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SuPeRBE

Pilot report

D2.5.1

ACTIVITY 2.5

Pilot Action Implementation and Assessment

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1. table

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Contents

Abbreviations

Acronyms	
SuPeRBE	Supporting Cross-scale Planning and Policy readiness for a Resilient Built Environment
AF	Application Form
RBTool	Resilient Building Tool
RNTool	Resilient Neighbourhood Tool
DX.X.X	Deliverable X.X.X
MX	Milestone X
AX.X	Activity X.X
SuPeRBE WP	SuPeRBE Work Package
RBE - CE	Resilient Built Environment Assessment System for Central Europe
SECAP	Sustainable Energy Climate Action Plan
IPCC	Intergovernmental Panel on Climate Change

Executive summary

This deliverable presents the implementation and outcomes of Activity 2.5 (A2.5) "Pilot Action Implementation and Assessment" within the Interreg Central Europe SuPeRBE project. The activity represented the operational validation phase of the Resilient Built Environment Central Europe (RBE-CE) framework through its application within five pilot territories across Central Europe: Piedmont Region and Veneto Region (Italy), Municipality of Šibenik (Croatia), Municipality of Schnifis (Austria), and the City of Prague (Czechia).

The pilot activities tested the applicability, robustness, usability, and transferability of the RBE-CE framework across different territorial, climatic, and governance contexts. The framework combines two complementary assessment methodologies: the Resilient Neighbourhood Tool (RNTool-CE) and the Resilient Building Tool (RBTool-CE), enabling climate resilience assessment at both neighbourhood and building scale. The methodology follows the IPCC risk assessment logic and EN ISO 14091:2021 principles by combining hazard, exposure, and vulnerability components into a harmonised risk assessment process. The pilot implementation included neighbourhood- and building-scale assessments, stakeholder consultations, GIS analyses, data collection, field inspections, and testing of the SuPeRBE digital platform. Across the territories, extreme heat and heavy precipitation emerged as the most relevant and recurrent climate hazards. The assessments consistently identified vulnerabilities related to impermeable surfaces, insufficient shading, limited vegetation and green-blue infrastructure, inadequate stormwater retention capacity, overheating risks, and insufficient passive cooling strategies. At the building scale, recurrent weaknesses included roof and façade exposure, limited rainwater reuse systems, insufficient external shading, and incomplete climate-adaptive building systems.

The pilot implementation demonstrated the importance of combining neighbourhood-scale and building-scale assessments within a unified framework. While RNTool-CE supported the identification of territorial hotspots, urban-scale vulnerabilities, and strategic adaptation priorities, RBTool-CE enabled a more detailed understanding of technical building-level weaknesses and resilience gaps. The combined application of both tools therefore provided a more comprehensive understanding of climate resilience conditions across multiple spatial scales. The activities also highlighted several operational and methodological challenges. Common issues included fragmented datasets, missing technical documentation, limited GIS-ready data, heavy reliance on expert judgement for complex indicators, and varying levels of technical capacity across municipalities. The pilots confirmed the importance of local contextualisation of benchmarks, indicators, and assessment workflows to reflect regional climatic conditions and local governance realities.

A significant outcome of the pilot phase was the progressive testing and operational validation of the SuPeRBE digital platform, which supported the structuring of assessment workflows, aggregation of results, and visualisation of resilience indicators and risk values. The pilot activities also generated a wide range of complementary outputs, including GIS maps, thematic visualisations, harmonised reporting templates, technical assessment reports, and dissemination materials. The pilot assessments directly supported the adaptation planning activities developed within WP3 by providing evidence-based identification of resilience gaps and adaptation priorities. The methodology demonstrated strong potential to support climate adaptation planning, resilience-oriented urban development, building renovation strategies, and evidence-based decision-making processes at the municipal level.

Overall, the pilot implementation confirmed that the RBE-CE framework represents a transferable and adaptable methodology for climate resilience assessment in Central European contexts. At the same time, the pilot experience highlighted the need to further simplify selected workflows, refine benchmark calibration, strengthen data integration procedures, and continue developing user-friendly digital support tools to facilitate broader operational uptake beyond the project duration.

1. Introduction

This deliverable presents the implementation and outcomes of Activity 2.5 within the SuPeRBE project. The document reports on the pilot implementation activities across the five participating pilot territories and summarises the main findings, experiences, and lessons learned from applying the Resilient Built Environment Central Europe (RBE-CE) framework.

The deliverable contributes to Work Package 2 (WP2), which focuses on the development, contextualisation, testing, and validation of methodologies and tools to support climate resilience assessment across multiple spatial scales. In particular, A2.5 represents the operational phase in which the methodologies, climate services, and assessment tools developed in the previous activities were applied within real pilot contexts.

Within A2.5, pilot partners PP6, PP7, PP8, PP9, and PP10 implemented the pilot activities designed under A2.2, with technical and scientific support provided by LP1, PP2, PP3, and PP5 through the climate services developed in A2.4. The activity aimed to test the applicability, usability, and transferability of the RBE-CE framework across Central Europe in different territorial and climatic contexts.

The pilot implementation process was conceived as one common pilot action carried out through the coordinated application of the RBE-CE framework across five pilot territories. While the methodological approach and assessment logic remained shared among all partners, the implementation included multiple case studies within certain territories in order to better reflect local conditions, urban typologies, and climate-related challenges. This approach enabled both territorial comparability and local contextualisation, supporting the validation of the framework under diverse real-world conditions.

The pilot activities included assessing buildings and neighbourhoods using the RBTool-CE and RNTool-CE methodologies, collecting and processing local climate and spatial data, engaging stakeholders, and identifying key vulnerabilities and adaptation priorities. Intermediate progress and experiences were exchanged among project partners during dedicated half-day roundtables coordinated by PP3, supporting methodological alignment and mutual learning throughout the implementation phase.

At the conclusion of the pilot activities, each pilot partner prepared local assessment outputs and organised at least one dissemination event within their territory to present the pilot results and engage local stakeholders.

This deliverable, therefore, serves both as a technical summary of the pilot implementation activities and as a consolidated overview of the practical application of the RBE-CE framework across the SuPeRBE pilot territories.

