027, though)	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options	Up to 48 times/day; live data options
Pricing	should already be part of our MS suite	Free and paid versions	Starting at $70 per month	Starting at $95 per month (some sources state there are free versions; I can't find it on Kibana's Website, though)	Custom pricing	Free and paid versions (free is self hosted!!)	Custom pricing (complex)	Free but self hosted!	Custom pricing	Starting at $850 per month
Closed/open source	Closed source	Open source	Closed source	Open source	Closed source	Open source	Closed source	Open source	Open source	Closed source
Support	Extensive support	Community and paid support	Extensive support	Community and paid support	Extensive support	Community and paid support	Extensive support	Community and paid support	Community and paid support	Extensive support

Figure 7: Overview software for digital tools & dashboards

The table provides a comparative overview of several popular dashboard tools widely used for data visualisation and reporting, highlighting key features relevant for the development of climate resilience dashboards. It covers ten tools: Power BI (Microsoft), Grafana, Tableau, Kibana, Domo, Metabase, Looker (Google), Redash, Plotly, and Qlik Sense.

Each tool is evaluated across multiple criteria important for dashboard implementation. The table includes information about the availability of dashboards for end users, noting whether each tool offers free or paid versions and the requirements for user access. Most tools operate on multiple global server locations and comply with GDPR, which ensures data protection and privacy.

API connectivity is available and easily supported across all tools, facilitating integration with diverse data sources. However, all tools have at least a moderate learning curve for project teams, indicating that while they are powerful, some familiarity or training is necessary for effective use.

The data visualisation options vary among tools, with some like Power BI and Tableau offering a very wide range of chart types such as bar charts, pie charts, heatmaps, scatter plots, waterfall charts, and custom visuals. More specialised visualisations including decomposition trees, R script visuals, and 3D charts are also supported by some tools. This variety allows for tailored presentations of complex climate resilience data.

Regarding data refresh capabilities, most tools support live data updates up to 48 times per day, facilitating near-real-time monitoring. Pricing models differ significantly; some tools have free tiers or versions included in broader software suites (e.g., Power BI within Microsoft 365), while others require monthly subscriptions or custom pricing, with prices ranging roughly from $70 to $850 per month or more.

Another critical distinction is in open-source versus closed source-licenses. Tools like Grafana, Kibana, Metabase, Looker, and Redash are open source with community and paid support, allowing for more customisation and transparency. Closed source tools such as Power BI, Tableau, Domo, Plotly, and Qlik Sense offer extensive vendor support but may entail higher costs and less customization flexibility.

For dashboard development practitioners, this table may help identify appropriate dashboard tools by balancing factors such as user accessibility, visualisation capabilities, data integration, cost, licensing type, and technical support, all of which are necessary for creating effective, user-friendly climate resilience dashboards tailored to varied stakeholder needs.

4.2. Supporting Initiatives

Main supporting technological initiatives on a European level include Copernicus and FI-WARE. Key highlights of both programmes are shown below.

4.2.1. Copernicus and other Earth Observation (EO) Data

The European Commission has launched several important initiatives to provide extensive data sources for climate-related research and applications, with the Copernicus programme being a flagship effort in this regard. Copernicus is the European Union's Earth observation and monitoring programme, offering full, free, and open access to environmental data based primarily on satellite Earth observation and complementary in situ data (Climate ADAPT, 2025). Copernicus encompasses six core services, among which the Copernicus Climate Change Service (C3S) focuses on providing authoritative information about past, present, and future climate conditions to support climate change mitigation and adaptation strategies across Europe. The service is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the Commission and offers access to a wide range of climate indicators and indices through its Climate Data Store.

A key component of Copernicus is the Sentinel satellite series (overview see in Table 2: Overview Sentinel Satellites), which provides critical Earth observation data covering atmosphere, land, oceans, and ice. Sentinel satellites serve as cornerstone satellites for delivering high-resolution, timely, and continuous data that underpins many climate monitoring applications. Sentinel data contribute to diverse sectors such as agriculture, forestry, water management, and disaster response, all of which help enhance climate resilience. Other Copernicus services, including the Copernicus Atmosphere Monitoring Service (CAMS), deliver quality-controlled information on air quality, greenhouse gases, and climate forcing, complementing climate data with atmospheric composition insights. Together, these initiatives ensure that public authorities, researchers, businesses, and citizens can access reliable, up-to-date climate data to inform policy, enhance early warning systems, and foster climate-resilient communities throughout Europe. The open data policy of Copernicus maximizes the potential for innovation and the development of downstream applications benefiting society and the environment.

Table 2: Overview Sentinel Satellites Capabilities

SATELLITE	PURPOSE	FEATURES	APPLICATIONS	MAIDEN

				LAUNCH
Sentinel-1[5]	Radar imaging for land and ocean services	Operates day and night, in all weather conditions	Monitoring sea ice, oil spills, and land surface movements	2014
Sentinel-2[6]	High-resolution optical imaging for land monitoring	Multispectral imaging with 13 bands[1]	Vegetation, soil, water cover, inland waterways, and coastal areas monitoring	2015
Sentinel-3[7]	Measuring sea-surface topography, sea and land surface temperature, and ocean and land colour	Multi-instrument mission[2]	Ocean forecasting, environmental and climate monitoring	2016
Sentinel-4[8]	Atmospheric monitoring	Embarked on a Meteosat Third Generation-Sounder (MTG-s) satellite in geostationary orbit[3]	Air quality and climate monitoring	2024
Sentinel-5[9]	Monitoring the atmosphere from polar orbit	Measures trace gasses and aerosols	Air quality and climate monitoring	2017
Sentinel-6[10]	Measuring global sea-surface height	Carries a radar altimeter[4]	Operational oceanography and climate studies	2021

4.2.2. FI-WARE technologies

The FIWARE programme by the European Commission and its community provides an open-source framework of components designed to accelerate the development of smart digital solutions, including those aimed at climate resilience. FIWARE's modular architecture and open standards enable the integration, management, and processing of diverse data streams from sensors, IoT devices, open data sources, and user inputs, which are crucial for building responsive, adaptive climate resilience dashboards and applications (FIWARE, 2025).

Several FIWARE components are particularly useful for climate resilience solutions:

[5] Sentinel 1 - https://sentiwiki.copernicus.eu/web/sentinel-1
[6] Sentinel 2- https://sentiwiki.copernicus.eu/web/sentinel-2
[7] Sentinel 3 - https://sentiwiki.copernicus.eu/web/sentinel-3
[8] Sentinel 4 - https://sentinels.copernicus.eu/en/web/sentinel/missions/sentinel-4/data-products
[9] Sentinel 5 - https://sentiwiki.copernicus.eu/web/sentinel-5p
[10] Sentinel 6 - https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-6

- The Orion Context Broker is the core element that manages context information, allowing real-time updates and interoperability between different data sources and applications.
- The Data Models and NGSI API standards facilitate standardised data exchange, supporting seamless integration of heterogeneous environmental data such as air quality, temperature, and humidity measurements.
- Generic Enablers like IoT Agents enable connection to various sensor types and protocols, essential for capturing local environmental data and citizen science inputs.
- Components like Complex Event Processing (CEP) tools analyse data streams to detect critical conditions such as extreme weather events or pollution spikes, triggering alerts or automated responses.
- Visualization support through FIWARE's dashboards and integration with third-party tools enhances data presentation for different stakeholders, from citizens to policymakers.

Use cases powered by FIWARE demonstrate practical applications, such as the ApriSensor platform for localised air quality monitoring, RainBrain for smart management of green roofs, and IDA for automated climate risk assessment in insurance (FIWARE Foundation, 2019).

These examples show how FIWARE's components enable scalable, interoperable, and replicable climate resilience solutions that engage communities, and may help to optimise resource use, and improve decision-making under climate stress.

The open-source nature of FIWARE combined with its flexible architecture encourages innovation, cost-effectiveness, and the broad inclusion of stakeholders in climate resilience efforts.

E. Good Practices - Pforzheim

In order to collect dashboards and digital solutions within the Mission CE Climate consortium, which can be classified as good practices, we defined a template which can be found in Appendix I.

5. General Information

The Mission Climate Digital Monitoring Platform is not a monolithic product from a single vendor, but a strategically curated ecosystem of best-in-class technologies designed for flexibility, scalability, and long-term viability. This approach ensures that each component of the solution is optimized for its specific function, from the sensor at the edge to the analytical dashboard in the cloud. The key technology providers and partners in this ecosystem include:

- **Hardware:** LoRaWAN-based IoT sensors provide a highly efficient and scalable solution for environmental monitoring by enabling wireless data collection from a wide variety of physical and chemical parameters—such as temperature, humidity, air quality, soil moisture, and water levels—across large and even remote areas. These battery-operated sensors are designed for low power consumption, offering battery life of up to ten years, and can transmit data over several kilometres, making them extremely cost-effective and suitable for hard-to-reach sites. The gathered data is securely transmitted to gateways and then to cloud servers, where it can be visualized and analyzed in real time, supporting immediate action and long-term planning for applications in fields like smart agriculture, urban infrastructure, disaster prevention, and biodiversity protection.

- **Network Infrastructure:** The Things Network (TTN) provides the primary LoRaWAN Network Server (LNS), offering a globally distributed, scalable, and professionally managed network infrastructure that accelerates deployment and ensures high reliability. The Mission Climate team also possesses demonstrated internal competency in deploying and managing alternative open-source LNS solutions like Chirp Stack, as validated in internal projects. This dual capability represents a significant strategic advantage, offering long-term autonomy from any single provider and ensuring adaptability to future network requirements.

- **Software Platform**: enerchart is the central IoT platform that serves as the system's analytical and visual core. It provides the essential tools for data ingestion, device management, visualization, dashboarding, and advanced analytics, transforming raw data streams into actionable intelligence. A central role in making this sensor data truly actionable is played by software platforms such as enerchart. Enerchart acts as the integrative digital hub of LoRaWAN IoT systems. It provides a comprehensive suite of tools for real-time data ingestion from sensors, device management, visualization, dashboarding, and advanced analytics. With enerchart, data from many different sources—including various LoRaWAN networks and sensor

payloads—can be unified and normalized, thanks to its modular architecture and dedicated payload parser. The platform's open approach means users have full access to their collected data and can interface with external systems through multiple supported standards (like Modbus TCP, OPC UA, SNMP, or common IoT clouds such as The Things Network and Chirpstack). Enerchart enables interactive dashboards, custom maps, and configurable analytics that transform raw IoT data streams into actionable intelligence. This empowers organizations to detect patterns and anomalies, conduct energy and environmental management in compliance with standards like ISO 50001, and generate meaningful reports for operational or regulatory needs. As a result, enerchart not only ensures seamless integration of IoT sensor data but also supports data-driven decision-making, driving both sustainability and efficiency in environmental monitoring initiatives.

6. Digital Solution

6.1. Digital Solution - Description

The Mission Climate Digital Monitoring Platform (MCDMP) is an integrated, end-to-end Internet of Things (IoT) solution designed to empower communities with the data and tools necessary for effective, evidence-based climate action. It leverages a low-power, wide-area network (LoRaWAN) to collect granular, real-time environmental and operational data from a diverse array of sensors deployed across the community. This data is then aggregated, visualized, and analyzed via the powerful enerchart platform, transforming raw sensor readings into actionable intelligence for a wide range of stakeholders, including urban planners, civil engineers, public works departments, and citizens themselves.

The project covers several innovative smart city use cases, each leveraging IoT sensor technology for sustainability and citizen engagement. Key use cases include monitoring water levels for flood prevention, tracking air quality and climate data in urban environments, optimizing road salt silo management for efficient winter maintenance, and analyzing soil conditions for sustainable land management. Additional cases focus on real-time traffic radar measurement and people counting systems to enhance urban mobility and energy efficiency. Each use case integrates sensor data into a central dashboard and features citizen participation through DIY sensor installations and collaborative data analysis.

Technology Stack: The technology stack for the Mission Climate Digital Monitoring Platform is a modular ecosystem integrating leading technologies for IoT-based environmental monitoring. LoRaWAN-based IoT sensors serve as the hardware layer, enabling energy-efficient, long-range, wireless collection of environmental data such as temperature, humidity, air quality, soil moisture, and water levels from even remote or hard-to-reach areas. The network infrastructure primarily relies on The Things Network (TTN) as the LoRaWAN server, with demonstrated in-house expertise for open-source alternatives like Chirp Stack, ensuring both reliability and long-term adaptability. The collected sensor data is centrally managed, visualized, and analyzed using the enerchart software platform, which provides real-time dashboards, analytics, and open interfaces, turning data into actionable insights to support environmental management and sustainable urban development.

Monitored Climate Indicators: The Project is designed to build climate resilience by developing and implementing innovative, smart city-based solutions for environmental monitoring and community engagement. At its core, the project empowers citizens, public institutions, and local authorities to collect, analyze, and act upon real-time climate data through a network of advanced IoT sensors, cloud analytics, and interactive dashboards. The pilot does not rely on a single product or provider but leverages a curated ecosystem of best-in-class hardware, network infrastructure, and software platforms, ensuring flexibility, scalability, and openness for future growth.

By monitoring a comprehensive set of climate indicators—ranging from air quality and soil moisture to flood risk, urban heat, and infrastructure health—the project delivers actionable insights for both immediate response and long-term planning. These indicators are directly linked to key climate adaptation and sustainability goals at the municipal level, enabling data-driven decision-making for public safety, environmental protection, energy efficiency, and citizen well-being. Through ongoing collaboration, testing, and feedback, the project advances public awareness, supports educational initiatives, and creates a robust foundation for replicable and scalable climate action across the region.

- **School Air Monitoring:** Air quality sensors installed in and around schools continuously measure concentrations of harmful pollutants like PM2.5 and NO_2. The collected data is visualized in real-time through dashboards, allowing for the early detection of pollution peaks associated with traffic patterns; directly linked to the climate indicator “urban air quality,” as pollution levels and exposure risk are critical for assessing the impact of emissions reduction and mobility interventions in cities.

- **Soil Moisture:** Citizen-deployed LoRaWAN soil moisture sensors in urban parks and community gardens gather hyper-local data on soil hydration. The results are mapped city-wide to guide efficient irrigation and drought response, supporting both public maintenance efforts and local initiatives; directly addresses the climate indicator “soil health and drought resilience,” since soil moisture trends reveal ecological impacts of climate change on urban greenery and water cycles.

- **Precipitation and Flood Risk**: Rain gauges and water level sensors managed by local residents deliver real-time, high-granularity measurements of rainfall intensity and flood risk across neighborhoods. This network feeds into flood preparation efforts and emergency planning dashboards; relates to “precipitation patterns and flood events” as climate indicators, providing vital evidence for changes in rainfall regimes and vulnerability to extreme weather.

- **Urban Heat**: Temperature and humidity are monitored with ground-based sensors and complemented by Copernicus satellite land surface data. This combination delivers detailed heat maps that help city planners understand and address the urban heat island effect; directly supports the indicator “urban temperature extremes,” crucial for monitoring heatwaves, public health risks, and the effectiveness of urban greening.

- **Road Salt Silo Levels:** Ultrasonic sensors in municipal road salt silos track fill levels, enabling responsive, data-driven logistics for winter road maintenance. The resulting operational gains lower emissions and ensure road safety during extreme cold events; aligns with the indicator "infrastructure resilience to extreme weather", as resource readiness and adaptive logistics are core to climate adaptation.

- **Water Levels in Infrastructure:** LoRaWAN sensors in rivers, canals, and storm drains monitor water levels over time, feeding into predictive dashboards for flood prevention. Alert systems help avoid infrastructure failure and manage stormwater; tied to "hydrological extremes and urban flood management" as climate indicators, since real-time hydrology data underpin adaptation to increased precipitation variability.

- **Soil Nutrients and pH**: Advanced sensors with AI-based analytics track soil moisture, nutrient content, and pH in urban gardens and parks. This enables tailored fertilization and plant care, optimizing green infrastructure resilience; corresponds to "urban soil quality and ecosystem services", a climate indicator reflecting city-level food sufficiency, biodiversity, and carbon sequestration capacity.

- **Outdoor Temperature and Humidity:** Distributed sensors continuously record temperature and humidity, establishing a long-term baseline for environmental conditions. This foundational data validates the impact of climate mitigation and adaptation strategies; core to tracking climate indicators like "ambient temperature and relative humidity", enabling evidence-based progress assessment.

- **Microclimate Accuracy**: High-precision sensors, some shielded to avoid solar bias, are installed at strategic points to capture accurate microclimate data. These data sets improve urban climate models and help set standards for scientific monitoring; directly serves "local microclimate variability" as a climate indicator, which is essential for fine-tuned city adaptation plans.

- **Traffic Flow**: Digital radar sensors count vehicles, measure speeds, and classify types across major intersections, feeding data into visualized analytics for congestion, emissions, and safety planning; strongly related to "urban mobility emissions and congestion", as observed traffic trends influence air quality, energy use, and the city's climate footprint.

- **Public Space Occupancy:** Infrared people counters at park and square entrances track the use of public spaces, providing data for efficient facility management and event planning; relates to "urban resilience and adaptive public space usage", climate indicator reflecting community adaptation, well-being, and effective use of green infrastructure.

- **Indoor Environment Quality**: Indoor sensors in municipal buildings measure temperature, humidity, and CO_2 levels, informing energy-saving ventilation

strategies and improving occupant health; these data support tracking "energy efficiency and indoor air quality"—climate indicators linked to building sector emissions, adaptation, and public health.

- **Sewer Gas and Humidity:** Ruggedized sensors track key gases (H_2S, CH_4) and humidity in the sewer network, helping identify maintenance needs and flagging risks; this feeds into the indicator "urban sanitation and climate-induced risk management", ensuring critical infrastructure remains resilient as weather patterns change.

- **LoRaWAN Network Health**: Infrastructure sensors report on the operational status and signal strength of the wireless network, providing early warning for communication issues in the sensor grid; directly supports the climate indicator "infrastructure robustness and monitoring capacity", as a functioning network is foundational for data-driven resilience.

- **Privacy-respecting People Detection:** Edge-computing AI cameras count people in public buildings without storing video, offering accurate occupancy data while maintaining privacy; addresses the indicator "adaptive building occupancy and privacy protection", which supports energy efficiency, crisis response, and social acceptance in climate-resilient cities.

Geographical Coverage: Pilot Project in Pforzheim and the Northern Black Forest

6.2. Target Group

6.2.1. Who uses the digital solution?

Local governments and municipalities
Use: Actively use dashboards and alerts for city management, emergency planning, and infrastructure maintenance. Passively benefit from automated monitoring and reports for policy evaluation.

Urban planners
Use: Actively consult data to guide urban development, design interventions for climate adaptation, and monitor the effects of green infrastructure. Passively access historical trends for strategic planning.