1.1. Objective of Deliverable

The objective of Deliverable D2.5.1 is to document and evaluate the implementation of the pilot actions carried out within the SuPeRBE project by applying the RBE-CE framework across the participating pilot territories. The deliverable aims to provide a comprehensive overview of the pilot assessment process, including the methodologies applied, the climate services and tools used, the results achieved, and the challenges encountered during implementation.

A further objective of the deliverable is to analyse the practical applicability, usability, and transferability of the RBE-CE framework within different territorial and climatic contexts across Central Europe. The report therefore consolidates experiences from the pilot phase and identifies key lessons, methodological insights, and recommendations to improve local planning and decision-making processes for climate adaptation and resilience.

In addition, the deliverable aims to highlight the participatory dimension of the pilot activities, including stakeholder engagement processes, dissemination activities, and knowledge exchange among project partners, supporting the future replication and upscaling of the framework beyond the project context.

1.2. Activity 2.5 within the SuPeRBE Project

A2.5 represents the implementation and validation phase of the RBE-CE framework within the SuPeRBE project. Building on the pilot design in A2.2 (D2.2.1) and contextualisation activities developed in A2.3 (D2.3.1), the pilot phase applied the adapted methodologies, indicators, benchmarks, and climate hazards within real pilot territories across Central Europe.

The activity was also closely linked to A2.4, which provided the climate services, datasets, methodological guidance, and technical support necessary for the implementation of the pilot assessments. These services supported the assessment of buildings and neighbourhoods through the RBTool-CE and RNTool-CE methodologies under local climatic and territorial conditions.

In parallel, the results generated through the pilot activities are going to contribute to the adaptation planning and stakeholder engagement processes developed within WP3. The pilot assessments helped identify key vulnerabilities, resilience gaps, and potential adaptation priorities, supporting local planning and participatory decision-making processes related to climate resilience.

1.3. Common Pilot Action and Multi-case Study Approach

A2.5 was implemented as one common pilot action carried out across five pilot territories in Central Europe. The objective was to test the applicability and transferability of the RBE-CE framework under different climatic, territorial, and governance conditions while maintaining a shared methodological structure across the partnership.

The pilot territories included the Piedmont Region and Veneto Region (Italy), the Municipality of Šibenik (Croatia), the Municipality of Schnifis (Austria), and the City of Prague (Czechia). Within these territories, the framework was applied to a series of neighbourhood-scale and building-scale case studies selected according to local climate risks, urban characteristics, data availability, and municipal priorities.

Throughout this deliverable, a distinction is made between “pilot territory” and “case study”. The pilot territory refers to the broader territorial or administrative context participating in the project, while the case studies correspond to the specific neighbourhoods, buildings, or urban areas assessed through RNTool-CE and RBTool-CE.

Some pilot territories included multiple case studies in order to test the framework across different urban typologies and spatial conditions within the same regional context.

For example, the Piedmont Region pilot included four municipal case studies (Chivasso, Gassino Torinese, Leinì, and Venaria Reale), each combining neighbourhood-scale and building-scale assessments. Similarly, the Veneto Region pilot included the case studies of Abano Terme and Verona. In contrast, the pilots in Šibenik, Schnifis, and Prague focused on one main territorial case study each, while still combining assessments at multiple spatial scales.

Although the pilot territories differed significantly in terms of scale, morphology, climate conditions, and data availability, all pilots followed the same methodological workflow based on hazard identification, exposure and vulnerability assessment, indicator normalisation, weighting procedures, and aggregation of final risk values. This ensured overall methodological consistency while allowing the necessary level of local contextualisation developed during A2.3 (D2.3.1).

2. Methodological Framework and Pilot Implementation Approach

2.1. RBE-CE Framework Applied in the Pilot Action

The pilot actions implemented within the SuPeRBE project were based on the application of the Resilient Built Environment Central Europe (RBE-CE) framework, developed to support climate resilience assessment at both building and neighbourhood scale. The framework follows the IPCC risk assessment approach and EN ISO 14091:2021 principles, combining the evaluation of climate hazards, exposure, and vulnerability to identify climate-related risks affecting the built environment.

The RBE-CE framework consists of two complementary tools: the Resilient Buildings Tool (RBTool-CE) and the Resilient Neighbourhoods Tool (RNTool-CE). RBTool-CE focuses on the resilience assessment of individual buildings, while RNTool-CE evaluates resilience conditions at neighbourhood scale through indicators related to urban morphology, green-blue infrastructure, land use, mobility, and social vulnerability.

Within the pilot action, the tools were applied through locally contextualised versions in five territories developed during A2.3 and integrated into the SuPeRBE platform. Although implemented across different territorial and climatic contexts, the same methodological structure, workflow, and assessment logic were applied in all pilot territories, ensuring methodological consistency and comparability across the partnership. The pilot assessments enabled the identification of key climate risks, resilience gaps, and adaptation priorities at both spatial scales.

The assessment methodology is based on the interaction between three main components: **Hazard Value (HV)**, **Vulnerability Value (VV)**, and **Exposure Value (EV)**. For each selected climate hazard, individual criteria and indicators were assessed, normalised, weighted, and aggregated into final risk values. Depending on the criterion, the assessment combined quantitative calculations, GIS analyses, expert-based evaluation, field observations, and qualitative scoring procedures.

All results were normalised on a **0-1 scale**, where 0 represents an optimal or resilient condition, and 1 represents a critical or highly vulnerable condition. Intermediate values reflect progressive levels of vulnerability, exposure, or risk. The final risk values were subsequently classified into qualitative performance classes used throughout the pilot assessments:

- **0.00-0.20 = Optimal**
- **0.21-0.40 = Rather Positive**
- 0.41-0.60 = Neutral
- 0.61-0.80 = Rather Negative
- **0.81-1.00 = Critical**

This normalised scoring system enabled the comparison and aggregation of different indicators, risk categories, hazards, and territorial contexts within a harmonised assessment framework.

2.2. Pilot Implementation Workflow

The implementation of the SuPeRBE pilot action followed a common methodological workflow developed within Activities A2.2 and A2.3 and subsequently applied during the pilot implementation phase under A2.5, as shown in the Gantt chart in Figure 1. The workflow was designed to ensure methodological consistency across all pilot territories while allowing sufficient flexibility to reflect local climatic, administrative, spatial, and data-related conditions. The overall implementation process included the definition of pilot areas, hazard prioritisation, exposure and vulnerability screening, local stakeholder validation, contextualisation of the RBE-CE tools, assessment execution, and interpretation of results.

The first phase of the workflow focused on the preparation of the Pilot Action Concepts developed under A2.2. Pilot partners identified the spatial boundaries of the case studies and selected the assessment scale to be applied (building scale, neighbourhood scale, or both), based on local priorities, data availability, and relevance for municipal planning processes. The pilot selection process considered factors such as exposure to relevant climate hazards, representativeness of local challenges, strategic planning relevance, and feasibility of implementation. This resulted in a diverse set of pilot territories, including urban districts, municipalities, and regional case studies across Austria, Croatia, Czechia, and Italy (Regione Veneto and Regione Piemonte).

Following the pilot definition phase, partners carried out hazard identification and prioritisation activities using outputs from WP1, local climate strategies, Sustainable Energy and Climate Action Plans (SECAPs), historical climate records, hazard maps, and regional climate datasets. The prioritised hazards differed depending on local conditions, but commonly included extreme heat and heavy precipitation. Exposure and vulnerability screening activities were subsequently conducted to identify the most sensitive assets, urban functions, population groups, and critical infrastructures affected by the selected hazards.

An important component of the workflow consisted of local validation activities involving Local Advisory Groups (LAGs), municipal departments, technical experts, schools, civil protection authorities, and other local stakeholders. These consultations were used to validate hazard prioritisation, verify the feasibility of assessment workflows, identify locally relevant indicators, and strengthen ownership of the pilot implementation process.

Parallel to these activities, pilot partners carried out structured reviews of data availability and developed practical workflows for indicator calculation and assessment implementation. The workflow included identifying hazard datasets, GIS layers, land-use information, building characteristics, socio-economic indicators, meteorological data, and infrastructure-related datasets. Depending on local data availability, assessments combined quantitative calculations, GIS analyses, proxy indicators, expert judgement, and qualitative evaluations. To ensure transparency and replicability, partners also documented data sources, assumptions, calculation procedures, benchmark values, and interpretation methodologies.

During A2.3, the generic versions of RBTool-CE and RNTool-CE were contextualised and integrated into locally adapted versions within the SuPeRBE platform. The contextualisation process included selecting relevant indicators, adapting benchmark ranges, adjusting the scoring logic, and integrating locally available datasets. This process resulted in customised versions of the tools for each pilot territory, ensuring that assessments reflected local climatic conditions, governance structures, regulatory frameworks, and available information sources while maintaining consistency with the overall RBE-CE methodology.

The implementation phase under A2.5 built directly upon these preparatory activities. Pilot partners applied the contextualised tools to the selected case studies using the agreed workflows and datasets. The assessments followed the RBE-CE methodology, which is based on the interaction among the hazard, exposure, and vulnerability components. For each selected hazard, individual indicators and criteria were assessed, normalised, weighted, and aggregated into vulnerability values, exposure values, hazard values, and final risk scores.

The pilot implementation activities were supported by the progressive deployment and testing of the SuPeRBE digital platform, which served as a central tool for organising assessment inputs, structuring the evaluation workflow, aggregating results, and visualising assessment outputs. Depending on the maturity of the platform functionalities during the pilot phase, the platform was used alongside spreadsheets, GIS analyses, and manual calculation procedures to support the implementation of RNTool and RBTool assessments. The pilot activities therefore contributed not only to the validation of the RBE-CE methodology itself, but also to the testing and refinement of the digital platform supporting its operational implementation.

To ensure harmonisation across pilots, all assessments followed a common reporting structure developed within the project. The assessment reports documented the complete workflow from pilot description and hazard characterisation to vulnerability assessment, exposure evaluation, weighting procedures, calculation methods, interpretation of results, and final aggregation of risk values. The reports were organised hazard-by-hazard and criterion-by-criterion, ensuring methodological consistency across the different territories and scales of assessment.

For each evaluated criterion, the reports included the criterion's objective, indicator definition, units of measurement, benchmark values, supporting materials, data sources, maps or visual documentation where relevant, calculation formulas, normalisation procedures, interpretation of findings, and justification of assigned scores. The assessments, therefore, combined quantitative calculations with expert-based interpretation and locally contextualised evaluation approaches. Depending on the criterion and data availability, the workflow integrated climate datasets, GIS analyses, technical documentation, cadastral information, building surveys, field observations, photographs, proxy indicators, and expert judgement.

In addition to the synthesis activities presented in this deliverable, each pilot assessment was therefore supported by a comprehensive technical assessment report developed at the criterion level – see the QR codes in each summary. These reports document in detail the assessment process for each evaluated criterion, the interpretation of findings, and the justification of assigned scores. The reports also include the aggregation process leading to the final vulnerability, exposure, and overall risk results for each assessed hazard and risk category.

The comprehensive reports, therefore, represent the full technical documentation of the pilot assessments, while Deliverable D2.5.1 provides a harmonised comparative synthesis of the pilot implementation activities and results.

Table 1 GANTT chart for the Pilot Action Concept.

Activity (Pilot Action Concept)	12-24	01-25	02-25	03-25	04-25	05-25	06-25	07-25	08-25	09-25	10-25	11-25	12-25	01-26	02-26	03-26	04-26	05-26
Pilot area selection & scale definition	■	■	■															
Hazard identification & prioritisation		■	■	■														
Exposure & vulnerability screening			■	■														
Local validation (LAG/stakeholder consultation)	■	■	■															
Data availability review (datasets, proxies, gaps)				■	■	■	■	■										
Definition of data workflows (roles, processing, calculations)						■	■	■										
Customization of RBTool/RNTool (indicator selection, benchmarks, weightings)									■	■	■	■						
Consolidation of Pilot Action Concept documentation											■	■						
Pilot Implementation and Assessment													■	■	■	■	■	■
National dissemination events													■	■	■	■	■	■

2.3. Stakeholder Involvement

Throughout the implementation of the pilot activities, local municipalities, public authorities, technical coordinators, urban planners, academics, private-sector representatives, and other experts were actively involved in workshops and consultations (A2.1), training sessions (A3.3), and dissemination events (A2.5). The objective was not only to present the developed assessment methodology, but also to create a collaborative environment for knowledge exchange, validation of results, and discussion of locally relevant climate adaptation challenges.