Experts (nature conservation, civil engineering, meteorologists, etc.)
Use: Actively analyze specialized sensor data to support technical decisions, risk assessment, and environmental protection. Passively utilize ongoing data streams for research and reporting.

NGOs

Use: Actively engage in citizen science campaigns, deploy sensors in targeted projects, and use data for advocacy. Passively benefit from transparent, real-time access to environmental conditions.

Research institutions
Use: Actively conduct studies based on raw sensor data, develop new analytical methods, and publish findings. Passively gain long-term, open datasets for academic analysis.

Other stakeholders (e.g., schools, businesses, citizens)
Use: Schools use live environmental data for STEM education (active); businesses adjust operations based on climate and air quality info (active/passive); citizens receive alerts and view dashboards for personal awareness (passive).

Active use: Direct interaction with the digital platform—installing sensors, managing dashboards, analyzing real-time data, or making operational decisions.

Passive use: Receiving automated alerts, accessing published reports or visualizations, and integrating trends into background planning and awareness without direct system management.

6.2.2. Stakeholder collaboration?

The Mission CE Climate Pilot Project is fundamentally rooted in robust stakeholder collaboration that spans local communities, academia, municipal authorities, advisory boards, NGOs, and research organizations. Community members are actively engaged through citizen science activities, where residents participate directly in sensor deployment and data gathering, ensuring that local knowledge and grassroots perspectives are integrated into environmental monitoring. Academia, particularly institutions like Hochschule Pforzheim, play a pivotal role in guiding the project's scientific rigor—leading technical prototyping, advanced data analytics, and validation of climate indicators, while also facilitating interdisciplinary teamwork and applied research. Close partnership with municipal authorities and their technical agencies ensures that the digital solutions respond directly to the real needs of city management, policy implementation, and resilience planning. Advisory boards, made up of experts from fields such as urban planning, environmental protection, and civil engineering, provide critical strategic direction and oversight, aligning project activities with policy priorities and national or European sustainability frameworks. NGOs and additional civil society actors contribute their specialized expertise, support outreach for environmental and social initiatives, and help drive public participation in project campaigns. These interconnected relationships foster transparency, shared responsibility, and cross-sector learning—laying a strong foundation for the success and future scalability of data-driven climate resilience in the region.

6.3. (Expected) Impact

The Pilot Project is designed to drive environmental monitoring and engagement through the deployment of smart city-based digital solutions. By harnessing the power of IoT sensors, participatory citizen science, and collaborative partnerships among

municipalities, academia, NGOs, and local communities, the project aims to strengthen climate resilience and promote sustainable urban development. The initiative brings together diverse stakeholders to collect, analyze, and act upon environmental data, supporting evidence-based decision-making and fostering public awareness about pressing climate and environmental issues. This integrated approach not only improves operational efficiency and policy effectiveness but also deepens the involvement of citizens and community groups in shaping solutions for a more sustainable and adaptive future.

Impact Dimension	Qualitative Outcomes	Quantitative Outcomes
Environmental Awareness	Citizens gain deeper understanding of local climate risks and sustainability topics through direct, hands-on participation. Enhanced public dialogue around environmental issues and climate adaptation.	Over 250 citizens attended the main public event; increased participation rate in citizen science activities (to be measured annually).
Evidenced-based Policy Making	Municipal officials and planners use real-time, granular sensor data to inform decisions, prioritize interventions, and monitor the results of climate adaptation strategies.	Number of policy interventions or planning adjustments informed by project data (target: 5+ per year).
Operational Efficiency	Automated data flows support faster response to weather, infrastructure, or environmental incidents (e.g., floods, road salt management), improving public safety and resource allocation.	Reduction in field staff deployment and response times for maintenance (target: -20%). Road salt logistics optimized (>10% fewer trips).
Community Engagement	Community members and NGOs collaborate more closely with local government, fostering mutual trust, knowledge-sharing, and co-creation of local solutions (“citizen science approach”).	Number of sensors co-installed by citizens (>50 by project end). Number of NGO partnerships (target: 3+ NGOs actively involved).
Educational Impact	Increased digital and environmental literacy for participants, especially students, through hands-on IoT activities and real-world data analysis.	Number of student projects utilizing project data (goal: >10 per year); feedback from workshops (target: 90% positive).

Impact Dimension	Qualitative Outcomes	Quantitative Outcomes
Data-driven Sustainability	Continuous monitoring and visualization (e.g., air quality, soil, flood risk) enables detection of trends, targeted intervention, and improved tracking of climate indicators for adaptation and resilience.	Volume of data points collected and visualized (target: millions per year). Number of new climate trends successfully identified.
Stakeholder Collaboration	Strengthened collaboration between academia, city, NGOs, and residents; new regional networks and transfer of best practices.	Joint reports, workshops, and presentations held (target: 6+ per year); cross-institutional projects initiated (target: at least 2).
Scalability & Replicability	Digital solutions and methodologies are documented and made available for replication in other municipalities or regions, contributing to national/EU climate resilience goals.	Number of replication pilots started by 2025 (target: at least 2 external cities/regions piloting similar approaches).
Public Safety and Risk Reduction	Faster, data-driven alerts for floods, traffic, air pollution, or facility management, reducing immediate risk to citizens and infrastructure.	Reduction in response time to environmental alerts; comparative before/after incident metrics (target: -25% average time to response).

6.4. Technical Implementation Details

The project employs a hybrid data sourcing strategy, combining the strengths of high-resolution ground-based sensors with the broad coverage of satellite-based remote sensing to create a comprehensive and multi-layered view of the community's environment.

Primary Source: Sensor Data - IoT (via LoRaWAN): This is the core data stream of the platform. It consists of real-time, time-series data generated by a distributed network of LoRaWAN sensors. This source provides the high-frequency, hyper-local "ground truth" that is essential for operational decision-making and detailed environmental analysis.

The platform is designed to handle and integrate the following types of data:

Time-series data: This is the continuous stream of measurements from the IoT sensors, where each data point is associated with a specific timestamp (e.g., temperature, humidity, air quality readings).

The architectural approach rooted in the use of open and widely-adopted standards to ensure maximum interoperability and future-proofing. The reliance on the LoRaWAN open standard for wireless communication, MQTT for data transport between network components, and the provision of open APIs by the enerchart platform ensures that the solution can seamlessly integrate with other municipal data systems (e.g., GIS platforms, asset management systems) and adapt to emerging technologies. This commitment to open standards prevents vendor lock-in and fosters a collaborative ecosystem where data can be easily shared and leveraged across different departments and applications.

6.5. Overview of Implementation

The process for deploying a new monitoring point on the MCDMP is a standardized and well-documented workflow, demonstrating the operational maturity of the solution. The implementation follows a logical progression from the physical device to the final data visualization.

Sensor Activation and Configuration: The first step takes place in the field. The specific sensor is activated and configured using its corresponding manufacturer's mobile application. For the recommended SenseCAP sensors, this is done via a Bluetooth connection using the SenseCraft app. For Milesight devices, configuration is performed via Near Field Communication (NFC) using the Milesight Toolbox app. This step involves setting key parameters such as the measurement and transmission interval.

Network Registration (TTN): Once configured, the sensor must be registered on the LoRaWAN network. This is done through The Things Network (TTN) console. The administrator adds a new end device to the appropriate application, manually entering the sensor's unique identifiers: the DevEUI (a global device identifier), the AppEUI (an application identifier), and the AppKey (a secret key used to secure the connection). The correct frequency plan (e.g., EU868) and LoRaWAN version must also be specified to ensure compatibility.
Platform Integration (enerchart): With the device now transmitting data to TTN, the final step is to integrate it into the enerchart platform. This involves a three-part process within the enerchart interface.

Device Registration: The new device is added as a data source within enerchart, linking it to the corresponding device in the TTN application.

Data Point Creation and Mapping: For each metric the sensor measures (e.g., temperature, humidity, battery), a corresponding data point is created in enerchart's evaluation structure. The incoming data fields from the TTN payload are then mapped to these newly created data points.

Structural Integration: The new data points are added to a logical evaluation structure (e.g., a structure for "Outdoor Environmental Monitoring"), which allows for aggregation and hierarchical analysis.

Visualization: The final step is to make the data visible and useful. Within enerchart, new charts (e.g., time-series line graphs) are created using the newly integrated data points as their source. These charts are then added to a new or existing dashboard, positioned, and sized as needed. Once the dashboard is saved, the sensor's data will begin to populate the charts in real time, completing the implementation process.

6.6. Screenshot

https://www.linkedin.com/pulse/streusalz-f%C3%BCllst%C3%A4nde-im-blick-mit-lorawan-und-schlauen-krutwig-riv9e/

Illustration 1:Streusalz-Silo in Pforzheim

This semester, the course “Managing of Emerging Technologies” at Pforzheim University under the direction of Prof. Dr. Bernhard Koelmel was offered. After a theoretical section on LoRa technology, the course was divided into individual teams, each of which was assigned its own smart city use case. Equipped with different LoRa sensors, each group was able to implement a typical use case from the Smart City sector.

This year, we were also able to count on the support of the City of Pforzheim and Stadtwerke Pforzheim (SWP), who provided us with interesting sensor technology and real-life scenarios as well as specific requirements. We would like to take this opportunity to express our sincere gratitude to our colleagues at the City of Pforzheim and SWP. This equipment not only enabled us to use high-quality hardware, but the expectation of useful research results also created a certain pressure to succeed, which led to excellent results.

Road salt is stored in high silos in many municipalities, and the city of Pforzheim has a total of 17 such containers. And these may well be filled with sufficient salt when winter sets in. Two to four fill level readings per day are sufficient for continuous monitoring, and even less frequently in summer, so the amount of data generated is perfectly suited to LoRa transmission. In addition to the suitability of the sensor, the study also assessed the complexity of the sensor configuration and network integration, so that the rollout to all silos remains enjoyable.

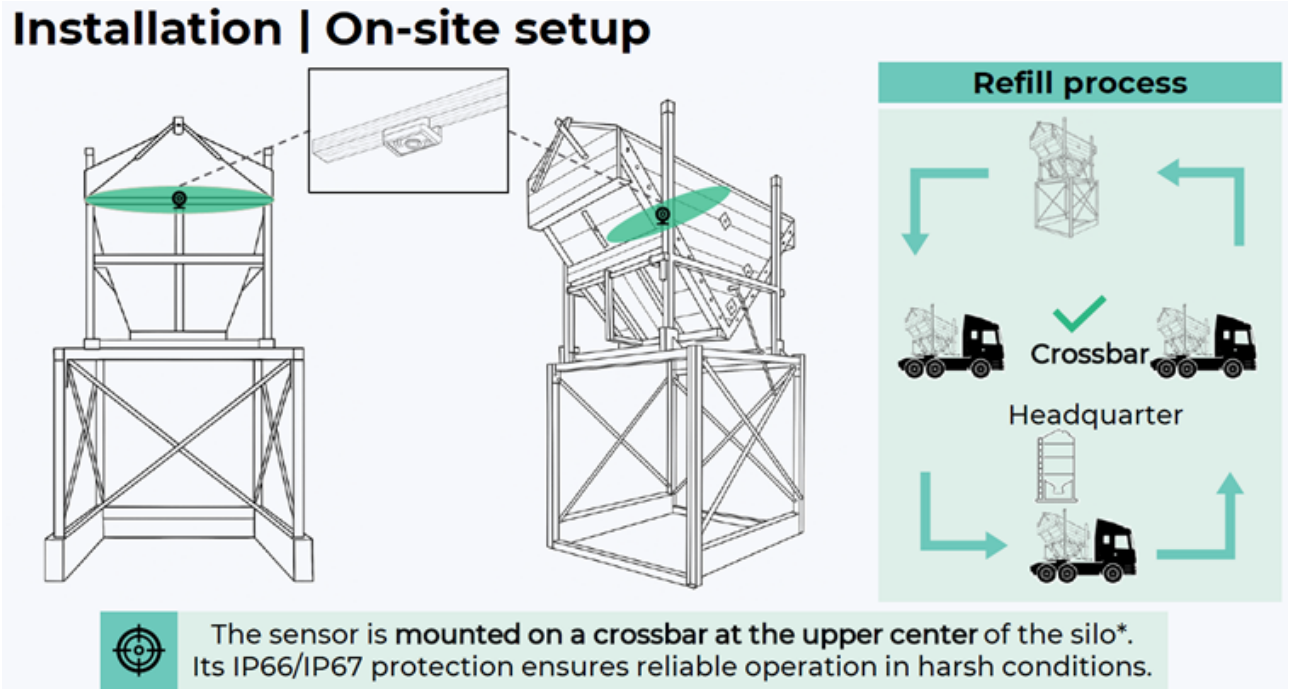


Illustration 2: Sketch of the sensor assembly

To keep track of the fill level in the silos, a WILSEN.sonic.level UCC400 ultrasonic sensor from Pepperl+Fuchs will be used. Mounted centrally on the inner top surface, it will measure the distance to the grit in the range from 0.25 m to 4 m. Thanks to IP67 protection, the device should be able to cope with dust, dirt, and moisture without any problems. The extent to which the salt will cause damage remains to be seen.

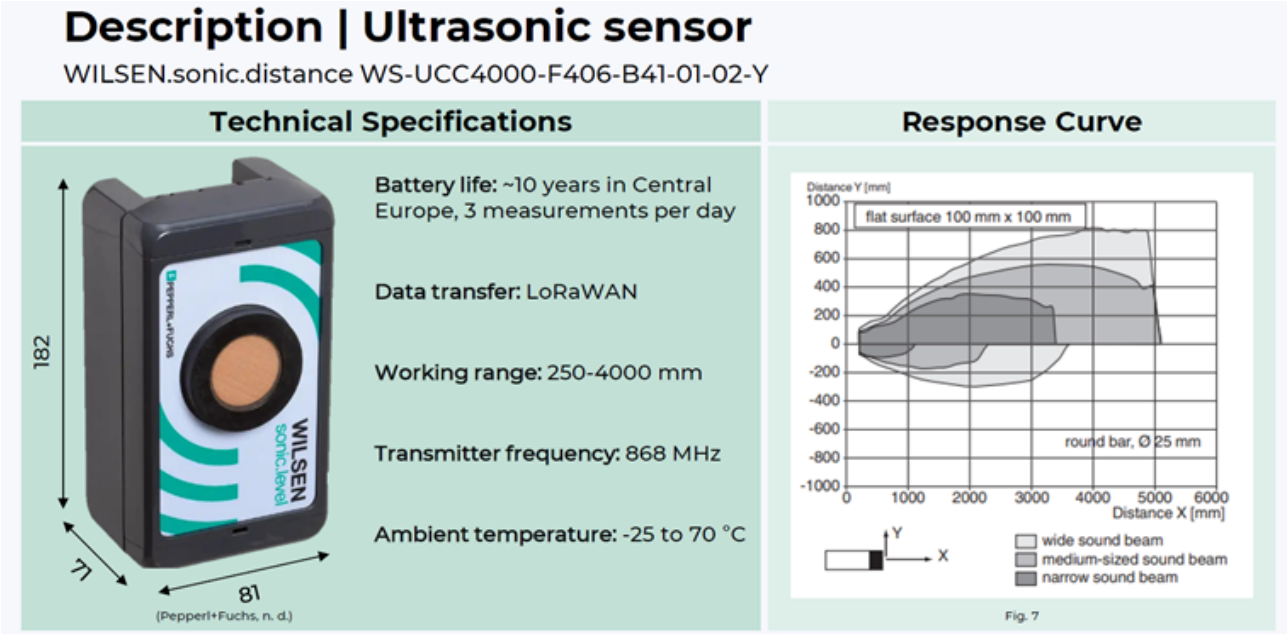


Illustration 3: Sensor Description

The TTN community network was used as the wireless counterpart (to be replaced later by the city's own infrastructure). During the TTN registration process, the students were able to successfully demonstrate their proficiency in nerdy topics.

Now it was time to create the dashboard in enerchart, which was essentially the final challenge, and one that was carried out with great detail and care in view of the promised grading. The dashboards go far beyond data visualization: they include the use case description, the sensor description (including manual download), illustrations, charts, statuses, interactive maps, and more. Unfortunately, the dashboard scrolls across four screens, so an overall view would be disadvantageous for this text. I will therefore limit myself to partial views; anyone who would like to see everything is encouraged to contact me. Incidentally, enerchart is actually a specialist in energy data—most of its functions were irrelevant to the project. However, it shows potential for use as a platform for a smart city (or smart building or smart production or ...).

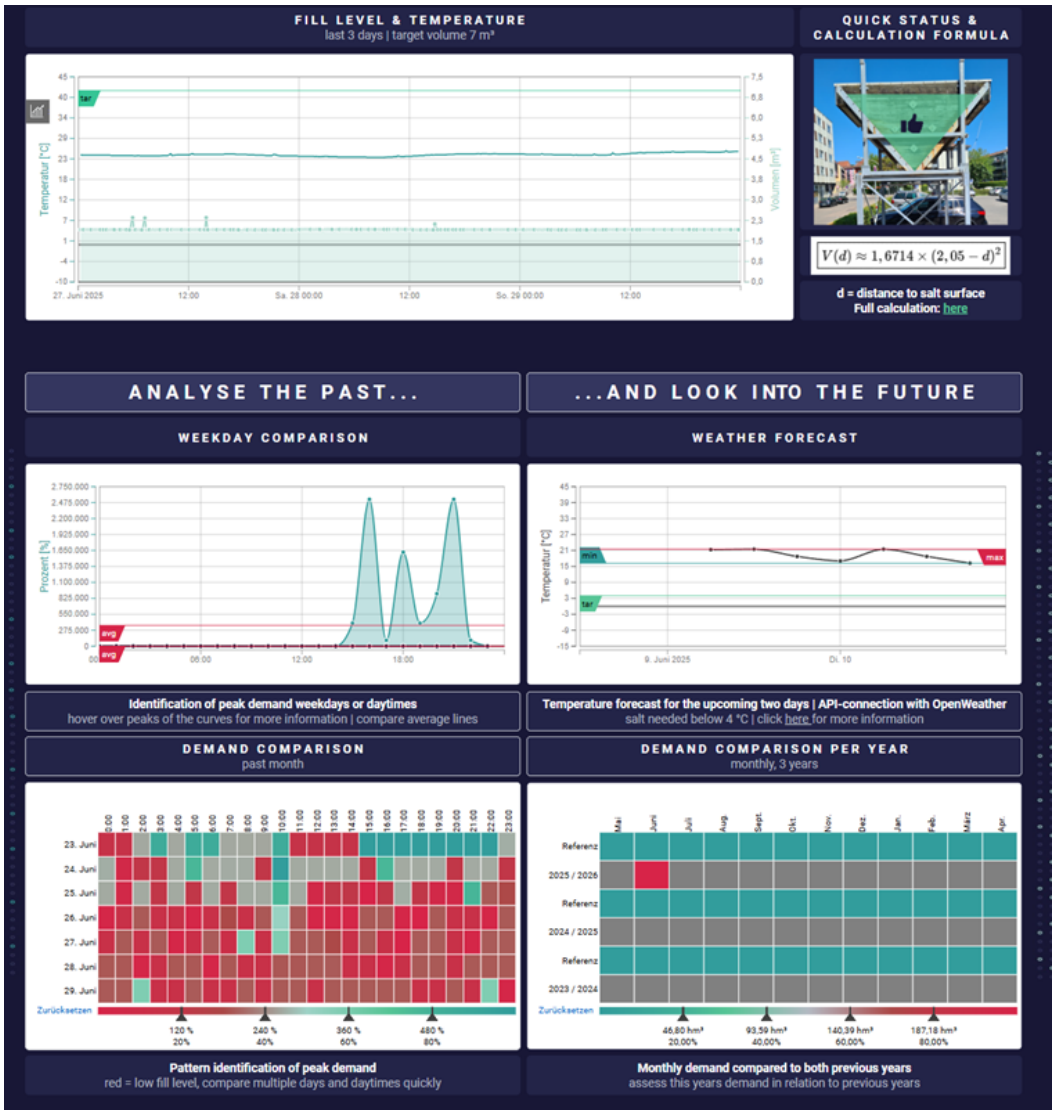


Illustration 4: enerchart Dashboard (excerpt)

I am every year amazed at how well students who have not received any training can use the software and exploit its full range of functions. It just goes to show how well you can get to grips with software – if you really want to. I would like to highlight two details that particularly impressed me: firstly, the formula for converting the fill level into the fill volume, taking into account the silo geometry, was easily implemented as a virtual data point using the integrated formula editor. Second, the function for illustrated statuses was used perfectly: an empty silo is colored red, half-full yellow, and full green (see image below). This is exactly how you build beautiful dashboards and control stations.