The participatory activities were implemented across all pilot territories through hybrid, online, and in-person workshops, enabling broad stakeholder engagement and accessibility. These events combined theoretical presentations, practical demonstrations of the RBTool and RNTool, local case studies, moderated discussions, Q&A sessions, and networking activities. A particular emphasis was placed on linking the assessment methodology to real pilot areas and ongoing municipal planning processes, which significantly improved stakeholder understanding and practical relevance.

The training and dissemination activities targeted a multidisciplinary audience including public authorities, municipalities, decision-makers, urban planners, architects, engineers, researchers, students, and private-sector representatives. This broad stakeholder composition supported cross-sector cooperation and facilitated the exchange of perspectives between academia, municipal administration, and professional practice. Professional organisations and chambers also played an important role in promoting participation and disseminating project outcomes.

Overall, the participatory process contributed not only to dissemination and capacity building, but also to the collaborative validation and contextualisation of the assessment methodology. Stakeholder feedback helped identify local priorities, practical implementation barriers, and opportunities for future application of the SuPeRBE tools in climate adaptation planning and decision-making processes.

2.4. Data Collection and Assessment Inputs

The pilot activities relied on a combination of quantitative datasets, spatial analyses, technical documentation, field surveys, expert judgement, and climate-related information collected from local and regional sources. The assessment process integrated both publicly available datasets and project-specific analyses in order to evaluate climate vulnerability, exposure, and risk at neighbourhood and building scale across the pilot territories.

At neighbourhood scale, the main assessment inputs included:(i) GIS datasets and spatial layers; (ii) orthophotos and satellite imagery; (iii) cadastral and land-use information; (iv) local planning documents and urban development plans; (v) SECAPs and local climate adaptation strategies; (vi) hazard maps and climate datasets; (vii) demographic and census data; (viii) urban green infrastructure maps; (ix) mobility and transport infrastructure data; (x) field observations and site inspections.

Several pilots developed dedicated spatial analyses to support the assessment workflow. For example, the Veneto pilot produced thermal risk maps, runoff vulnerability maps, land surface temperature analyses, and vulnerable population maps to support the RNTool assessment. The Prague pilot developed GIS analyses and spatial mapping for infiltration capacity, rainwater retention, bio-retention areas, and urban heat-related indicators. Similarly, the Piedmont pilots combined GIS land cover data, satellite imagery, field surveys, and municipal environmental planning documents to assess permeability, shading, vegetation buffers, and urban heat exposure.

At building scale, the assessments relied mainly on: (i) building technical documentation and design drawings; (ii) energy audit reports and EPC-related information; (iii) site inspections and photographic surveys; (iv) material catalogues and technical specifications; (v) CAD drawings and BIM-related information where available; (vi) construction stratigraphy and envelope specifications; (vii) municipal archives and maintenance documentation; (viii) simulation tools and engineering software.

Several pilots highlighted the importance of on-site inspections to compensate for missing or incomplete documentation. In Prague, the building assessment combined technical documentation with direct site inspections to clarify missing data. In the Piedmont and Veneto pilots, site visits were essential to assess façade conditions, drainage infrastructure, permeability, shading systems, and exposed building components.

The pilot activities also relied extensively on expert-based evaluation and qualitative assessment methods, particularly where highly technical data or simulation outputs were unavailable. Several indicators required the interpretation of site conditions, approximation methods, or proxy indicators. Examples included simplified methodologies for drainage assessment, estimation of reflective properties of materials, qualitative evaluation of ventilation and shading strategies, and the use of building age as a proxy for structural vulnerability.

Climate hazard information was derived from multiple sources depending on the pilot territory, including SECAPs, regional climate analyses, hazard maps, rainfall datasets, thermal maps, and local climate projections. The selected hazards varied according to territorial priorities and local climate conditions, resulting in heavy precipitation, extreme heat, drought, and storms.

The pilot implementation process highlighted significant differences in data availability and technical capacity between municipalities. Common challenges included fragmented datasets, missing technical documentation, a lack of GIS-ready information, limited access to infrastructure data, and the absence of detailed maintenance or monitoring records. Several pilots also identified difficulties related to hydraulic modelling, thermal simulations, and the availability of detailed building envelope information.

Assessment inputs and outputs were progressively integrated within the SuPeRBE platform environment, allowing pilot partners to test the digital workflow supporting RNTool-CE and RBTool-CE implementation. The platform was used to structure criteria and indicators, input assessment values, normalise scores, aggregate vulnerability and exposure results, and visualise risk outputs. Several partners combined platform use with spreadsheets, GIS workflows, manual calculations, and external modelling tools.

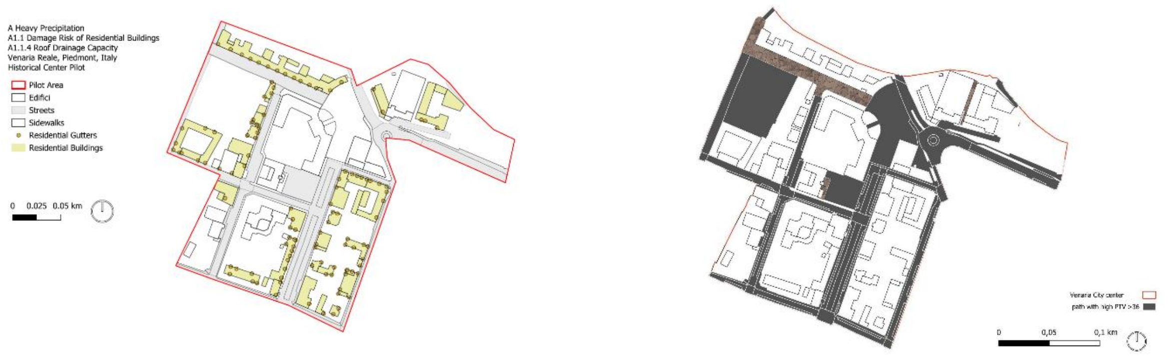
The pilot activities hence contributed not only to the validation of the RBE-CE methodological framework itself, but also to the testing, refinement, and operational development of the SuPeRBE digital platform.

3. Assessment Visualisations

The pilot activities generated a wide range of visual, technical, and reporting materials supporting both the implementation and communication of the RBE-CE assessment framework (Figure 1-3). These materials contributed to the harmonisation of the pilot activities across the partnership and supported the interpretation, validation, and dissemination of the assessment results.

The generated materials included: (i) harmonised pilot presentations prepared for meetings and project roundtables; (ii) neighbourhood- and building-scale assessment tables; (iii) GIS-based spatial analyses and thematic maps; (iv) climate risk visualisations and hotspot mapping; (v) platform-based assessment outputs and score aggregation visualisations; (vi) comprehensive criterion-level technical assessment reports; (vii) dissemination materials and webinar presentations.

Several pilot territories developed dedicated spatial analyses and maps to support the interpretation of the assessment results. Examples include thermal risk maps, vulnerable population maps, land surface temperature analyses, runoff vulnerability maps, rainfall maps, permeability analyses, and urban heat hotspot mapping developed during the Veneto pilot activities. These visual outputs supported both the RNTool assessments and the subsequent identification of adaptation priorities within WP3.



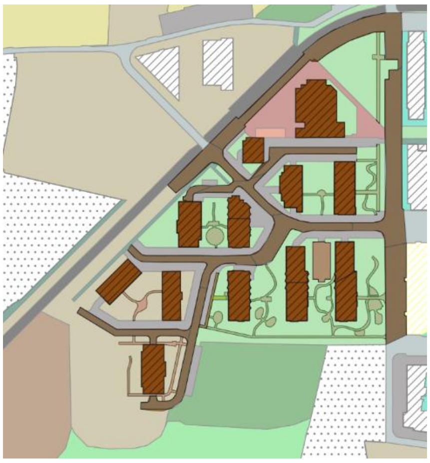
(a) (b)

Figure 1 (a) A1.1.4 Roof Drainage Capacity map; (b) A2.4.11 Slip resistance of cycling and pedestrian surfaces map – Venaria Reale (Piedmont Region – Italy).

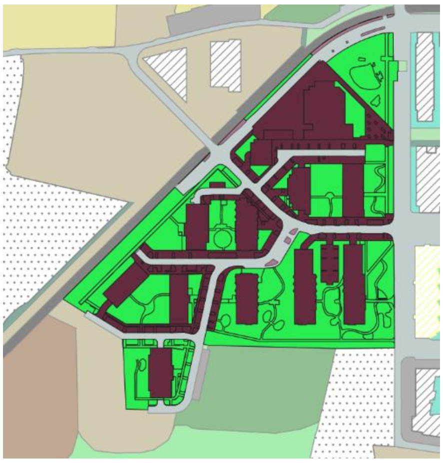
(a) (b)

Figure 2 (a) C8.1.7 – Presence of households in bad conditions map – Chivasso (Piedmont Region – Italy); (b) C2.4.2 Surface Material Albedo map – Abano Terme (Veneto Region – Italy).

In addition to the synthesis material included in this deliverable, each pilot territory prepared comprehensive technical assessment reports documenting the detailed RNTool-CE and RBTool-CE assessment process for each case study. These reports include: (i) criterion-level calculations; (ii) benchmark references; (iii) data sources; (iv) maps and visual evidence; (v) aggregation procedures; (vi) interpretation of results; (vii) final risk values by hazard and risk category.



(a)



(b)

Figure 3 (a) C1.1.4 Dark Surface Exposure map; (b) C14.2.1 Greenery and water on the property map - Novy Barrandov, Prague (Czechia).

To improve the accessibility and usability of the assessment documentation, the case study summary pages (Section 4) in this deliverable include QR codes and direct links to the corresponding comprehensive technical reports.

4. Pilot Territories and Case Study Assessments

4.1. Piedmont Region (Italy)

The Piedmont Region pilot included four municipal case studies: Chivasso, Gassino Torinese, Leinì, and Venaria. Each case study included both a neighbourhood-scale assessment using RNTool and a building-scale assessment using RBTool. The selected neighbourhoods and buildings were: Piazza d'Armi and Demetrio Cosola School in Chivasso, the historical city centre and Borione School in Gassino, the Michelangelo Square area and Di Vittorio School in Leinì, and the Via Ronco area and Carlo Collodi Kindergarten in Venaria.

The main hazards assessed were heavy precipitation and extreme heat in all four municipalities, while drought was additionally assessed in Chivasso. The number of indicators assessed varied across the municipalities due to data availability. For RNTool, 63 indicators were considered in Chivasso, 54 in Gassino, 54 in Leinì, and 54 in Venaria, with data gaps ranging from 17.5% to 36%. For RBTool, 37 indicators were considered in Chivasso and 28 in the other three municipalities, with generally fewer data gaps at the building scale, especially in Leinì and Venaria.

The comprehensive criterion-level assessment reports for the Piedmont Region territory are available via the QR code or link at the end of the pilot summary section. The tables presented in the following sections represent only a selected extract of the full assessment results and are intended to illustrate methodological examples identified during the pilot implementation.

4.1.1. Neighbourhood-scale Assessment (RNTool)

At neighbourhood scale, the overall results ranged from neutral to rather negative. Chivasso reached an overall RNTool risk value of 0.38, classified as rather positive. Heavy precipitation was classified as rather positive (0.39), while extreme heat reached a neutral value (0.4) and was the main contributor to the neighbourhood-scale result. Drought was also assessed and resulted in a positive value (0.17). The assessment highlighted that heat-related vulnerability was linked to paved surfaces, limited shading, and exposure to health-related indicators. An example criterion calculated for extreme heat was C2.4.4 Shade Provision, where 46% of path segments were shaded, corresponding to a neutral vulnerability level.