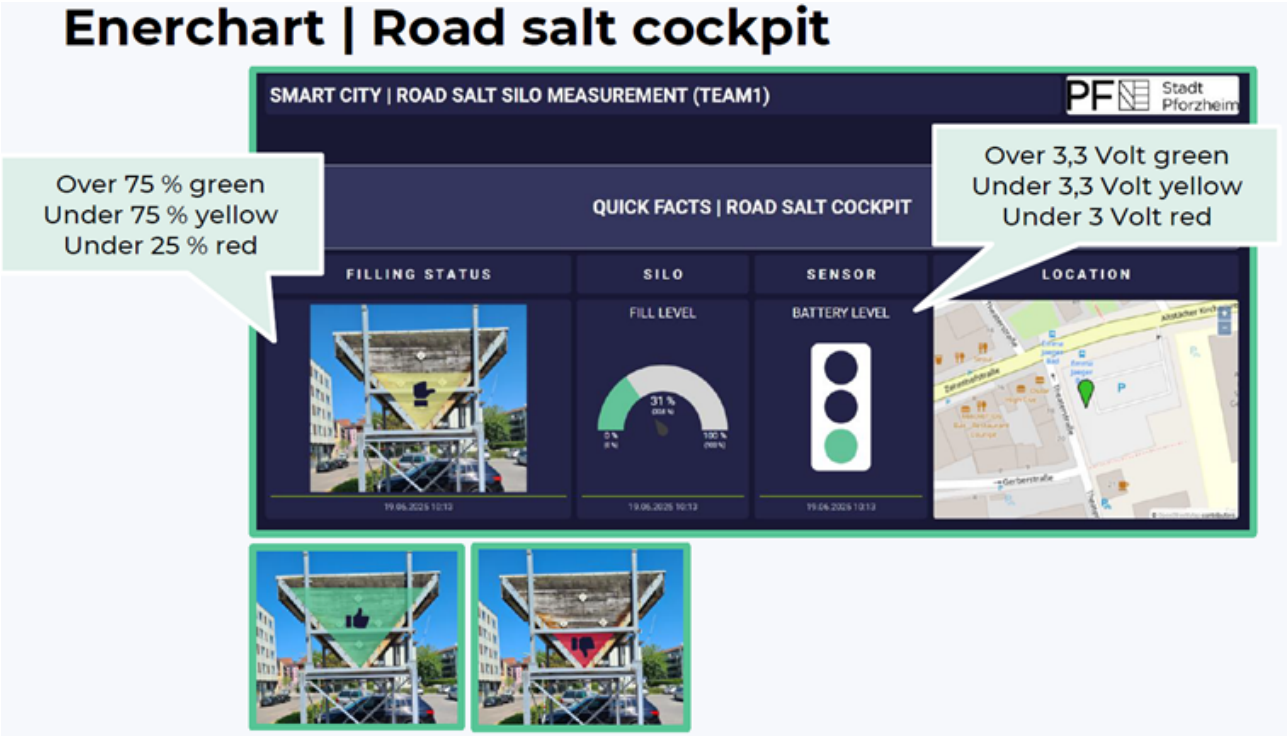


Illustration 5: Condition-dependent representation of the silo

Now the utility value explodes: in addition to the historical progression of sensor data (fill level, outside temperature) and various comparative analyses, a weather forecast has also been added. The students developed their own API for OpenWeather in Python and integrated this data into enerchart as well. The alarm is triggered as soon as the temperature is expected to drop below four degrees and the silo is not prepared for this. The students put a lot of thought into their ideas and implemented them perfectly.

The images are taken from the enerchart dashboards of the projects and/or from the presentation slides of the respective group. The project groups' presentations were given in English.

Smart City - Air Quality Monitoring with Milesight EM500

Outdoor Environment Monitoring Sensor zur Messung von Temperatur, Luftdruck, Luftfeuchtigkeit & CO2 Gehalt

Smart City Use Case

Luftqualitätsüberwachung in einer Smart City

Hintergrund	Anwendungsfall	Anwendungsfall - Balkon
Luftqualität in Städten: . kritisch für Gesundheit und Wohlbefinden **Verschmutzungsquellen:** . Verkehr, Industrie **Gesundheitliche Risiken:** - Atemwegserkrankungen - Herz-Kreislauf-Probleme, etc. **Luftqualitätsüberwachung:** - wichtiger Teil von Smart City Initiativen **Ziele:** - Verbesserung der Lebensqualität - Schaffung nachhaltiger Zonen	**Überwachung der Luftqualität** **Fokus:** . Stadtzentren, Schulen und Krankenhäuser **Vorteile:** . Kontinuierliche Überwachung - Schnelle Reaktion auf erhöhte Schadstoffwerte **Mögliche Maßnahmen:** - Temporäre Verkehrsbeschränkungen - Erhöhung der Grünflächen **Aktueller Standort:** - Balkon in dicht besiedeltem Gebiet in Höfingen - Nähe zu Schulen und Kitas	

Uber Milesight EM500-CO2 Sensor

Allgemeines und Anwendugsgebiet

Datenqualität	Standort	Sensorbild	Beschreibung
SNR-Wert dB 5,50 RSSI-Wert dBm -113		 Datenblatt	**Sensor-Funktionen:** . **CO2-Messung**: Bereich von 400 bis 5000 ppm **Zusätzliche Messungen (jede 10 Minute):** . Luftdruck . Temperatur . Luftfeuchtigkeit **Luftqualitätsanalyse:** - Kombination der vier Messwerte (CO2, Luftdruck, Temperatur, Luftfeuchtigkeit) ermöglicht zuverlässige Aussagen zur Luftqualität **Energieversorgung** - **Akku**: 19000 mAh - **Stromverbrauch**: Gering - **Nutzungsdauer**: Mehrere Jahre **Einsatzgebiete:** - **Umweltüberwachung**: Verschiedene Szenarien - **Gehäuse**: Sehr stabil, widersteht schwierigen Umweltbedingungen - **Professioneller Einsatz**: Geeignet für anspruchsvolle Anwendungen

Installation

Installationsbeschreibung für den Milesight EM500 CO2 Sensor

Vorbereitung

1. **Auspacken**: Sensor und Zubehör auspacken.
2. **Überprüfung**: Überprüfen, ob alle Teile vorhanden sind (Sensor, Batterie, Anleitung).

Hardware-Installation

1. **Batterie einlegen**: 19000 mAh Batterie in den Sensor einsetzen.
2. **Montageort wählen**: Einen geeigneten Standort für den Sensor auswählen
3. **Befestigung**: Sensor mit dem mitgelieferten Befestigungsmaterial montieren (z.B. an einer Wand oder einem Mast).

Konfiguration

1. **LoRaWAN**: Sensor in das LoRaWAN-Netzwerk integrieren (Details in der Anleitung).
2. **Kalibrierung**: Sensor gemäß Anleitung kalibrieren.

Milesight EM500-CO2 Sensor

Datenauswertung

7. Use Cases

The true power and versatility of the Mission CE Climate Digital Monitoring Platform are best understood through its diverse portfolio of practical use cases. Each use case represents a specific application of the platform's core capabilities to solve a real-world problem for a particular stakeholder group. The following table provides a comprehensive summary of the platform's demonstrated and potential applications, followed by detailed descriptions of each use case.

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
School Air Monitoring	Air Pollution	LoRaWAN air quality sensors (PM2.5, NO_2) on school grounds	Real-time graphs of pollutant concentrations on enerchart dashboards	Health risks from traffic-related air pollution; lack of tangible environmental education materials.	Adjusting school travel plans to reduce car arrivals/departures; integrating real-world data into STEM curricula.
Citizen-Led Soil Quality	Soil Health	Citizen-deployed LoRaWAN soil moisture sensors in urban green spaces	City-wide map of soil moisture levels on public enerchart dashboard	Water wastage from inefficient irrigation; declining health of urban trees and plants due to drought stress.	Data-driven irrigation scheduling for public works; targeted watering efforts by community volunteer groups.
Citizen-Led Flood Risk	Precipitation	Citizen-managed LoRaWAN rain gauges and water level sensors	Real-time precipitation intensity and flood risk map on enerchart dashboard	Lack of granular, real-time data on localized heavy rainfall events, leading to delayed flood response.	Proactive deployment of flood barriers by emergency services; operational planning for fire departments and civil engineering.
Urban Heat Monitoring	Urban Heat Islands	Copernicus satellite data (LST) fused with	Multi-layered enerchart dashboard	Increased public health risks during	Prioritizing urban greening interventions

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
		ground-truth LoRaWAN temperature/humidity sensors	showing heat maps and sensor readings	heatwaves; degradation of urban green spaces due to heat stress.	(e.g., tree planting, green roofs); strategic placement of public cooling centers.
Road Salt Silo Logistics	Winter Maintenance	LoRaWAN ultrasonic level sensors in road salt silos	enerchart dashboard showing real-time fill levels of all silos	Inefficient, schedule-based logistics; risk of resource depletion during critical winter weather events.	Just-in-time, route-optimized replenishment of salt supplies, ensuring road safety and reducing operational costs.
Predictive Flood Prevention	Infrastructure Resilience	LoRaWAN water level sensors in rivers, canals, and storm drains	Well-designed enerchart dashboard with alert thresholds and historical trends	Reactive response to flooding; potential for catastrophic failure of critical drainage infrastructure.	Early warning alerts for civil engineering; proactive management of sluice gates and pumps to mitigate flood impact.
AI-Enhanced Soil Analysis	Precision Agriculture	Advanced LoRaWAN soil sensors (moisture, pH, nutrients) with AI-configured sampling	enerchart dashboards with predictive analytics on soil health	One-size-fits-all approach to urban agriculture and park management; inefficient use of fertilizers and soil amendments.	Precision application of water and nutrients; tailored soil management plans for different urban green spaces.
Outdoor Environmental Monitoring	Baseline Monitoring	Standard LoRaWAN temperature and humidity sensors (e.g.,	Baseline time-series graphs and statistical summaries in enerchart	Lack of foundational environmental data for climate action	Establishing long-term climate trends; validating the impact of

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
		SenseCAP S2101)		planning and tracking progress over time.	environmental interventions.
Hyper-Local Urban Climate	Scientific Research	High-accuracy LoRaWAN sensors with custom 3D-printed radiation shields	enerchart dashboards for comparative analysis of shielded vs. unshielded sensor data	Inaccurate microclimate data due to measurement biases (e.g., solar radiation), leading to flawed models.	Improving the accuracy of urban climate models; developing best practices for scientific sensor deployment.
Advanced Traffic Analysis	Urban Mobility	LoRaWAN-connected traffic radar sensors	enerchart dashboard visualizing vehicle count, speed, and classification data	Traffic congestion leading to increased emissions and economic loss; lack of data for road safety analysis.	Optimizing traffic signal timing; identifying accident hotspots for infrastructure redesign; planning for future mobility needs.
Public Space People Counting	Urban Planning	LoRaWAN infrared people counters at entrances to parks and public squares	Visually strong enerchart dashboard showing footfall patterns over time	Inefficient management of public spaces; lack of data to justify investments in public amenities.	Optimizing maintenance schedules; planning for events; providing evidence for funding requests for park improvements.
Local AI People Detection	Privacy & Efficiency	LoRaWAN camera sensor with on-board (edge) AI for people detection and counting	enerchart dashboard showing anonymous people counts	Privacy concerns with traditional video surveillance; high bandwidth	Monitoring occupancy in sensitive areas (e.g., public buildings) while preserving privacy; efficient use of

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
				requirements for streaming video.	network bandwidth.
LoRaWAN Network Management	Infrastructure Health	Monitoring of LoRaWAN gateway status and performance metrics (e.g., signal strength)	Internal enerchart dashboard showing network health and coverage map	Unreliable data delivery due to network issues; lack of visibility into the performance of the core infrastructure.	Proactive maintenance of network gateways; optimizing gateway placement to improve coverage and reliability.
Smart Building Management	Energy Efficiency	Indoor LoRaWAN sensors (Temp, Humidity, CO_2) in municipal buildings	enerchart dashboard for facility managers showing real-time indoor environmental quality	High energy consumption from inefficient HVAC operation; poor indoor air quality affecting employee health and productivity.	Demand-controlled ventilation based on CO_2 levels; optimizing heating/cooling schedules to reduce energy waste.
Proactive Sewer Management	Public Health	Ruggedized LoRaWAN sensors in sewer systems (Temp, Humidity, H_2S, CH_4)	enerchart dashboard with alerts for anomalous conditions	Health risks from pest infestations and hazardous gas build-ups; costly, reactive maintenance of sewer infrastructure.	Predictive maintenance alerts for cleaning and repairs; targeted pest control measures to protect public health.

Table 3: Summary of all use cases of the digital solution

7.1. Detailed Use Case Descriptions

7.1.1. School Air Monitoring (Awareness & Education)

Objective: To raise awareness about local air pollution and provide tangible educational tools for students by monitoring air quality directly on school grounds.

Technical implementation: LoRaWAN-enabled air quality sensors, measuring key pollutants like Particulate Matter (PM2.5) and Nitrogen Dioxide (NO2), are installed in strategic locations such as playgrounds and near parent drop-off zones. Data is streamed in real time to a dedicated enerchart dashboard accessible to school administrators, teachers, and students.

Problem Addressed (Strategic Context): This use case directly confronts the public health risk of traffic-related air pollution, which disproportionately affects children. It also addresses a gap in modern education by transforming an abstract environmental issue into concrete, localized, and data-driven learning experiences, fostering a new generation of environmentally literate citizens.

Decision Support: The real-time graphs on the enerchart dashboard provide clear, visual evidence of pollution peaks, particularly during morning drop-off and afternoon pick-up times. This data empowers school administrators to advocate for and implement changes to school travel plans, such as promoting walking or cycling, or redesigning pick-up procedures to reduce vehicle idling. For educators, the dashboard becomes a dynamic textbook, allowing students to download real data for analysis in science, technology, engineering, and math (STEM) classes.

7.1.2. Citizen-Led Soil Quality Monitoring

Objective: To create a high-resolution, city-wide map of soil moisture to enable efficient water management for urban green spaces and empower citizens to take an active role in caring for their local environment.

Technical Implementation: Citizen volunteers or "community scientists" are equipped with simple, robust LoRaWAN soil moisture sensors. They deploy these sensors in local parks, community gardens, and tree pits. The collective data is visualized on a public-facing enerchart map, showing the real-time moisture status of green spaces across the city.

Problem Addressed (Strategic Context): This addresses the dual challenges of increasing water scarcity due to climate change and the financial pressure on municipal budgets. Inefficient, timer-based irrigation systems lead to significant water wastage, while under-watering during drought periods threatens the health and survival of the city's vital green infrastructure.

Decision Support: For the municipal public works department, the soil moisture map provides the basis for a data-driven, city-wide irrigation strategy, ensuring water is delivered only when and where it is needed. For community groups and individual citizens, the dashboard provides the information they need to organize targeted watering efforts

for specific trees or garden beds in their neighborhood, fostering a sense of stewardship and collective action.

7.1.3. Citizen-Led Precipitation & Flood Risk Monitoring

Objective: To build a dense, hyper-local precipitation monitoring network that provides early warnings of flash flooding and enhances the city's resilience to extreme weather events.

Technical Implementation: Building on the citizen science model, volunteers host LoRaWAN-connected rain gauges. For critical areas, these can be supplemented with ultrasonic water level sensors in culverts or small streams. The data feeds into an enerchart dashboard that displays a real-time map of rainfall intensity and flags areas where water levels are rising rapidly.

Problem Addressed (Strategic Context): Climate change is increasing the frequency of intense, localized downpours that can overwhelm urban drainage systems. Traditional, sparsely located weather stations often fail to capture this variability, leading to a delayed and inefficient response to flash floods. This use case addresses this critical "governance lag" by providing unprecedented situational awareness.

Decision Support: The enerchart dashboard becomes a critical operational tool for emergency services. Civil engineering departments can monitor the real-time load on their drainage infrastructure, while fire departments and emergency response teams can use the map to anticipate which neighborhoods are at highest risk and proactively deploy resources, such as temporary flood barriers or evacuation teams, before a crisis escalates.

7.1.4. Copernicus-Enhanced Urban Heat & Vegetation Monitoring

Objective: To create a comprehensive understanding of the urban heat island effect by fusing broad-area satellite data with precise, ground-level sensor measurements.

Technical Implementation: The platform ingests Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) data from Copernicus satellites. This is integrated within enerchart and displayed as map layers. This satellite data is then correlated with data from a ground network of LoRaWAN temperature and humidity sensors. The resulting multi-layered dashboard allows users to compare macro-level heat patterns with micro-climate conditions on the ground.

Problem Addressed (Strategic Context): Urban heat islands pose a significant and growing public health risk, exacerbating heatwaves and disproportionately affecting vulnerable populations. Effective mitigation requires a detailed understanding of which parts of the city are hottest and why—a question that cannot be answered by either satellite data or ground sensors alone.