Code	Name	Weight	Risk value
A	Heavy Precipitation	40.00%	0.39
B	Extreme Heat	40.00%	0.48
C	Drought	20.00%	0.17

Figure 4 Risk score and weights for each considered hazard for Chivasso. Graph extracted from the SuPeRBE platform.

Gassino showed the highest neighbourhood-scale risk among the Piedmont pilots, with an overall RNTool value of 0.631, classified as rather negative. Both heavy precipitation and extreme heat were classified as rather negative, indicating relevant vulnerabilities in buildings, transport and health-related categories, with particular attention to public buildings, road infrastructure, bicycle and pedestrian paths, and population exposure.

Leinì reached an overall RNTool value of 0.583, classified as neutral, although extreme heat was assessed as rather negative and represented the dominant contributor to the final score. Heavy precipitation remained neutral.

Venaria also resulted in an overall RNTool value of 0.39, classified as rather positive. Heavy precipitation was neutral, while extreme heat was rather positive. The assessment highlighted relevant vulnerabilities linked to surface infiltration, urban heat, and the limited capacity of some areas to mitigate thermal stress. For example, the presence of vegetated buffers along paths was assessed positively, while surface infiltration capacity in the Michelangelo Square area was found to be critical, with only 20.4% of the surface area permeable.

Table 2 Overall risk value for Extreme Heat at the neighborhood scale - Venaria.

Code	Urban sector	Vulnerability class	Normalized score	Weight	VV
C2	Transports	Optimal	0.00	20%	0.00 * 0.2 = 0.0
C7	Environment and biodiversity	Optimal	0.00	30%	0.00 * 0.3= 0.00
C8	Health	Neutral	0.58	50%	0.58*0.50 = 0.20
Total Risk value Extreme Heat					0.29 - Rather positive

Across all four municipalities, extreme heat was identified as the most relevant recurring neighbourhood-scale issue, while heavy precipitation remained important due to drainage, runoff, and impermeability-related weaknesses.

4.1.2. Building-scale Assessment (RBTool)

At the building scale, all four case studies resulted in an overall rather negative risk classification. Chivasso and Venaria showed the highest RBTool overall values, both reaching 0.701. In Chivasso, heavy precipitation, extreme heat, and drought were all classified as rather negative, with extreme heat and drought contributing most strongly to the overall score. The building-scale assessment identified vulnerabilities related to façade and roof systems, openings, landscaping, stormwater retention, and water management.

For example, the assessment of A4.2.1 Safe Windows and Shutters showed that only 35% of windows were equipped with protective elements, resulting in a rather negative vulnerability score.

In Gassino, the Borione School reached an overall RBTool risk value of 0.693, classified as rather negative. Heavy precipitation reached 0.616, while extreme heat reached 0.770, confirming extreme heat as the dominant building-scale risk. A positive example was A13.1.3 Permeable Outdoor Surrounding Surfaces, where 63% permeability resulted in a rather positive vulnerability level, although this did not compensate for the broader heat-related weaknesses.

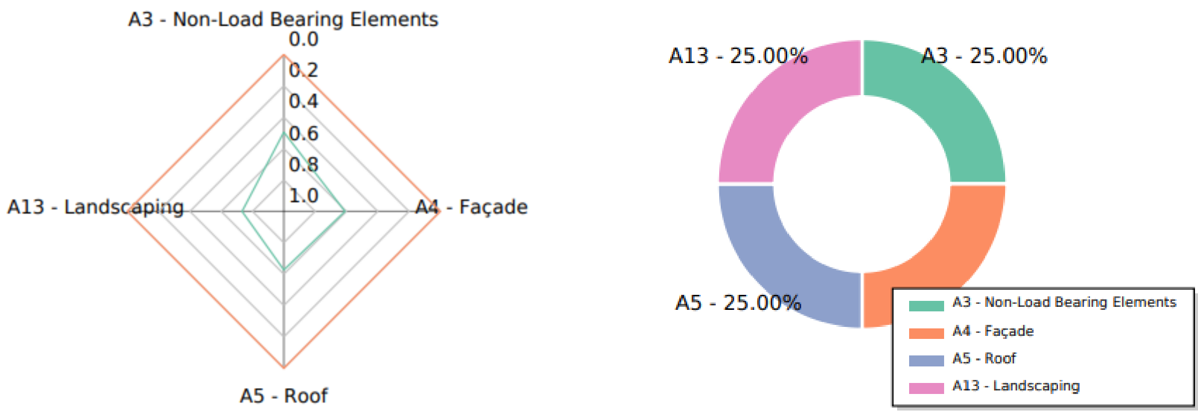


Figure 5 On the left, the level of risk by building component for Heavy Precipitation. On the right, active weights by building components for Heavy Precipitation. Both graphs for Gassino were extracted from the SuPeRBE platform.

In Leinì, the Carlo Collodi Kindergarten had an overall RBTool value of 0.660, which is also classified as rather negative. Heavy precipitation was neutral, while extreme heat was rather negative, with critical issues related to roof reflectance and limited tree-based shading. The most relevant weaknesses were linked to roof solar reflectance, façade and roof exposure, limited tree-based shading, and outdoor overheating. For example, the roof solar reflectance indicator resulted in a critical score due to a low SRI value of 40.6, while tree-based building shading reached only 5%, also resulting in a critical vulnerability level.

In Venaria, the assessed school building reached an overall RBTool value of 0.708, with heavy precipitation at 0.682 and extreme heat at 0.735, both classified as rather negative. The assessment highlighted vulnerabilities in roof and façade protection, outdoor surfaces, heat exposure, and insufficient adaptive systems.

4.1.3. Main Issues Identified

The main issues identified across the Piedmont pilot territory were strongly linked to data availability, technical documentation gaps, and recurring physical vulnerabilities.

At the neighbourhood scale, the most frequent weaknesses concerned the limited availability of stormwater and drainage data, incomplete information on sewer systems, lack of data on rainwater retention capacity, limited information on Sustainable Urban Drainage Systems, and missing irrigation or tree-health data. Several datasets were created from online sources, GIS interpretation, satellite imagery, and field observations.

At the building scale, the main vulnerabilities were linked to roof performance, façade and opening protection, lack of shading, low reflectivity of roof and paving materials, limited green roofs or vertical greening, insufficient stormwater retention, and weak water reuse systems. Historical building records often date back to the pre-digital era, and detailed technical information such as wall assemblies, window specifications, and drainage details is often missing.

A methodological issue also emerged: several indicators were considered very data-intensive or too technical for direct municipal application without expert support.

4.1.4. Adaptation Needs and Strategic Recommendations

For neighbourhood-scale adaptation, the recommended priorities include implementing Sustainable Urban Drainage Systems, permeable pavements, on-site rainwater retention, upgrading roof drainage infrastructure, hydraulic modelling, and more detailed digital archives of urban infrastructure. For extreme heat, the main priorities include high-albedo roofs and pavements, structural shading along active mobility corridors, strategic placement of tree canopy, and building envelope retrofits in vulnerable areas.

For building-scale adaptation, the recommended measures include waterproof and hail-resistant façade, roof and opening retrofits, stormwater retention and detention systems, rainwater harvesting, green roofs, nature-based solutions, permeable outdoor surfaces, reflective paving materials, external shading systems, improved insulation, mechanical ventilation and cooling upgrades, and integration of renewable energy systems.

For Chivasso, drought-related measures were also relevant, including rainwater harvesting, greywater reuse, smart irrigation, drought-tolerant vegetation, and improved water-related documentation.

4.1.5. Lessons Learned and Transferability

The Piedmont pilot demonstrated that the RBE-CE framework is applicable across multiple municipalities and building types, but its implementation requires strong technical support, especially where local data systems are fragmented. The experience showed that municipalities and regions are likely to depend on external expertise for complex indicators, GIS processing, benchmark interpretation, and technical calculations.

The pilot also highlighted the need to streamline data collection, focus on essential indicators, recalibrate some benchmarks, and improve methodological consistency between RNTool and RBTool. A shared platform was identified as important for improving consistency and comparability across pilots.

Scan the QR code or click here to access the full assessment reports for the Piedmont Region (Venaria Reale, Gassino Torinese, Leini, and Chivasso). The report includes calculations, criterion-by-criterion (maps and sources available), and summary tables for vulnerability, exposure, and hazard to determine the overall risk score.

4.2. Veneto Region (Italy)

The Veneto Region pilot territory included two case studies: Abano Terme and Verona. Both pilots addressed climate risks at the neighbourhood scale, while the building-scale assessment focused on selected public buildings. The main hazards assessed were heavy precipitation and extreme heat, reflecting the key climate pressures affecting highly urbanised areas in the Veneto context.

In Abano Terme, the neighbourhood-scale assessment covered 30 criteria distributed across 6 risk categories for heavy precipitation and 17 criteria distributed across 3 risk categories for extreme heat. At the building scale, the assessment included 20 criteria for heavy precipitation and 25 criteria for extreme heat. In

Verona, the neighbourhood-scale assessment included 23 vulnerability criteria and 7 exposure indicators for heavy precipitation, and 13 vulnerability criteria and 4 exposure indicators for extreme heat, for a total of 47 criteria. The pilot activities combined GIS analyses, satellite imagery, field surveys, technical documentation, expert judgement, and platform-supported result processing.

The comprehensive criterion-level assessment reports for the Veneto Region territory are available via the QR code or link at the end of the pilot summary section. The tables presented in the following sections represent only a selected extract of the full assessment results and are intended to illustrate methodological examples identified during the pilot implementation.

4.2.1. Neighbourhood-scale Assessment (RNTool)

In Abano Terme, the RNTool assessment focused on a compact urban area characterised by public functions, paved surfaces and limited green infrastructure. The overall neighbourhood-scale results were classified as neutral for both heavy precipitation and extreme heat. Heavy precipitation reached a risk score of approximately 0.56, while extreme heat reached approximately 0.49. Despite the neutral classification, the assessment identified relevant weaknesses linked to impermeable surfaces, limited infiltration capacity, insufficient shading and gaps in water-related data. Water criteria could not be fully assessed due to data limitations. Examples included limited surface infiltration capacity, roof drainage issues, and weaknesses in pedestrian and cycling infrastructure under intense rainfall conditions. For extreme heat, relevant criteria included surface material albedo, roof reflectance, shading, greenery and the capacity of urban surfaces to reduce heat accumulation. Water-related criteria could not be fully assessed due to data gaps.

Table 3 Vulnerability value for Heavy Precipitation at the neighbourhood scale - Abano Terme.

Code	Urban sector	Vulnerability class	Normalized score	Weight	VV
A1	Buildings	Neutral	0.55	33%	0.55*0.33
A2	Transport	Neutral	0.49	33%	0.49*0.33
A5	Health	Neutral	0.32	33%	0.32*0.33
Total VV for Heavy Precipitation					**0.45**

In Verona, the RNTool assessment focused on the Piazzale Romano Guardini area, a highly urbanised and infrastructure-oriented district close to Verona Porta Nuova railway station. The area includes schools, administrative buildings, transport infrastructure and large paved surfaces. Heavy precipitation was the dominant hazard, with a neighbourhood-scale risk score of 0.63, classified as rather negative. Extreme heat resulted in a lower score of 0.36, classified as rather positive, although the assessment still highlighted relevant physical vulnerabilities linked to asphalt surfaces, limited trees and reduced shading. The assessment highlighted extensive impervious surfaces, limited green infrastructure, drainage limitations and increased runoff potential. For example, road infrastructure showed weaknesses linked to drainage capacity, pavement material resistance and high road density exposure.