Decision Support: This integrated dashboard is a powerful strategic planning tool for urban planners and public health officials. By analyzing the relationship between surface temperature, air temperature, and vegetation cover, planners can identify the most effective locations for greening interventions like planting trees, creating parks, or

installing green roofs. During a heatwave, the dashboard can be used to strategically locate public cooling centers in the areas with the highest combination of heat and social vulnerability.

7.1.5. Road Salt Silo Logistics Management

Objective: To optimize the logistics of winter road maintenance by providing real-time inventory data for road salt supplies.

Technical Implementation: LoRaWAN-enabled ultrasonic level sensors are mounted inside each of the city's road salt storage silos. These sensors continuously measure the distance to the surface of the salt, providing a real-time calculation of the remaining volume. An enerchart dashboard provides the logistics manager with a single, clear overview of the fill level of every silo in the network. The project's excellent organization and requirements analysis ensured a technically optimal solution.

Problem Addressed (Strategic Context): This use case is a prime example of enhancing municipal resilience to extreme weather events while simultaneously improving operational efficiency under increasing "economic pressure". Traditional, schedule-based inspections are inefficient and create the risk of a critical resource shortage during a prolonged snow or ice storm.

Decision Support: The enerchart dashboard transforms the replenishment process from reactive to proactive and data-driven. The logistics manager can see at a glance which silos are running low and dispatch delivery trucks on optimized, just-in-time routes. This minimizes vehicle miles traveled, saves fuel, reduces emissions, and, most importantly, ensures that public works crews always have the resources they need to keep the city's roads safe during winter weather emergencies.

7.1.6. Predictive Flood Prevention System

Objective: To provide an early warning system for riverine and surface water flooding by monitoring critical water infrastructure in real time.

Technical Implementation: This use case expands on the citizen-led precipitation network by deploying industrial-grade LoRaWAN water level sensors in key locations such as rivers, canals, and major storm drains. The data is visualized on a "beautifully and attractively designed" enerchart dashboard that shows current water levels, historical trends, and pre-configured alert thresholds.

Problem Addressed (Strategic Context): As cities grow and climate change brings more intense rainfall, the risk of catastrophic failure of aging drainage and flood control infrastructure increases. This system addresses the need for a resilient infrastructure by providing the continuous monitoring required for predictive maintenance and proactive management.

Decision Support: The dashboard serves as a command-and-control interface for the civil engineering department. When water levels approach a critical threshold, the system automatically triggers alerts to key personnel. This enables them to take preemptive

action, such as closing flood gates, activating pumps, or clearing blockages, well before flooding occurs. The historical data also provides invaluable insights for long-term capital planning and infrastructure upgrades.

7.1.7. AI-Enhanced Soil Condition Analysis

Objective: To move beyond simple irrigation scheduling to a more holistic, AI-driven approach to managing the health of urban soils.

Technical Implementation: This advanced use case deploys multi-parameter LoRaWAN soil sensors that measure not only moisture but also variables like pH and electrical conductivity (as a proxy for nutrient levels). A key innovation is the "use of AI for configuration," where a machine learning model might optimize the sampling interval based on weather forecasts and historical data. The project team developed their own "payload decoder" and 3D-printed a protective housing, demonstrating a high degree of technical innovation and going the "triple extra mile".

Problem Addressed (Strategic Context): A one-size-fits-all approach to managing urban green spaces is both inefficient and ineffective. This use case addresses the need for more precise, data-driven techniques in urban agriculture and park management, aligning with the broader trend towards a more circular and resource-efficient economy.

Decision Support: The enerchart dashboard, enhanced with predictive analytics, provides park managers and urban farmers with unprecedented insight into soil health. It can provide decision support for the precision application of fertilizers or soil amendments, recommend crop rotation schedules for community gardens, and identify areas where soil is becoming compacted or salinized, allowing for early intervention.

7.1.8. Outdoor Environmental Monitoring

Objective: To establish a foundational network for collecting baseline environmental data, serving as the backbone for more specialized climate initiatives.

Technical Implementation: This use case involves the systematic deployment of the recommended SenseCAP S2101 and benchmarked Milesight EM300-TH LoRaWAN temperature and humidity sensors across the community. The presentation was "solid, but unspectacular," focusing on the core, reliable implementation of the technology . Data is visualized in enerchart using standard time-series graphs and statistical summary widgets.

Problem Addressed (Strategic Context): Many communities lack the long-term, high-resolution environmental data needed to accurately assess their climate risks, develop effective adaptation plans, and track their progress over time. This use case addresses this fundamental data gap. It also highlights the importance of addressing "small inconsistencies" in data through proper validation and quality control procedures within enerchart.

Decision Support: This baseline network provides the essential climatic context for all other use cases. For municipal planners, it enables the tracking of long-term trends, such as the increasing number of high-heat days per year. It also provides the data needed to

quantitatively evaluate the impact of interventions, for example, by measuring whether a newly created park has a measurable cooling effect on its immediate surroundings.

7.1.9. Hyper-Local Urban Climate Monitoring

Objective: To conduct scientifically rigorous microclimate research to improve the accuracy of urban climate models and develop best practices for sensor deployment.

Technical Implementation: This research-oriented use case focuses on the nuances of accurate environmental measurement. The team investigated the "importance of a [radiation] shield" to protect sensors from direct solar radiation, which can introduce significant measurement errors. They "designed and 3D-printed the shield themselves," demonstrating a capacity for rapid, in-house hardware prototyping. The technical and visual quality of the presentation was high.

Problem Addressed (Strategic Context): Inaccurate microclimate data can lead to flawed urban planning decisions and ineffective climate adaptation strategies. This use case addresses the scientific challenge of ensuring data quality and reliability, which is a prerequisite for evidence-based policy.

Decision Support: The findings from this research provide direct decision support for the managers of the MCDMP itself. The comparative data from shielded vs. unshielded sensors in enerchart allows for the development of a standardized, best-practice deployment guide for all future sensor installations. For academic partners, the high-quality, validated dataset produced by this project can be used to calibrate and improve the accuracy of sophisticated urban climate models.

7.1.10. Advanced Traffic Radar Analysis

Objective: To provide city transportation planners with rich, detailed data on traffic flow to improve mobility, enhance safety, and reduce emissions.

Technical Implementation: This sophisticated use case utilizes LoRaWAN-connected traffic radar sensors. Unlike simple magnetic loop detectors, these radars can provide data on not just vehicle count, but also speed and classification (e.g., car, truck, bus). The student team correctly identified the "complexity of the sensor" and demonstrated "very good methodology and project management," earning an "optimal rating in all points" . The data is visualized in an advanced enerchart dashboard.

Problem Addressed (Strategic Context): Traffic congestion is a major contributor to urban air pollution and greenhouse gas emissions, and it imposes significant economic costs through lost time and wasted fuel. Effective traffic management requires granular data that traditional methods often cannot provide.

Decision Support: The enerchart dashboard provides transport planners with a powerful analytical tool. They can identify congestion bottlenecks in real time, analyze speeding on residential streets to inform traffic calming measures, and understand the mix of vehicle types on different roadways to plan for freight management or public transit improvements. This data is critical for optimizing traffic signal timing, redesigning

intersections to improve safety, and making informed decisions about long-term transportation infrastructure investments.

7.1.11. Public Space People Counting

Objective: To understand how public spaces are used to optimize their management and justify investments in their improvement.

Technical Implementation: Discreet LoRaWAN-based infrared people counters are installed at the entrances to public spaces like parks, libraries, or pedestrian zones. The project team demonstrated "good teamwork" and delivered a "good presentation" that relied exclusively on a "visually strong" enerchart dashboard, forgoing traditional slides

Problem Addressed (Strategic Context): The management of public spaces is often based on anecdotal evidence rather than hard data. This makes it difficult to allocate maintenance resources efficiently, plan for events, or make a compelling, evidence-based case for funding new amenities or improvements.

Decision Support: The enerchart dashboard provides clear, intuitive visualizations of footfall patterns, showing not just how many people use a space, but when they use it. Park managers can use this data to schedule cleaning and maintenance during off-peak hours to minimize disruption. City event planners can analyze historical data to better manage crowd flow. Most importantly, the quantitative data on park usage provides a powerful justification for budget requests for new playgrounds, benches, or landscaping.

7.1.12. Local AI-Powered People Detection

Objective: To monitor occupancy and usage patterns in a way that is both highly efficient and protective of individual privacy.

Technical Implementation: This cutting-edge use case employs a sensor with an integrated camera and a small, on-board (edge) AI processor. The "local AI programming" allows the device to perform people detection and counting directly on the sensor itself. It then transmits only the final, anonymous count (e.g., "5 people detected") over the low-bandwidth LoRaWAN network. The team conducted a "small live demo" and ran "two test cases" to prove the concept's viability.

Problem Addressed (Strategic Context): While video surveillance can provide rich data, it raises significant privacy concerns and requires high-bandwidth (and high-cost) networks like Wi-Fi or 5G. This use case addresses both of these challenges, demonstrating a privacy-preserving and highly efficient architecture for occupancy monitoring.

Decision Support: This technology enables occupancy monitoring in sensitive locations where traditional cameras would be inappropriate, such as inside public buildings, libraries, or transit shelters. Facility managers can use the data to optimize HVAC systems based on real-time occupancy. Transit authorities can understand waiting times at bus stops. The key decision support is enabling data collection in new contexts by designing privacy and efficiency into the solution from the ground up.

7.1.13. LoRaWAN Network Infrastructure Management

Objective: To ensure the reliability and performance of the entire Mission Climate platform by monitoring the health of its underlying LoRaWAN network infrastructure.

Technical Implementation: This is a "meta" use case where the platform monitors itself. Instead of focusing on a dashboard of environmental data, the "focus was on the setup" of the network itself . Data on LoRaWAN gateway status (online/offline), signal strength (RSSI), and signal-to-noise ratio (SNR) from incoming sensor messages are ingested and visualized in a dedicated enerchart dashboard. The project team also set up a TTN network "in addition for comparison" with a self-hosted Chirp Stack server, providing a valuable "comparison" and evaluation of different LNS options.

Problem Addressed (Strategic Context): The reliability of every single use case on the MCDMP depends on the health and performance of the LoRaWAN network. A single offline gateway could create a data blackout for an entire neighborhood. This use case addresses the critical operational need for network visibility and proactive maintenance.

Decision Support: The network health dashboard provides the platform's technical administrators with immediate alerts if a gateway goes offline. By analyzing signal strength data over time, they can identify areas of poor coverage and make informed decisions about relocating gateways or installing new ones to improve network-wide performance. The strategic comparison between TTN and Chirp Stack provides critical decision support for long-term network architecture planning, weighing the trade-offs between a managed service and a self-hosted solution.

7.1.14. Smart Building Energy Management

Objective: To reduce the energy consumption and carbon footprint of municipal buildings while improving the health and comfort of occupants.

Technical Implementation: This use case, derived from smart building examples, involves deploying indoor LoRaWAN sensors like the Milesight EM300-TH and AM107 to monitor a range of Indoor Environmental Quality (IEQ) parameters, including temperature, humidity, and CO2 levels.[1, 1] The data is fed to an enerchart dashboard designed for facility managers.

Problem Addressed (Strategic Context): Municipal buildings are often significant energy consumers. Inefficient operation of Heating, Ventilation, and Air-Conditioning (HVAC) systems not only wastes public money and contributes to greenhouse gas emissions but can also lead to poor indoor air quality, which has been shown to affect employee productivity and well-being.

Decision Support: The enerchart dashboard provides facility managers with the data they need to move from scheduled to demand-controlled building operations. For example, instead of running ventilation systems continuously, they can be programmed to activate only when CO2 levels (a proxy for occupancy) exceed a certain threshold. This single change can lead to significant energy savings. The data also allows for the fine-tuning of heating and cooling setpoints to optimize for both energy efficiency and occupant comfort.

7.1.15. Proactive Sewer System Management

Objective: To enhance public health and improve the efficiency of municipal services through the predictive maintenance of the sewer system.

Technical Implementation: Inspired by the successful deployment in Córdoba, this use case involves deploying ruggedized, IP67-rated LoRaWAN sensors within the sewer network.[1, 1] These sensors monitor key indicators such as temperature, humidity, and the levels of hazardous gases like hydrogen sulfide (H2S) or methane (CH4). An enerchart dashboard visualizes the data on a map and triggers alerts when any parameter exceeds a safe threshold.

Problem Addressed (Strategic Context): Sewer systems are critical but invisible infrastructure. Failures can lead to significant public health risks, from pest infestations (as high temperature and humidity create ideal breeding grounds) to dangerous gas leaks. Traditional maintenance is reactive and expensive. This use case addresses the need for proactive, data-driven management of this vital asset.

Decision Support: The dashboard provides the public works department with an early warning system for potential problems. An anomalous spike in temperature and humidity could trigger a targeted pest control intervention, preventing a larger infestation. A rise in methane levels could indicate a blockage and prompt a cleaning crew to be dispatched before a dangerous backup occurs. This predictive approach reduces health risks, minimizes costly emergency repairs, and improves the overall safety and efficiency of sewer system management.

F. Good Practice - Košice

8. General Information

Project Partners:

- Technical University of Košice (TUKE), City of Košice
- Contributors/Team Members/Experts involved:
- TUKE – Faculty of Economics (pilot team)
- City of Košice
- Department of Strategic Development
- Department of Environment
- Department of Education
- Elementary schools
- ZŠ Požiarnická
- ZŠ Staničná
- ZŠ Gemerská
- ZŠ Hroncova
- ZŠ Tomášikova
- ZŠ Nám. L. Novomeského
- ZŠ Park Angelinum

IoT weather station supplier – Multi-parameter climate stations for school environments (11 indicators) – (procured in 2025, no public URL)

Microsoft Azure – Cloud infrastructure (IoT Central, IoT Hub, Blob Storage, Data Lake, Log Analytics, Monitor, Security Center for IoT, DPS, Functions) – https://azure.microsoft.com

Microsoft Power BI – Data visualization and reporting – https://powerbi.microsoft.com

City of Košice Open Data Platform – Integration of sensor outputs for transparency and public access – https://data.kosice.sk Dataset

TUKE Faculty of Economics IT team – Local implementation, dashboard customization, interoperability support – (internal team, no public URL)

9. Digital Solution - Description

9.1. Digital Solution - Description

The solution ensures continuous monitoring of local climate conditions in Košice through a network of IoT weather stations installed at elementary schools. The stations record air quality indicators (particulate matter PM10, PM4,PM1; gases NO_2 and CO), meteorological parameters (temperature, humidity, atmospheric pressure), and wind dynamics (speed, gusts, direction). Data are transmitted in real time to the Microsoft Azure cloud infrastructure and subsequently visualized in dashboards made available through the City of Košice Open Data Platform.

The Košice pilot introduces an intelligent climate monitoring system that combines technical and educational objectives. Seven participating elementary schools serve as monitoring sites, providing both representative territorial coverage and active community engagement. The solution delivers transparent data for urban climate adaptation planning, while at the same time offering practical tools for environmental education of pupils and their families.

Technology Stack:

- IoT multi-parameter weather stations (11 indicators)
- Fixed power supply (230V), Ethernet/WiFi connectivity
- Microsoft Azure IoT Central / IoT Hub (data collection and management)
- Azure Blob Storage & Data Lake (data storage)
- Azure Log Analytics, Azure Monitor, Azure Security Center for IoT (security and monitoring)
- Microsoft Power BI (visualization and reporting)
- Integration with Košice Open Data Platform for public access
- Local customization and dashboard development by TUKE Faculty of Economics IT team

Monitored Climate Indicators:

- Meteorological conditions: temperature, humidity, atmospheric pressure
- Wind dynamics: wind speed, wind gusts, wind direction
- Air quality – particulate matter: PM10, PM4, PM2.5, PM1
- Air quality – gases: CO, NO_2
- Full List of Indicators with Units:
- Temperature – °C
- Humidity – %
- Atmospheric Pressure – hPa
- Wind Speed – m/s
- Wind Gusts – m/s
- Wind Direction – °
- PM10 – µg/m³
- PM4 – µg/m³
- PM2.5 – µg/m³
- PM1 – µg/m³
- CO – ppm
- NO_2 – ppm

Geographical Coverage:

The pilot covers seven elementary schools in the city of Košice, Slovakia. Monitoring stations are installed in schoolyards and rooftops across different districts, providing representative coverage of residential and traffic-exposed areas. The geographical focus ensures both educational impact (direct engagement with school communities) and spatial diversity in climate data collection.

7 elementary schools involved within the area of the City of Košice:

- ZŠ Požiarnická
- ZŠ Staničná
- ZŠ Gemerská
- ZŠ Hroncova
- ZŠ Tomášikova
- ZŠ Nám. L. Novomeského
- ZŠ Park Angelinum

9.2. Target Group

9.2.1. Who uses the digital solution?

- **Local governments and municipalities** – City of Košice (Department of Environment, Department of Education) for adaptation planning, transparency, and decision support.
- **Elementary schools** (7 involved) – teachers, pupils, and parents use the data for climate education, awareness raising, and participatory school projects.

- **Urban planners and experts** – using open data to integrate evidence into strategic plans (Adaptation Plan of Košice, Climate City Contract).
- **NGOs and community initiatives** – e.g., Klíma ťa potrebuje, Východné pobrežie, supporting public engagement and communication.
- **Research institutions** – TUKE (Faculty of Economics), Slovak Academy of Sciences, Climate and Development Institute, for technical expertise and long-term research on climate resilience.
- **General public** – citizens access open dashboards and receive transparent information on local climate trends.

9.2.2. Stakeholder collaboration

The pilot project in Košice is fundamentally built on close collaboration among multiple local stakeholders, ensuring both technical feasibility and community ownership.

- City of Košice – the Departments of Strategic Development, Environment, and Education play a central role in aligning the pilot with the city's Adaptation Plan and Climate City Contract.
- TUKE – Faculty of Economics – responsible for technical implementation, data governance, dashboard development, and methodological support.
- Elementary schools (7 sites) – act as monitoring locations and educational partners, actively engaging teachers, pupils, and parents in the interpretation of climate data.
- NGOs and community initiatives – support communication, awareness raising, and participatory engagement (e.g., local campaigns, school-level micro-projects).
- Research institutions – Slovak Academy of Sciences (Institute of Social Sciences) and Climate and Development Institute provide expertise on vulnerability assessment and integration of findings into resilience strategies.
- Technology providers – suppliers of IoT weather stations and Microsoft Azure services ensure reliable data collection, storage, and visualization.
- This collaborative framework not only guarantees technical robustness but also fosters participatory co-creation, with schools and local communities treated as active co-designers of the solution rather than passive recipients.

9.3. (Expected) Impact

9.3.1. Qualitative Outcomes

- Increased awareness of climate change impacts among pupils, teachers, and the wider community through direct interaction with real-time environmental data.
- Strengthened cooperation between the City of Košice, TUKE, and local schools, creating a replicable model for other municipalities.
- Enhanced evidence-based policy making, as reliable local data support the implementation of the Adaptation Plan of Košice.
- Improved integration of climate education into school curricula, supporting STEM education and active citizenship.
- Greater transparency and trust, as open data dashboards make climate indicators publicly available and easy to interpret.

9.3.2. Quantitative Outcomes

- Seven elementary schools actively participating in climate data collection and education.
- Eleven climate indicators continuously monitored across school sites.
- Three types of dashboards developed and in operation:
  - Seven individual school dashboards designed for teaching purposes and school community use.
  - Seven LED-screen dashboards installed in school entrance halls to raise awareness among pupils, parents, and visitors.
  - One integrated dashboard on the City of Košice Open Data Platform, supporting research, policy-making, and municipal management.
  - In total, fifteen dashboards are operational across the pilot ecosystem.
- More than 500 pupils directly engaged in educational activities and workshops.
- Four school subjects enriched with real data and climate content: Biology, Physics, Chemistry, and Civics.
- At least four regional stakeholders formally supporting the pilot through acceptance letters.
- Two local and regional strategies directly supported by the pilot solution (Adaptation Plan of Košice 2022–2030 and Košice Development Programme 2022–2027).
- Continuous collection of millions of data points per year, forming the basis for adaptation planning and future research.

9.4. Technical Implementation Details

9.4.1. Data sources:

The main source of data is IoT sensor stations installed at seven elementary schools in Košice. Each station measures eleven indicators, including particulate matter (PM10, PM4, PM1), gases (NO_2, CO), and meteorological variables (temperature, humidity, atmospheric pressure, wind speed, wind gusts, wind direction). Data are collected every minute and transmitted to the cloud in five-minute intervals.

9.4.2. Data type:

Sensor Data IOT -The solution generates continuous time-series data with precise timestamps. These data allow both real-time analysis and long-term evaluation of local climate conditions. They are suitable for anomaly detection, educational purposes, and integration into adaptation planning and research.

Interoperability - IoT devices are integrated into the Microsoft Azure IoT Central platform, supporting standard protocols (MQTT, AMQP, HTTPS). Data are stored in Azure Blob Storage and Azure Data Lake, while access and security are managed through Azure Active Directory (Entra ID). System monitoring and stability are supported by Azure Log Analytics, Azure Monitor, and Azure Security Center for IoT.

Data are further processed and visualized in Microsoft Power BI dashboards. Three types of dashboards have been developed and interconnected within the ecosystem: seven

individual school dashboards for teaching and school community use, seven LED-screen dashboards in school entrance halls for awareness raising, and one integrated dashboard on the City of Košice Open Data Platform for research, municipal governance, and transparency.

9.5. Overview of Implementation

The implementation of the Košice pilot followed a phased approach, starting with analytical activities and proceeding to technical deployment and educational engagement. During the first stage, vulnerability and heatwave maps were analyzed to identify suitable school locations for sensor installation. Based on this analysis, seven elementary schools were selected in cooperation with the Department of Education of the City of Košice.

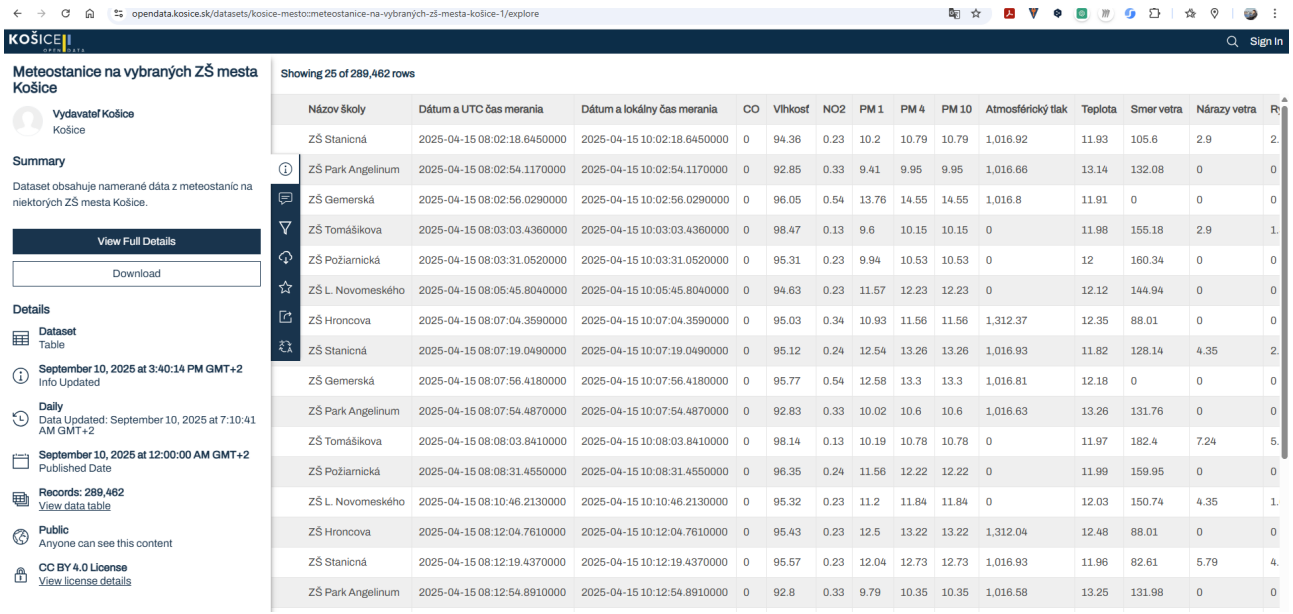
A public procurement process was conducted to acquire IoT climate stations, ensuring compliance with technical specifications and long-term warranty conditions. The sensors were installed in schoolyards and rooftops in early 2025, each measuring eleven indicators of air quality and meteorological conditions. The stations were connected to the Microsoft Azure IoT Central platform, enabling secure data transfer, cloud storage, and integration with visualization tools.

In parallel, cooperation with schools was established through preparatory meetings, classroom activities, and a co-creation workshop held on April 3, 2025. This workshop defined four data-use scenarios (pedagogical, strategic, community, spatial) and laid the foundation for integrating climate monitoring into curricula and school development plans.

Currently, three types of dashboards are operational: seven school dashboards, seven LED-screen dashboards in school entrances, and one integrated dashboard on the City of Košice Open Data Platform. This setup ensures a balance between educational use, community awareness, and public transparency.

Detailed documentation of the design and implementation process is provided in the following reports:
- MISSION CE CLIMATE – Pilot Design Report Košice
- Pilot Implementation Status Reports Nr.01 and Nr.02 and Nr.03
- Annexes to pilot activities (sensor specification, KPI coherence, curriculum design)

9.6. Screenshot



opendata.kosice.sk/datasets/kosice-mesto::meteostanice-na-vybranych-zs-mesta-košice-1/explore

KOŠICE OPEN DATA — Sign In

Meteostanice na vybraných ZŠ mesta Košice

Vydavateľ Košice
Košice

Summary

Dataset obsahuje namerané dáta z meteostanic na niektorých ZŠ mesta Košice.

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Dataset
Table

September 10, 2025 at 3:40:14 PM GMT+2
Info Updated

Daily
Data Updated: September 10, 2025 at 7:10:41 AM GMT+2

September 10, 2025 at 12:00:00 AM GMT+2
Published Date

Records: 289,462
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Showing 25 of 289,462 rows

Názov školy	Dátum a UTC čas merania	Dátum a lokálny čas merania	CO	Vlhkosť	NO2	PM 1	PM 4	PM 10	Atmosférický tlak	Teplota	Smer vetra	Nárazy vetra	R
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ZŠ Gemerská	2025-04-15 08:02:56.0290000	2025-04-15 10:02:56.0290000	0	96.05	0.54	13.76	14.55	14.55	1,016.8	11.91	0	0	0
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ZŠ Požiarnická	2025-04-15 08:03:31.0520000	2025-04-15 10:03:31.0520000	0	95.31	0.23	9.94	10.53	10.53	0	12	160.34	0	0
ZŠ L. Novomeského	2025-04-15 08:05:45.8040000	2025-04-15 10:05:45.8040000	0	94.63	0.23	11.57	12.23	12.23	0	12.12	144.94	0	0
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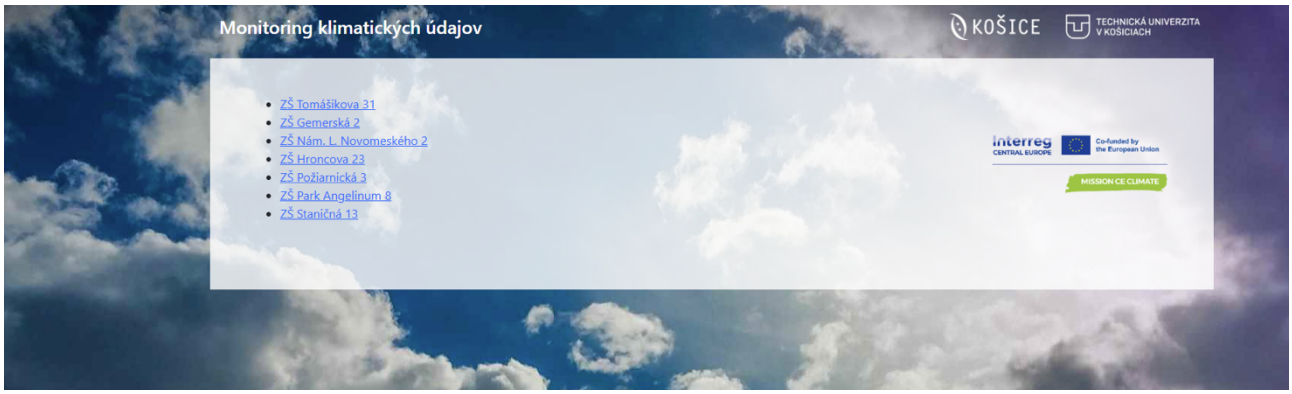
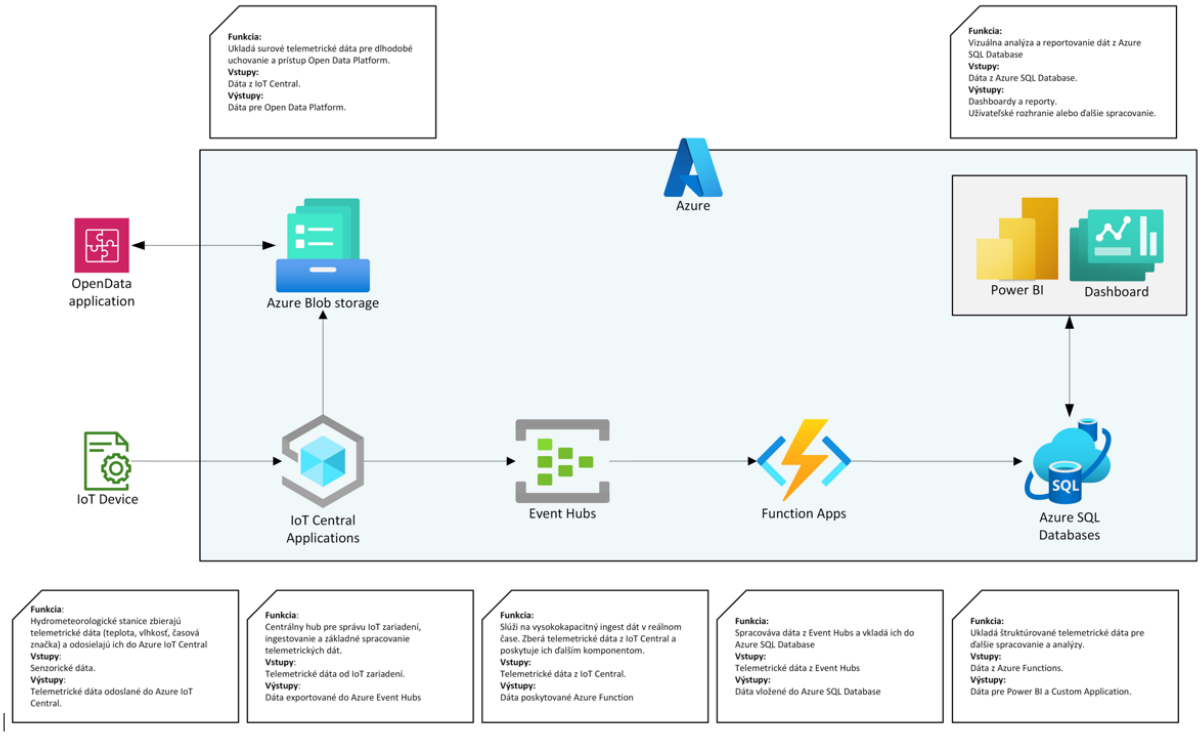


High Level architektúra riešenia



10. Use Cases

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
Educational and Curricular Integration	STEM education and climate literacy	IoT climate stations measuring 11 indicators on school premises	Local school dashboard for teachers and pupils; QR codes linking to dashboards during lessons	Lack of real-world and local environmental data in school curricula	Enables integration into Biology, Physics, Chemistry, and Civics; supports project-based learning, hackathons, and environmental clubs
Awareness and Community Engagement	Raising awareness among pupils, parents, and local community	IoT data from school stations, linked to school communication channels	LED-screen dashboards in school entrances with QR codes; Edupage links to local dashboards	Limited visibility of environmental data and low parental/community engagement	Strengthens school–community cooperation; encourages behavioral change (transport, greening); motivates joint micro-interventions
Strategic Use by School Management	Evidence-based decision-making at the school level	Aggregated IoT data from school dashboards	School dashboards used internally by principals and staff	Lack of reliable evidence for investments and improvement projects	Provides arguments for grants, municipal communication, and physical planning of interventions)
Municipal Governance and Research	City-wide adaptation, transparency, and scientific use	Aggregated IoT data from all schools integrated into the Open Data	One integrated central dashboard on the City of Košice	Lack of open and reliable local climate data for adaptation planning, research, and	Supports city governance (Adaptation Plan 2022–2030, Development Programme

		Košice platform	Open Data Portal; detailed datasets for TUKE researchers; simplified	public transparency	2022–2027); provides datasets for research; offers low-threshold access for citizens

10.1. Educational and Curricular Integration (School Basic Dashboard)

The first use case is centred on the basic school dashboard, which functions as the primary entry point for accessing local climate data. Each participating school has its own dashboard displaying real-time measurements of air quality and meteorological indicators, along with historical records of environmental conditions. The dashboard provides access not only to current data but also to more detailed datasets for further exploration by teachers, pupils, and interested stakeholders.

All other communication and awareness tools – such as LED screens in entrance halls or Edupage channels for parents – are linked to this central school dashboard, making it the core reference point for information. In addition, specific worksheets and educational materials will be developed for teachers of different subjects (Biology, Physics, Chemistry, and Civics), enabling them to use the dashboard data in structured lessons and projects.

This approach ensures that each school has its own identity in climate monitoring, while at the same time establishing a standardized entry gateway for educational use and community engagement.

10.2. Awareness and Community Engagement (LED app linked to School Basic Dashboard)

The second use case focuses on raising awareness among pupils, parents, and the broader school community. Environmental data collected by the IoT stations are made visible through simplified visualizations on LED screens located in school entrance halls and through school communication channels such as Edupage. These entry points provide daily exposure to local climate data in an easy-to-understand form, helping to foster curiosity and awareness.

All these communication tools are directly linked to the School Basic Dashboard, where more detailed information and historical records can be explored. In this way, the LED screens and Edupage serve as gateways that encourage parents, pupils, and visitors to deepen their understanding by navigating to the school's main dashboard.

This setup ensures that climate data do not remain hidden in technical systems but are actively shared with the school community. It builds awareness, motivates behavioural change (e.g., transport choices, greening activities), and supports the school's role as a hub for environmental education and community dialogue.

10.3. Strategic Use by School Management (linked to School Basic Dashboard)

This use case highlights how school leadership can leverage climate data to strengthen its institutional position and improve the school environment. Principals and management teams use the School Basic Dashboard to review current and historical data as a foundation for evidence-based decision-making.

The dashboard enables schools to showcase their best results in climate monitoring and education, positioning themselves as leaders within the city, the region, or even nationally. This visibility provides strong arguments for securing financial resources, preparing project proposals, and building strategic partnerships.
The data also serve as practical input for planning improvements of the school grounds. Evidence from the dashboards can justify greenery and shading projects, redesign of outdoor spaces, or upgrading ventilation systems, ensuring that interventions are based on measurable needs.

Beyond the school premises, the data further inform discussions on traffic safety and mobility management in the school's vicinity. They provide a factual basis for introducing measures such as traffic calming, school zones, or reduced car arrivals. In cooperation with municipal authorities, these data can also support adjustments to local regulations (VZN), giving the school a stronger voice in shaping its broader environment.

In this way, the School Basic Dashboard is transformed into a strategic management tool. It allows schools not only to improve their own facilities but also to actively contribute to city-level discussions on transport, environmental quality, and regulatory change.

10.4. Municipal Governance and Public (Open Data Portal linked to School dashboards)

This use case brings the climate monitoring system to the city and academic level. All data from the seven elementary schools are integrated into one central dashboard on the City of Košice Open Data Platform. This ensures transparency for the wider public and makes climate data accessible to all interested stakeholders.

For municipal governance, the integrated dashboard provides a reliable evidence base for strategic documents such as the Adaptation Plan of Košice 2022–2030 and the Development Programme 2022–2027. City officials can use the data for climate adaptation planning, urban mobility regulation, and prioritization of investments. The open format also allows departments to cooperate more effectively across environmental, educational, and transport agendas.

For research purposes, detailed datasets are available to TUKE and other academic institutions. Researchers can use the time-series data for vulnerability assessments, climate modelling, and evaluation of microclimate interventions at the city level. This scientific use creates opportunities for joint projects, publications, and further innovation in digital monitoring.

G.Good Practice - Dornbirn

11. General Information

The city of Donbirn, the University of Applied Sciences in Vorarlberg and weavs collaborated on this pilot project. To investigate heat islands effect, the pilot project encompasses a digital solution supporting nature-based solutions in urban areas, to compare heat islands microclimate to ones of different nature-based solutions and sealed and unsealed surface areas. This will allow a better understanding of the temperature reducing potential of nature-based solutions. The collected data will be presented in order to raise awareness of climate change adaptation measures. Three different LoRaWAN® sensors were used to measure the surface temperature, air temperature and humidity.

12. Digital Solution - Description

12.1. Digital Solution - Description

Heat islands are a pressing issue for the city of Dornbirn and nature-based solutions such as tree planting can reduce the heat island effect. This preliminary pilot study focuses on exploring the potential impact of trees and different surfaces on temperature reduction. The aim is to quantify the extent of temperature reduction achievable through nature-based solutions. Through a sensor network, the cooling effect of trees will measured. By using sensors, we will gather data on surface and air temperature, as well as humidity levels. Specifically, different climate data indicators (surface and air temperature, humidity) will be collected to compare the perceived temperature on different surface types, as well as on places with and without shade from trees. Subsequently, the perceived temperature (heat index) will be calculated, enabling an assessment of the actual reduction in perceived temperature. To minimize external influences on the microclimate, all data collection for different surfaces and shading conditions will be conducted within the same park, ensuring consistent general weather conditions for accurate comparison.This pilot can be described as a digital solution, supporting the decision for nature-based solutions through climate data results.

The primary objective is to gain insights into the potential of nature-based solutions and unsealed surfaces to improve urban microclimate by mitigating the heat island effect. A secondary objective of the pilot project is to raise public awareness and educate citizents. Additionally, the pilot project aims to support the city of Dornbirn´s existing climate action plan by providing data-driven evidence on the importance of nature-based solutions and temperature-reducing surfaces. The third objective is to provide data-driven insights to strengthen Dornbirn´s climate action plan. The project results will be integrated into the Citymonitor dashboard (https://www.city-monitor.com/en/energie-und-umweltmonitoring) for transparency and informed decision-making.

12.2. Technology Stack:

The following senosors were installed:

Air temperature and humidity sensor for LoRaWAN®

TEMPERATURE
Range: -40 ... +125 °C
Resolution: 0.01 °C
Accuracy: ±0.1 °C from 20 ... 60 °C, ±0.2 °C from -40 ... 90 °C
RELATIVE HUMIDITY
Range: 0 ... 100% RH
Resolution: 0.01% RH
Accuracy: ±1.5% RH from 0 ... 80% RH, ±2% RH from 80 ... 100% RH

Winter road maintenance sensor for LoRaWAN®

SURFACE TEMPERATURE / INFRARED PYROMETER
Range:
-40 ... 1030 °C (target temperature)
-20 ... 80 °C (sensor head temperature)
Resolution: 0.1 °C
Accuracy: ±1.5 % or ±1.5 °C
Repeatability: ±0.75 % or ±0.75 °C
Spectral range: 8...14µm
Optical Resolution: 15:1
Environmental rating: IP 63
AIR TEMPERATURE
Range: -40 ... 125 °C
Resolution: 0.01 °C
Accuracy:
±0.1 °C (20 ... 60 °C)
±0.2 °C (-40 ... 90 °C)
AIR HUMIDITY
Range: 0...100%RH
Resolution: 0.01 % RH
Accuracy:
±1.5%RH(0...80%RH)
±2.0 % RH (80 ... 100 % RH)

Infrared thermometer/surface temperate sensor for LoRaWAN®
INFRARED PYROMETER
Range:
-20 ... 80 °C for ambient temperature
-40 ... 1030 °C for object temperature
Accuracy: ±1.5 % or ±1.5 °C
Optical Resolution: 15:1
Repeatability: ±0.75 % or ±0.75 °C
Spectral Range: 8 ... 14 µm
Environmental rating: IP 63

12.3. Monitored climate indicators

In this pilot study, the surface temperature, air temperature, and humidity are measured to investigate the effect of nature-based solutions on surface temperature, air temperature, and humidity and to allow the calculation of the heat index.

12.4. Geographical Coverage:

It is a local pilot project in Dornbirn.

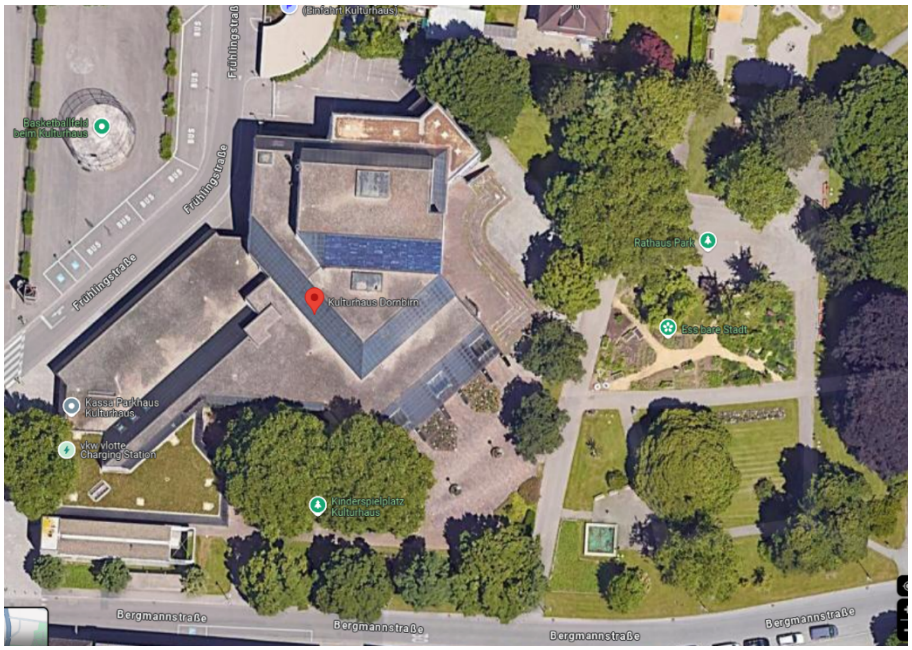


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Figure 8: Pilot study site, showing the "Kulturhaus"

Illustration 6: Location of sensors

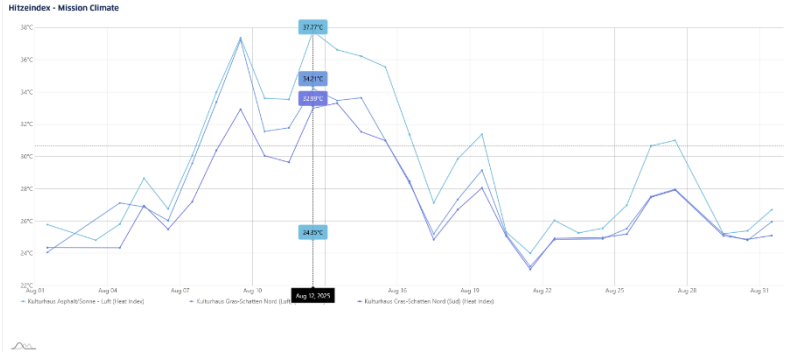
12.5. Target Group

The main target group of the pilot study is the city of Dornbirn to enable informed for adaptation planning and decisions. Further, the University of Applied Sciences will use it for research purposes to gain a better understanding of the cooling effect of trees on the urban heat island effect. Additionally, the results will be disseminated to the wider public through information and events.

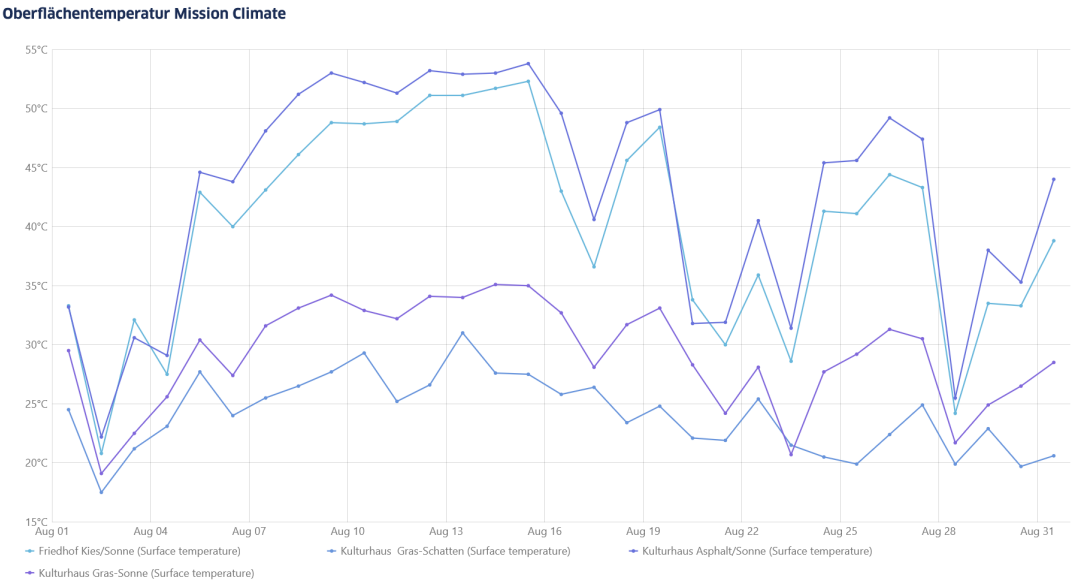
The pilot was only possible through a strong collaboration between the city of Dornbirn including different departments, the University of Applied Sciences, and weavs.

12.6. (Expected) Impact

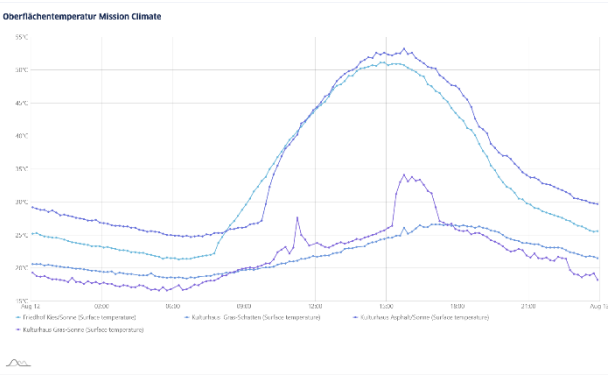
For the analysis of the collected data, the perceived temperature was assessed through measuring the heat index. The heat index combines air temperature and relative humidity in order to posit a human-perceived equivalent temperature. The heat index allows comparisons between the perceived temperature in shaded and non-shaded areas. However, it does not account for heating from direct sunlight or the effect of physical activity. In the Kulturhauspar are three locations. The light blue is a sealed surface exposed to



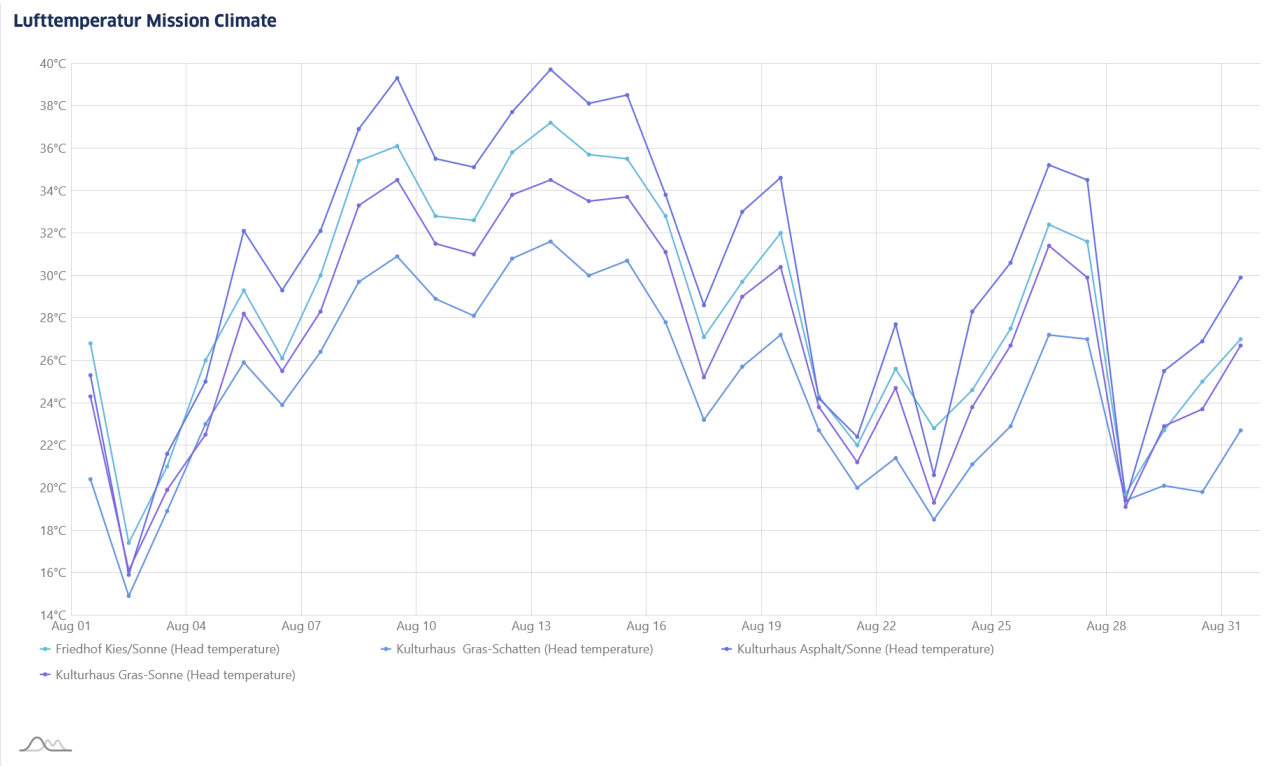
sun, the darker blue is grass exposed to sun and the violett is grass in the shade. The graphs shows the differences of the heat index of the different sensor locations. On the 12th of August, their was a differnece in perceived temperature of almost 4,78°C between sealed surface/sun and grass/shade with 32.99°C compared to 37.77°C. The difference is even bigger if you look at surface temperature. On the 12th of August, the difference between sealed surface/sun and grass/shade reached 27.2°C. The sealed surface in the sun reached a temperature 53,2°C, gravel surface in the sun reached 51,1°C, grass in the sun 34.1°C and grass in the shade 26.0°C. This shows, on the one hand, the effect of shade as a cooling effect with reaching a difference with the same surface of 8,1°C and on the other hand, it highlights the importance of surfaces. Grass in the sun and shade have a temperature difference of 19,1°C.



Here, you can see the temperature development throughout the day of the 12th of August for all four locations. What is striking here, is that there is a temperature difference of more than 10°C during the night. Thus, the sealed surface has similar temperature at night as the gras area with shade during the day.



By looking into air temperature, the difference is smaller. The difference between sealed surface in the sun and grass in the shade, was on the 12th of August 6,9°C ranging from 37,7°C to 30,8°C. This highlights again, the heating effect of sealed surfaces in cities.



Findings:

- Nature-based solutions can play a very important role for enhancing climate resilience for cities. They can help cities reducing the urban heat island effect. Vegetation provides shade, enhances evapotranspiration, and lowers surface and air temperatures, making urban areas more resilient to heatwaves while improving comfort, health, and livability. Tree shade can also have a positive effect on the perceived temperature.
- The importance of surfaces should not be underestimated. Sealed surfaces like asphalt and concrete trap heat, block water infiltration, and intensify the urban heat island effect, while non-sealed surfaces—such as soil, permeable pavements, and vegetated areas—allow for cooling through water infiltration, evaporation, and plant growth. Shifting from sealed to non-sealed surfaces, where it is possible in terms of accessibility, it can reduce the urban heat island effect as well.

Methodological lessons:

- **Data compatibility**: Thorough planning of the conceptual design is essential to ensure that the collected climate data are compatible with exisiting networks.
- **Data reliablity**: In this pilot study, which assesses the potential of various surfaces and nature-based solutions to reduce perceived temperatures, it is crucial to minimize any disturbance factors (e.g., varying weather conditions). Therefore, the sensor networks used to measure different microclimatic conditions should be implemented in areas with similar external microclimatic characteristics (e.g., deploying sensor networks in different spots within the same park).
- Resolution trade-offs: Trade-offs between density and quality of sensors and costs.

Operational lessons:

- **Maintenance**: Regular site visits are necessary.
- **Wording matters:** The description of the study´s area of classification was changed from the phrasing "combined nature-based and digital solution" to "digital solution supporting nature-based solutions in urban areas" to avoid any confusions.

Impact

- **Better understanding of microclimates.** It will enable a better understanding of urban microclimates and the effects of surfaces and shades on microclimates. The study will provide quantitative evidence of how trees influence local temperature and humidity.
- It will allow **informed decision-making** on the city level through data collection that delivers reliable, localized measurements can inform urban planning.
- Further, it will show what role different surfaces have regarding the perceived temperature.
- The study can help to learn more about measurement protocols, sensor accuracy, and data collection logistics (e.g., placement height, time intervals, calibration).
- The results could quantify one of the ecosystem services provided by urban trees—temperature regulation—which is valuable for environmental valuation and cost-benefit analyses of green infrastructure.
- Communicating the findings can **raise awareness** among residents and policymakers about the tangible cooling benefits of trees.
- **Visualization of the data**: Turning technical readings into accessible outputs for policymakers, urban planners, or community members (e.g., dashboards) is as critical as the measurements themselves.
- **Scalability:** It will also offer methodological insights for scalability. A pilot study can inform municipalities on large-scale rollouts and maintenance efforts. Following the pilot study, the City of Dornbirn has shown interest in further developments and extensions of the pilot dashboard to other usage scenarions.

12.7. Overview of Implementation

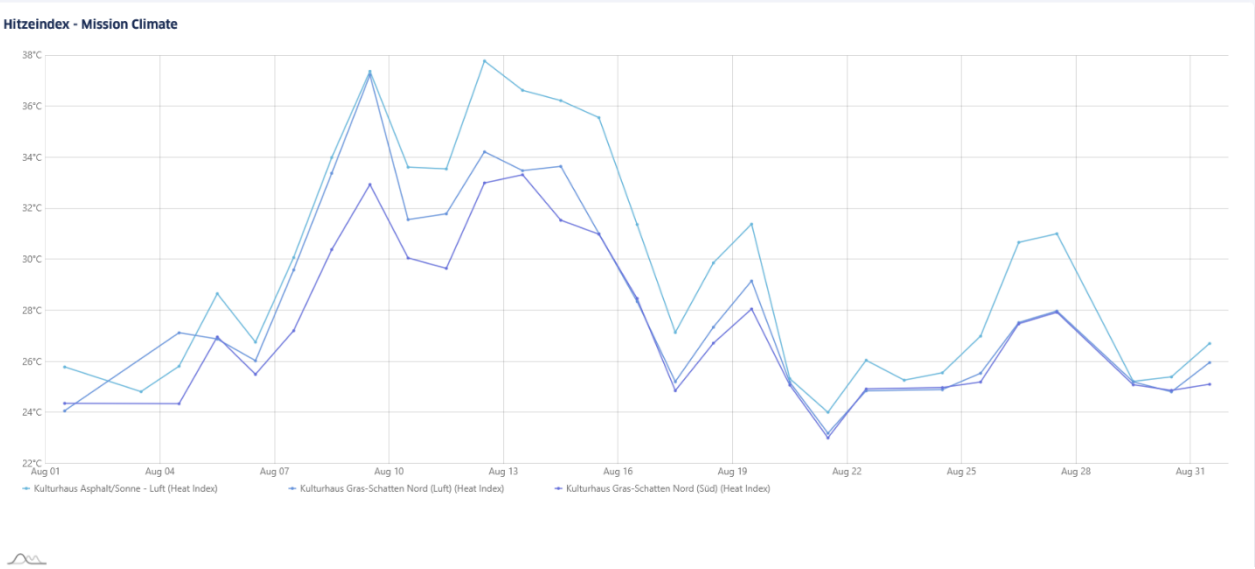
The pilot project was designed through a co-creation process between the city of Dornbirn and the University of Applied Sciences. To assess the potential of nature-based solutions within the project duration, it was decided to measure the shading effect and the associated temperature reduction of existing trees, allowing the focus on gathering data for supporting future implementations of nature-based solutions.The identified pilot study location ("Kulturhauspark" at the "Kulturhaus Dornbirn") allows access to various different shaded areas as well as different surface types. Further, it allows data collection immediately after the implementation of the sensor networks without any time delays due to finding an appropriate spot, planning and growing of new planted trees.

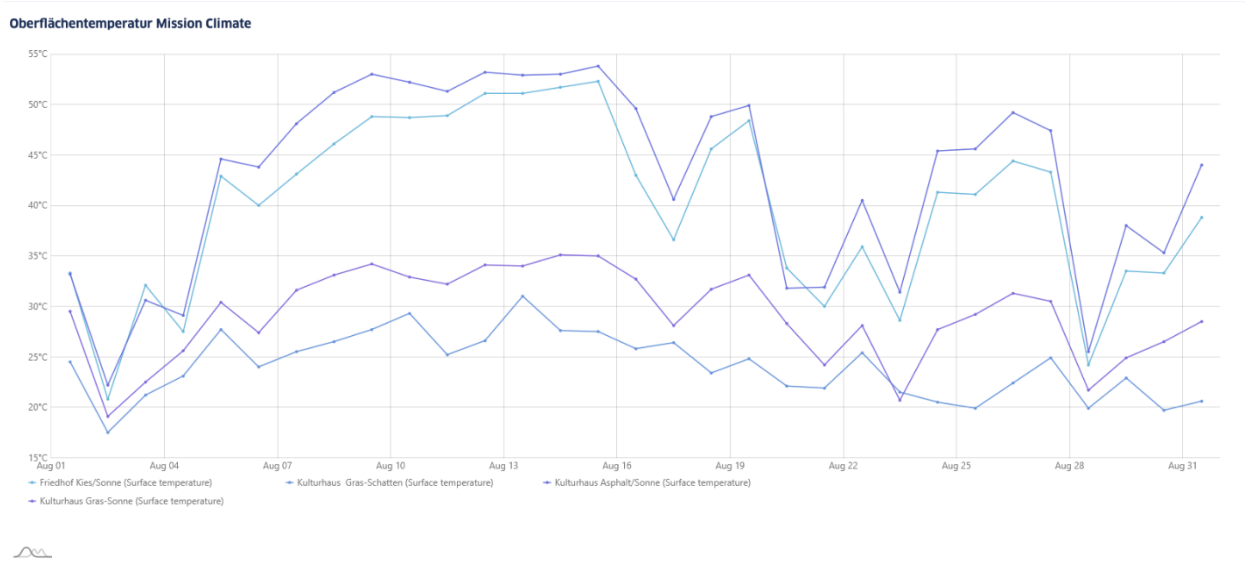
After careful considerations, the climate indicators and the respective sensor network were defined. The main criteria are compatibility with existing data and choosing equipment which allows adequate data accuracy. The requirements on the sensor networks were defined together with the city of Dornbirn. Quotations were requested by the city of Dornbirn after assessing the quotation requests for the equipment, the sensors were installed in spring 2025.

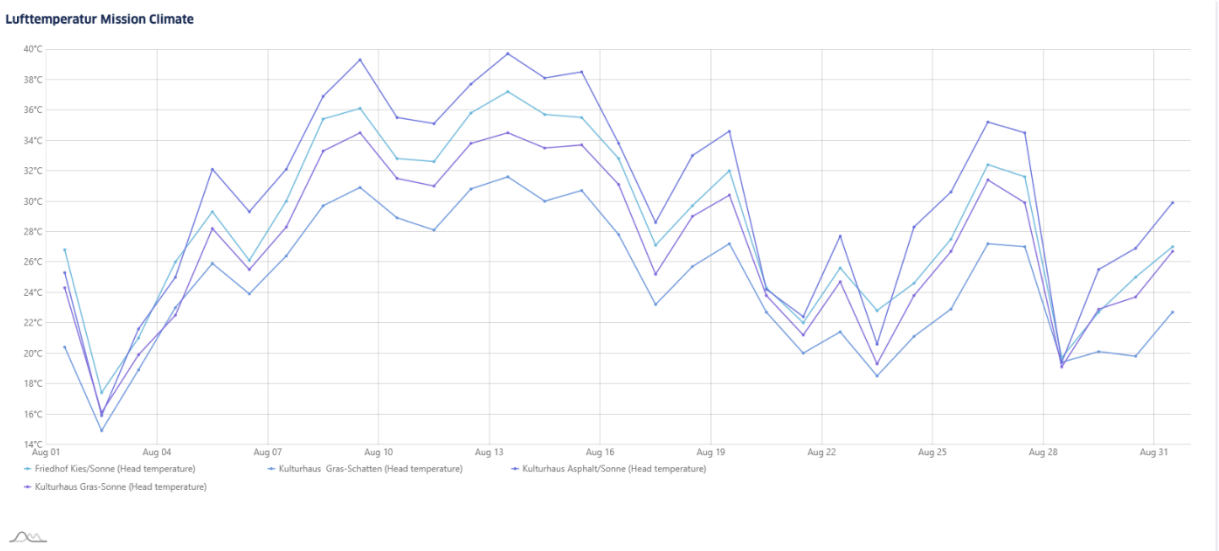
After evaluating various suitable locations during periods 1 and 2, the “Kulturhauspark” surrounding the “Kulturhaus Dornbirn” was selected as the final site for the pilot study. The park offers diverse surface types, including grass areas with and without tree shading, sealed surfaces with and without tree shading, as well as permeable surfaces with and without shading. Additionally, a basketball court with sealed ground and no tree shading was identified as a significant heat island within the park. This area was identified as the most appropriate spot to study and compare the microclimate of heat islands with other heat-reducing areas within the park.

The sensor network has been installed and the data collection is ongoing. The gathered data is visible on the citymonitor website for the city of Dornbir. This activity ensures that the gathered information is presented in a clear and easily understandable way, enabling effective communication of the findings. Further, the pilot study and its results have been disseminated through various media outlooks and dissemination events.

12.8. Screenshot







13. Use Cases

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
Air Temperature	Heat index	Air temperature and humidity sensor for LoRaWAN®	Dashboard with daily maximum temperature	Urban heat island effect; Awareness Raising and Decision Support for the city	Importance of nature-based solutions
Surface Temperature	Heat Index & importance of surfaces	Winter road maintenance sensor for LoRaWAN® and Infrared thermometer/surface temperate sensor for LoRaWAN®	Real-Time graphs; daily maximum temperature	Urban heat island effect, Awareness Raising and Decision Support for the city	Illustrating the difference between sealed and non-sealed surfaces
Humidity	Heat index	Air temperature and humidity sensor for LoRaWAN®	-	Showing the effect of trees on humidity	Importance of nature-based solutions

Table 4: Summary of all use cases of the digital solution

CONCLUSION & OUTLOOK

The development of modular climate resilience dashboards faces important challenges, particularly in ensuring interoperability, adaptability across regions, and usability for diverse stakeholder groups. Designing a dashboard that can accommodate complex scientific data while remaining accessible and meaningful to citizens and decision-makers requires balancing technical sophistication with intuitive user experience. Furthermore, the integration of diverse data sources, from European climate programmes to local monitoring initiatives, demands robust data governance frameworks and scalable architectures. Addressing these challenges is essential for enabling communities to make informed decisions, strengthen resilience, and actively participate in climate adaptation processes.

In total, this document consists of seven parts; part A consists of an introduction, part B sets the context towards climate resilience, part C focuses on dashboard design, and part D looks at existing tools and initiatives of digital solutions. Parts E, F, and G describe good practices.

This deliverable has explored the multi-faceted requirements for building such solutions in detail. First, we have examined the purpose and context, highlighting the urgent climate challenges in Central Europe (part B, page 9), the relevance of quadruple and quintuple helix approaches (chapter 1, page 11), the inclusion of citizens, and the existing climate change information services. We then discussed requirements modelling based upon regional climate models (chapter 1.4, page 17), as well as technical considerations such as the importance of UI/UX in making dashboards both functional and engaging (part C, page 11). Building on this, various design approaches were introduced, with a focus on modular dashboard development, design goals, the participation matrix linking data depth with levels of citizen involvement, and a technical description referencing potential key technologies (chapter 2.2 and following, from page 24). The analysis of user needs included the definition of stakeholder and user groups, climate indicators relevant to resilience, and findings from the consortium survey (chapter 3, page 31). Additionally, the study presented selected publicly available EU data sources (part D, page 42) as well as a compilation of good practices from the Mission CE Climate consortium partners. These insights collectively demonstrate that developing effective modular dashboards requires not only technological innovation but also cross-sector collaboration and sustained community engagement to truly support climate-resilient futures. The findings of three best practices (Pforzheim, Košice, Dornbirn) are consolidated in the final parts (parts E, F, & G; starting from page 86).

Looking ahead, the next steps will focus on long-term testing of the developed solutions in real-world settings to evaluate their effectiveness and usability, while ensuring that the modular dashboard concept can be replicated and adapted to other regions and potentially use cases beyond the initial scope.

A particular emphasis will be placed on furthering the inclusion of citizen science approaches, allowing communities to actively contribute data and insights that enrich the dashboards and strengthen local ownership. At the same time, efforts will continue to

deepen awareness-raising activities, both within target communities and the broader public, to build trust and understanding of climate resilience measures. An in-depth, long-term evaluation phase of the pilot results and the use of dashboards in practice remains an outstanding priority, ensuring that lessons learned can inform iterative improvements, broaden replicability, and ultimately establish a durable framework for climate resilience in diverse contexts.

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MISSION CE CLIMATE

APPENDIX I: Best Practice Template

Appendix I lists the template used to collect good / best practices.

Template – part of *D3.4.1 Good Practices*
Design of a digital solution for monitoring of climate change in communities

CONTRIBUTION TEMPLATE – DIGITAL SOLUTION DESCRIPTION

Deliverable D.3.4.1. Design of a digital solution for monitoring of climate change in communities

Please fill in one form per best-practice tool, project, or platform. This information helps the Mission CE Climate FHV-Team to identify transferable ideas, visualize opportunities, and plan dashboard features that are grounded in proven methods.

A. General Information

Project Partner:

Contributors/Team Members/Experts involved:

Date:

If any, technology providers:

Title / Name of the digital tool + URL:

B. Digital Solution - Description

1. Digital Solution - Description

- What does the digital tool or solution monitor? 2-4 sentences
- Brief Summary (2–4 sentences):

- Technology Stack:

- Monitored Climate Indicators:
  - Air Quality (e.g., PM2.5, CO_2, NO_2)
  - Temperature, Humidity
  - Precipitation / Flood Risk
  - Heat Islands
  - Land Use Change / Vegetation Index (NDVI)
  - Citizen feedback & perception

- Geographical Coverage:

2. Target Group

- Who uses the digital solution?
  - Local governments and municipalities
  - Urban planners
  - Experts (natural protection, civil engineering, meteorologists etc.)
  - NGOs
  - Research
  - Other:

- Stakeholder collaboration?
  - Describe the collaboration (e.g. with local communities, teachers, academia, schools, advisory board), if any collaboration is happening

3. (Expected) Impact

- If feasible, provide the expected impact (for recent digital solutions), or reported impact (for well established digital solutions)
- Qualitative Outcomes?
- Quantitative Outcomes?

4. Technical Implementation Details

- Data sources:
- Data type:
  - Satellite Data
  - Sensor Data - IoT
  - LoRaWAN
  - Other:
- Interoperability:

5. Overview of Implementation

- Attach any relevant documents/ reports, that illustrate your work.
- Attach any relevant documents/reports, further describing the digital tools.

6. Screenshot

- Share screenshots or Links, if feasible

C. Use Cases

Please replace the following Table 1 with your own use cases. The Table summarizes some exemplary use case description.

Table 5: Summary of all use cases of the digital solution

Use Case	Topic	Data Collection	Visualisation	Problem Addressed	Decision Support
School Air Monitoring	Air Pollution	IoT air quality sensors on school areas	Real-Time graphs; Peak-Times/ "rush hours" (e.g. when parents come by cars)	Awareness Raising and Decision Support for schools	Reduce exposure on schools; reduce arrival/departure by car
School Air Monitoring	Air Pollution	IoT air quality sensors on school areas	Real-Time graphs; Peak-Times/ "rush hours" (e.g. when parents come by cars)	Curriculum for students (digital solutions; climate data)	Real-world cases as educational material; integration into curricula
Citizens Involvement into climate data collection	Soil quality	LoRaWAN citizen reporting via soil moisture sensors	Map of soil moisture on urban green places	Dry soil and plant/tree health	Irrigation planning based on data analysis

Citizens Involvement into climate data collection	Precipitation	LoRaWAN citizen reporting	Map of rainfall and flood risks via public dashboards	Awareness of locations of high flooding risk	Map and alert system to inform civil engineering planning and fire department for operational management
Copernicus Land Monitoring	Vegetation / Heat	Copernicus NDVI and Land Surface Temperature data	Satellite time series maps in web interface	Urban heat island effects; green space degradation	Urban greening decisions; heat management planning; early alerts for heatwaves

Please provide a short descriptive text on all use cases.

Use Cases:

1. Use Case Name

2. Use Case Name

3. Use Case Name

4. Use Case Name

D.3.4.2 Pilot testing of digital solution for monitoring of climate change in communities

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MISSION CE CLIMATE

D.3.4.2. Pilot testing of digital solution for monitoring of climate change in communities

Deliverable 3.4.2 – Activity 3.4

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1. Introduction

This report summarizes the outcome of the pilot testing by three cities of the design of the digital solution (D.3.4.1.). The objective was to gain a better understanding of the feasibility for its uptake by communities by considering administrative and legal issues, looking at organizational models, data availability and compatibility. Hence, the design of the digital solution was evaluated by three communities, namely Dornbirn, Košice, and Pforzheim to establish its usability.

To enable the testing, a webinar was organized to provide the cities and other relevant stakeholders an overview of D.3.4.1. "Design of a digital solution for monitoring of climate change in communities". The webinar was organized by the Vorarlberg University of Applied Sciences and took place on the 16th of March. First, the deliverable D.3.4.1. "Design of a digital solution for monitoring of climate change in climate change communities" was explained. Afterwards, the highlights of three different climate resilience pilot projects were presented:

- Citizen science and participation (pilot project in Pforzheim)
- Climate data management (pilot project in Dornbirn)
- Climate data management (pilot project Košice)

Lastly, the questionnaire for testing the "Design of a digital solution for monitoring of climate change in communities" was discussed. The questionnaire was refined after the meeting and in three bilateral meetings filled-out with the three respective cities to learn more about the challenges and opportunities of implementing digital solutions in cities for climate monitoring. This report will highlight the main findings of the questionnaire.

2. Results

2.1. Administrative Feasibility

The objective of the first section was to understand the administrative processes in the respective municipalities and the willingness to adopt new digital solutions. Dornbirn and Pforzheim already had previous experiences with climate monitoring to some extent. For Košice, the pilot study within the Mission CE Climate project was the first time climate data was gathered.

In **Dornbirn**, sensor data on temperature, humidity and precipitation from various applications (departments: building construction, civil engineering and urban planning) is collected, processed,

and archived centrally in the 'City Monitor'. In addition, the data is presented in the form of dashboards for analysis. This service is provided by an external company - WEAVS GmbH.

The municipality of **Košice** currently possesses only the climate data and related processes, that come from the Mission CE Climate project. The data is measured by IoT weather stations, that are placed and operated in city's cloud infrastructure.

In **Pforzheim**, climate data is assessed and managed through a combination of long-term historical records from sources like the German Weather Service (DWD) and real-time IoT sensors deployed citywide. These sensors monitor parameters such as temperature, humidity, air quality, and precipitation, with data collected on our central Smart City platform for analysis and public visualization. This approach enables us to identify local climate variations and inform resilience actions, as seen in our Community Climate Mission living lab.

The processes to adopt new digital tools or implement new software differ between the three cities.

In **Dornbin**, there is no standardized process for introducing new digital tools. The city's IT department ensures the day-to-day operation of traditional administrative tools. For specific requests from individual city departments or city-affiliated organizations, the relevant departments usually commission external service providers.

In **Košice**, the decisions about new digital tools and software on the strategic level is based on the document "Conception of development of information technologies". For partial decisions and individual solutions, there is the obligation to elaborate a Business Analysis as preparation for minor projects. Further, the city's organizational structure clearly defines the responsibilities of each department. Requirements for implementing a digital solution may come from various sources—for example, from decisions made by local government bodies, from requirements set forth in the terms of reference for international projects in which the city acts as a project partner, or from various organizations under the jurisdiction of the local government. Based on this, the relevant department will contact other departments whose involvement is necessary. In the case of MISSION CE CLIMATE project, the Department of strategic development was involved as the initiator of further actions.

In Pforzheim, adopting new digital tools typically begins with pilot projects funded through programs like the Smart Cities Model Projects, involving testing, data evaluation, and iterative refinement. The process emphasizes citizen participation via dedicated platforms, cross-departmental collaboration, and alignment with sustainability goals before full rollout. For instance, IoT sensors and tools like waste robots were implemented after successful trials.

The primary point of contact for implementing and managing digital solutions like expanded LoRaWAN/IoT systems is Fabian Böpple, Project Manager for the Smart City funding program. He oversees initiatives from strategy to execution and can be reached via the city's Smart City team through our official website (www.pforzheim.de).

2.2. Legal Feasibility

The objective of this section was to establish whether there are any legal barriers or requirements that need to be considered. All three municipalities mentioned that there are no specific legal regulations or restrictions for climate monitoring. Further, data protection and data security are clearly set out in the cities and data privacy is managed in full compliance with the EU GDPR (DSGVO). However, climate data currently created is considered as publicly accessible.

In Dornbirn, based on the minimum legal requirements, individual departments may establish higher security requirements based on the nature of their work and data processing activities.

In Pforzheim, at the municipal level, the IoT deployments for climate monitoring follow Baden-Württemberg's smart city guidelines and federal funding requirements from programs like the Smart City Model Projects, which mandate sustainable and standardized tech use. Nationally, Germany's Energy Efficiency Act (EnEfG) governs energy-related aspects of digital infrastructure, including monitoring tools, with requirements for efficiency and renewable energy integration. EU-wide, the Data Act and environmental directives shape data handling in IoT systems, ensuring interoperability and minimal environmental impact.

Data privacy is managed in full compliance with the EU GDPR (DSGVO), Baden-Württemberg State Data Protection Act (LDSG), and TTDSG, prioritizing data minimization, purpose limitation, and user rights like access and erasure. For our LoRaWAN sensors, all transmissions are end-to-end encrypted, with anonymized aggregation of non-personal environmental data (e.g., temperature, air quality) on our secure central platform. Security features include robust network segmentation, regular audits, and citizen consent mechanisms where applicable, as demonstrated in our student IoT pilots and public dashboards.

Another important learning from the workshop and the questionnaire was that if the goal is to influence legislation through learnings or results from climate monitoring, the measured data must be created by officially certified devices and processes. Thus, depending on the objectives, the criteria for data quality and compatibility can vary significantly.

2.3. Organizational Feasbility

The objective of this section was to analyze organizational readiness and capacity. Therefore, we were interested in whether there are already existing teams or roles dedicated to climate monitoring and if not if there is enough capacity at the municipal level to maintain the sensor networks and other relevant infrastructure.

One of the bottlenecks of implementing climate monitoring in cities is the maintenance of sensor networks and relevant infrastructure. Here, a lack of resources is often an issue. The cities, currently, outsource these tasks to external partners. Another important challenge is the integration of 'external data' from federal, state and external providers, as there are no standardized interfaces and the readings from different types of sensors vary and differ from the results of calibrated (and significantly more expensive) systems. Data quality consistency across expanding networks and balancing citizen engagement with technical scalability can also pose hurdles. Overcoming these requires sustained cross-partner coordination.

In the city of **Košice**, there is a team dedicated to digital transformation of municipality and future creation of a digital twin of our municipality. The highest accent of this team is currently placed on the readiness of modern infrastructure for future development in regard of main legal duties of municipality.

In Slovakia, the municipality's responsibilities regarding air quality management are governed by Act No. 146/2023 on Air Protection. This area is not under the jurisdiction of the City of Košice. There is no team dedicated to climate monitoring, specifically.

One drawback or challenge to implement further climate monitoring is that mmunicipalities are not obliged to directly monitor climate by law. Regarding air quality monitoring, once the Slovak Hydrometeorological Institute issues a meteorological report — such as a smog alert — the municipality notifies the public of the smog alert in accordance with paragraph 12 section 9 of the Act No. 146/2023 on Air Protection. The City of Košice website publishes air quality data from the Slovak Hydrometeorological Institute, which uses official air quality monitoring stations for its measurements.

In **Dornbirn**, there is a dedicated unit (Digital Transformation) within the IT department. The Urban Planning Department has dedicated posts for environmental issues.

In **Pforzheim**, they have specialized teams including the Smart City project team, led by figures like Fabian Böpple, and the Climate Protection Department under Elias Weigel, Head of Climate Protection in the Environmental Protection Office. These groups collaborate with Stadtwerke

Pforzheim for IoT infrastructure and Pforzheim University students for pilots, handling monitoring and data analysis. Digital transformation is further bolstered by roles like Digital Transformation Officers within the municipality.

In Pforzheim, they have sufficient capacity through Stadtwerke Pforzheim's LoRaWAN network operations and their central data platform team, already managing over 50 sensors with plans for expansion. Partnerships with local universities provide additional expertise for upkeep and optimization, supplemented by low-maintenance, low-cost sensor designs. Full scalability would depend on project funding but aligns with our proven pilot-to-production model.

2.4. Data Availability and Quality

The objective of this section was to assess the availability, quality, and accessibility of relevant data in the three cities.

The city of **Pforzheim** collects real-time climate data including air temperature, humidity, air pressure, solar radiation, dew point, wind speed, precipitation, and soil moisture from ~50 sensors citywide. Additional parameters cover air quality, traffic impacts, and urban heat via standardized IoT setups, supporting comparisons between green and built areas.

Data transmits every 10 minutes to their central Smart City data platform, where it is aggregated, analyzed, and stored for optimization during test phases. Management involves iterative processing with partners like Stadtwerke and university teams for visualization and consolidation into a robust database.

Challenges include incomplete spatial coverage outside pilots, potential inconsistencies from non-uniform calibration during expansion, and reliability risks from unproven long-term sensor durability. Accessibility remains limited — data is internal during testing, with public dashboards planned but not yet fully rolled out, hindering real-time citizen use. Overall completeness lags for hyper-local microclimates, which requires standardization.

A digital solution should enable better-informed decisions for climate adaptation planning, such as urban greening and heat mitigation, while raising public awareness through accessible visualizations. Long-term, it would support predictive modeling for city development and legal compliance with CO_2 reduction targets (55% by 2030 vs. 1990).

For these goals, we need high reliability (99% uptime), completeness across key urban zones, and validated accuracy (±0.5°C for temperature) with standardized formats for interoperability. Timely, anonymized public access via APIs or dashboards is essential for awareness and decision-making.

In the city of **Košice**, temperature, humidity, barometric pressure, PM1, PM4, PM10, CO, NO_2, wind speed, wind direction, wind gusts are measured. The data is currently stored in a cloud database. The data is managed by several cloud applications to address the data complete flow from IoT device to visualisations. They face various issues, such as local power / internet connection outages, failure of sensors (invalid data). Further, IoT devices are not certified and calibrated by the local authority (high costs). Through a digital solution for climate monitoring better informed decision-making, support for legal changes and raising awareness in public could be achieved.

In **Dornbirn**, sensor data on temperature, humidity and precipitation from various applications (departments: building construction, civil engineering and urban planning) is collected, processed, and archived centrally in the 'City Monitor'. In addition, the data is presented in the form of dashboards for analysis. This service is provided by an external company - WEAVS GmbH. Further, through the scale-up of the pilot study, a new thematic focus is also monitored. By leveraging data and sensor technology, the dashboard brings together information from various different sources in regards to water management and makes it accessible and applicable. This allows authorities to monitor climate risks, while also enabling informed decision-making in the case of an emergency. As part of the measures described, selected climate resilience and disaster control-related content was integrated into and processed by the existing data and visualization platform of the city of Dornbirn (Citymonitor). The aim was to structure existing data sources, integrate additional relevant data points, and present them in such a way that they can be used in both operational and strategic contexts.

2.5. Technical Compatibility

The objective of this section was to evaluate the technical environment and integration needs. One common finding is that there exists a certain lock-in once certain infrastructure or software is implemented to enable technical compatibility, but also to ensure data compatibility.

In **Pforzheim**, environmental data from sensors feeds into their central Smart City data platform, which aggregates, analyzes, and visualizes metrics like temperature and humidity in test phases. This integrates with broader city IT via Cisco DNA and SD-Access for secure networking, supporting IoT gateways operated by Stadtwerke Pforzheim.

New solutions must comply with LoRaWAN protocol for low-power, long-range transmission, including end-to-end encryption and EU CE certification for low radiation. Additional mandates include GDPR-compliant data handling, standardized sensor formats (e.g., baugleiche Sensorik for comparability), and interoperability with open data platforms like CKAN.

Maintenance is handled collaboratively: Stadtwerke manages LoRaWAN gateways and solar-powered sensors, with our IT teams using custom monitoring and ticketing software for oversight. Pilots involve university students for testing, but full operations rely on iterative optimization during data evaluation phases, lacking dedicated 24/7 sensor teams.

The LoRaWAN network proves energy-efficient with long battery life and citywide coverage, delivering data reliably in pilots (e.g., every 10 minutes). However, vulnerabilities like urban signal hurdles, unproven long-term sensor durability, and scaling issues in non-pilot areas have been noted in a SWOT analysis. Urban deployments highlight low power as a strength but expose calibration inconsistencies during expansion

In **Košice** and **Dornbirn**, the integration of the pilot study worked out well and the maintenance of the sensor network is working as well. In **Košice,** the Azure infrastructure is stable. There are some issues with reliability of individual sensors, but after several adjustments of firmware the issues are less frequent.

2.6. Learnings from the pilot studies

In **Pforzheim**, the pilots shine in providing hyper-local, comparable data on urban heat islands and microclimates, enabling evidence-based planning for greening, flood prevention, and heat adaptation. Low-cost, low-power LoRaWAN unlocks scalable, radiation-minimal networks for broader Smart City apps like tree irrigation and waste management.

They learned that standardized sensors ensure reliable comparisons across sites (e.g., inner city vs. parks), while custom dashboards empower visualization and citizen insights. Iterative student-led testing highlights the value of multi-stakeholder collaboration for quick prototyping and long-term data utility.

Integration of raw data into actionable recommendations proved tough, alongside calibration inconsistencies and explainability for non-experts. Logistical hurdles like site access, signal coverage in dense areas, and transitioning from pilots to permanent infrastructure delayed full rollout.

Speak with our partners in the Smart City LoRaWAN Integration Labs@BW project: citysens GmbH (Ulm), Fichtner IT Consulting (Stuttgart), and SWP Stadtwerke Pforzheim. Nearby municipalities like Friedrichshafen, Neckarsulm, Neulingen, Ölbronn-Dürrn, and Ulm offer parallel experiences. Pforzheim University provides academic pilot perspectives.

Recommendation: Start small with student or partner pilots using LoRaWAN for cost-efficiency, prioritize data standardization and public dashboards for buy-in, and secure cross-departmental

funding early to bridge pilot-to-scale gaps. Focus on citizen participation for sustained relevance and benchmark against urban vs. green sites for quick wins.

In **Košice, t**he biggest opportunity lies in turning climate data into a practical tool for both local decision-making and community awareness. The pilot shows strong potential for scaling to additional schools and other public spaces, while also supporting municipal planning through reliable, site-specific evidence. A particularly valuable opportunity is the combination of digital monitoring with education, because it not only improves climate resilience today, but also builds long-term climate literacy and engagement among future generations.

The pilot also showed that climate data must be communicated carefully and in context, so that schools or neighbourhoods are not stigmatized. One of the main lessons learned when creating education program is that co-creation is essential. Early involvement of school leaders and teachers significantly increased ownership, motivation, and the usability of results. Integrating data into education proved to be one of the strongest drivers of long-term sustainability. Another key learning is that technical details matter: sensor placement and installation quality directly affect data reliability. The set up a meaningful activity it is necessary to better prepare the budget and allocate personnel resources.

The pilot faced both technical and organizational challenges, mainly due to lack of experiences in implementing such project activities. On the technical side, some sensors required repositioning or replacement due to interference or defects, which highlighted the importance of careful commissioning and maintenance. On the organizational side, coordinating multiple schools with different needs and capacities required significant communication and flexibility. Another challenge was ensuring that the collected data was not only accurate, but also understandable and meaningful for non-expert users such as teachers, students, parents, and the wider public.

In **Dornbirn**, the main goal of the pilot project was to demonstrate the temperature reduction potential of nature-based solutions. Specifically, different climate data indicators (surface and air temperature, humidity) are collected to compare the perceived temperature on different surface types, as well as on places with and without shade from trees. To minimize external influences on the microclimate, all data collection for different surfaces and shading conditions will be conducted within the same park, ensuring consistent general weather conditions for accurate comparison.

Within the project time of Mission CE Climate, the pilot study has already been up-scaled. Through the risk workshop and the pilot study, the team for disaster control in Dornbirn expressed the interest in an improved access to data and especially, in data visualization to enable better-informed decision-making in emergencies. As part of the measures described, selected climate resilience and disaster control-related content was integrated into and processed by the existing data and visualization platform of the city of Dornbirn (Citymonitor). The aim was to structure existing data sources, integrate additional relevant data points, and present them in such a way that they can be used in both operational and strategic contexts.

The implementation was carried out with consistent consideration of the existing technical, organizational, and specialist framework conditions of the city of Dornbirn. The project built on existing sensor technology, existing data flows, and established processes.

Vorarlberg has always been exposed to natural hazards, such as flooding and thus, Vorarlberg already has a high level of protection against floods. Nonetheless, climate change intensifies the severity and the frequency of heavy rainfall. This makes the implementation of robust monitoring and early warning systems not just important, but urgent, which is exactly the focus of this scale-up initiative.

The integrated content contributes in particular to:

- making climate and disaster control-related information centrally available facilitating the use of data in daily workflows
- making findings from existing measurement and monitoring activities visible – also to citizens
- creating a basis for the further use of data in future projects and use cases
- Citymonitor acts as a central platform for consolidating, visualizing, and interpreting relevant data without replacing existing systems.

These three pilot studies demonstrate that effective climate monitoring in cities is not only feasible but also best initiated through small, focused pilot projects. These pilots open up new opportunities, generate valuable insights, and build awareness. As cities learn which data is needed—and at what quality—decision-making for scaling up becomes significantly easier and more informed.

3. Synthesis

This report highlights the testing of a digital solution for climate change monitoring in municipalities, carried out within the Mission CE Climate project. The pilots were implemented and assessed in three European cities: **Dornbirn (AT)**, **Košice (SK),** and **Pforzheim (DE).** The objective was to evaluate the feasibility, usability, and scalability of the proposed digital solution by analyzing administrative, legal, organizational, technical, and data-related dimensions.

The pilots demonstrate that digital climate monitoring solutions are both feasible and valuable for municipalities, especially when introduced through small, well-defined pilot projects. Each city started from a different maturity level in digitalization and climate monitoring, yet all were able to integrate sensor-based data collection and visualization into their local contexts.

Key findings show that administrative and legal barriers are generally low, as climate data is typically considered public information and GDPR compliance frameworks are already well established. However, organizational capacity — particularly for maintaining sensor networks, ensuring data quality, and coordinating across departments — emerged as a critical constraint. Most cities rely on external partners for infrastructure operation and data management.

From a technical perspective, the pilots underline the importance of building on existing platforms and standards (e.g. LoRaWAN, central city dashboards) to avoid lock-in and ensure interoperability. Data availability varies widely, but data quality, calibration, and comparability are decisive factors, especially if the data is to support legal decisions or policy change.

Overall, the pilots confirm that digital climate monitoring can support evidence-based urban planning, climate adaptation, disaster preparedness, and citizen awareness. Success depends less on technology alone and more on governance structures, stakeholder involvement, and clear alignment between data quality and intended use.

3.1. Recommendations

Below, you can find the key learning and recommendations that result from the testing of a digital solution for climate change monitoring in municipalities:

1. **Start small and scale incrementally** - small, focused pilot projects lower risk, create quick wins, and help municipalities learn what data is needed and at what quality.
2. **Align data quality with intended use** - Data requirements differ depending on objectives. For instance, if the objective is awareness-raising non-certified sensors suffice. However, if compliance and legislative influence are the objective, certified devices and higher data

quality are necessary. Defining clear objectives at the outset of the planning phase is essential.

3. **Organizational capacity is crucial** - sensor maintenance, data validation, and integration are resource-intensive.
4. **Build on existing structures and platforms** – New data should be integrating into existing city dashboards and IT systems rather than replacing them. Digital solutions should complement existing systems, not compete with them as this reduces costs, time, and training needs.
5. **Standardization and interoperability are essential -** Early technical choices can create long-term lock-in. Thus, taking enough time for the decisions at the beginning is important and where possible, open and widely adopted standards can be useful.
6. **External data integration remains challenging -** Differences between low-cost sensors and calibrated reference stations can create inconsistencies. Thus, this should be always a part of the planning phase – data integration.
7. **Reliability and maintenance should not be underestimated -** Technical challenges can include: Sensor failures and calibration issues, power and connectivity outages or signal coverage problems in dense urban areas. Thus, redundancy, monitoring, and maintenance should be accounted for from day one.
8. **Citizen participation increases impact—but needs careful preparation** - Public dashboards, citizen science, and educational use increase relevance and acceptance. However, communication is key here and thus, the objectives should be clear and the data must be put into context and communicate understandably.
9. **Digital Climate Monitoring Enables Strategic Value** – The pilots highlight that digital solutions can support climate adaptation, improve and support disaster risk management, enables better informed urban planning and enhances the transparency through public access to data. Climate monitoring becomes more valuable when directly linked to decision-making processes.

3.2. Final Takeaway

The pilots highlight the value of digital solutions for climate monitoring and confirm that the implementation and uptake of D.3.4.1. is feasible and valuable. Regarding the challenges the testing highlighted that technology is not the limiting factor in municipal digital climate monitoring. The decisive factors are governance, organizational readiness, data strategy, and

stakeholder engagement. Municipalities that start small, build on existing systems, and align data quality with purpose can successfully implement and scale digital solutions for climate resilience.

4. Questionnaire

Administrative Feasibility

Objective: Understand the administrative processes and willingness to adopt new digital solutions.

- How is climate data currently assessed and managed in your municipality?
- What is the typical process for adopting new digital tools or software in your municipality?
- Who would be the main point of contact for implementing and managing this solution?

Legal Feasibility

Objective: Identify potential legal barriers or requirements.

- Are there specific regulations or laws in your municipality or country that govern the use of digital tools for climate monitoring?
- How is data privacy and security handled for digital solutions in your municipality?

Organizational Feasibility

Objective: Analyze organizational readiness and capacity.

- Are there existing teams or roles dedicated to climate monitoring or digital transformation?
- What are the biggest organizational challenges you foresee in adopting a digital solution for climate monitoring?
- Would there be enough capacity at your municipality for maintaining the sensor network and other relevant infrastructure?

Data Availability and Quality

Objective: Assess the availability, quality, and accessibility of relevant data.

- What types of climate-related data does your municipality currently collect?
- How is this data currently stored and managed?
- Are there any known issues with data quality, completeness, reliability, or accessibility?
- What would you like to achieve through a digital solution of climate monitoring (better informed decision-making, enable legal changes, raising awareness, etc.)?
- What data quality do you need for your respective objective?

Technical Compatibility

Objective: Evaluate the technical environment and integration needs.

- What IT systems or platforms are currently used for environmental or climate monitoring?
- Are there any technical standards or protocols that new digital solutions must comply with?
- How is IT support and maintenance handled for digital tools, sensor networks and other relevant infrastructure in your municipality?
- What experience do you have with reliability of sensor networks or other relevant infrastructure?

Learnings from the pilot study

Objective: Evaluate learnings from the already implemented pilot study

- Where do you see the biggest opportunities of the pilot study?
- What are the biggest learnings from the pilot study?
- What were challenges you faced?
- Are there other municipalities or partners you would recommend we speak with?
- What would you recommend other interested municipalities?