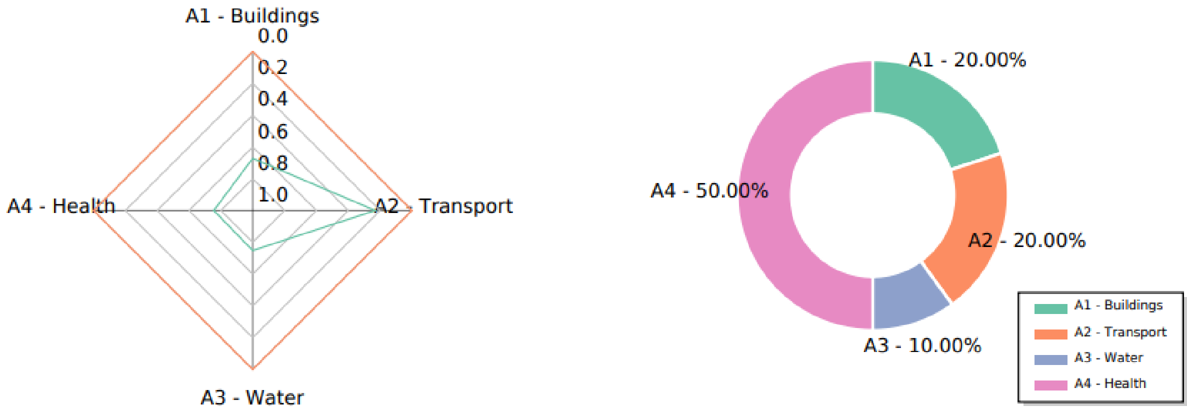


Figure 6 On the left, the level of risk by urban sector for Heavy Precipitation. On the right, active weights by urban sectors for Heavy Precipitation. Both graphs for Verona were extracted from the SuPeRBE platform.

4.2.2. Building-scale Assessment (RBTool)

In Abano Terme, the RBTool assessment focused on the "Ex casa delle Maestre" municipal office building. Heavy precipitation was the most critical building-scale hazard, with a final risk score above 0.6, classified as rather negative. The main weaknesses were linked to façade, roof and landscaping conditions, including limited rainwater management and insufficient adaptive capacity of the surrounding outdoor areas. The assessment highlighted weaknesses related to rainwater management, envelope protection, roof drainage, and the limited capacity of surrounding outdoor areas to manage runoff. Extreme heat was classified as neutral, with a risk score of approximately 0.50, but several vulnerable elements were identified, particularly landscaping, location, ventilation and surface overheating.

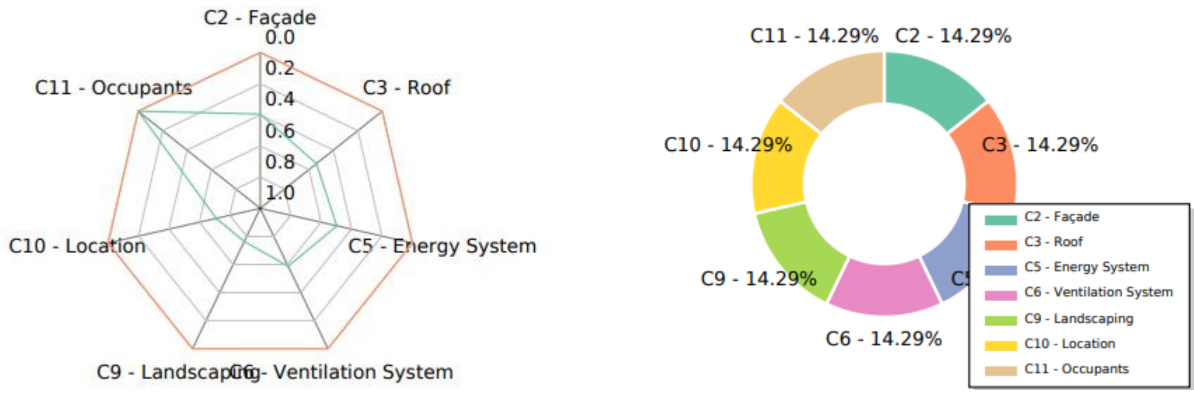


Figure 7 On the left, the level of risk by building component for Extreme Heat. On the right, active weights by building components for Extreme Heat. Both graphs for Abano Terme were extracted from the SuPeRBE platform.

In Verona, the building-scale assessment focused on the Marconi School. Both assessed hazards were classified as rather negative. Heavy precipitation reached a final risk score of 0.67, driven by vulnerabilities in façade openings, stormwater retainage, absence of green roofs and limited flood retention capacity. Extreme heat reached a final risk score of 0.75, mainly due to overheating, lack of external shading, low roof reflectance, absence of green roof systems, limited cooling capacity and thermal comfort risks in occupied spaces.

4.2.3. Main Issues Identified

Across the Veneto pilot territory, the main issues were related to the high share of impervious surfaces, limited green infrastructure, insufficient shading, and weak integration of water-sensitive urban design measures.

In Abano Terme, the assessment highlighted fragmented and non-harmonised datasets, limited accessibility of technical information on public buildings, and the need for expert judgement for several indicators. At the neighbourhood scale, the lack of complete water management data limited the assessment of some criteria. At the building scale, significant manual work was required, especially for older buildings where technical documentation and energy-related information were incomplete.

In Verona, the main issues were extensive asphalt and paved surfaces, limited green areas, insufficient stormwater infiltration and retention capacity, and heat accumulation due to low-albedo materials and scarce shading. At the building scale, the Marconi School showed repeated vulnerabilities around openings, roofs, outdoor surfaces and missing nature-based systems. The assessment also highlighted uncertainty associated with incomplete drainage drawings, envelope specifications, hydraulic data, and calibrated thermal comfort modelling.

4.2.4. Adaptation Needs and Strategic Recommendations

For Abano Terme, adaptation priorities should focus on improving water management, strengthening the role of the Green Space Plan, and better integrating existing planning tools such as PIQMA into practical adaptation guidance. At the neighbourhood scale, priority actions include improving permeability, increasing green and blue infrastructure, enhancing shading, and linking water management with urban greening strategies. At the building scale, recommendations include developing standard adaptation packages for typical older public buildings, improving roof and façade resilience, and strengthening the use of reflective, permeable and vegetated surfaces.

For Verona, priority actions should address both stormwater and heat stress. Neighbourhood-scale measures should include permeable paving, green roads, bioretention areas, stormwater tree trenches, urban forests, green roofs, green walls and retroreflective materials. At the building scale, recommended measures for the Marconi School include improving façade waterproofing, protecting openings, introducing rainwater retention or temporary stormwater storage, increasing permeable paving, installing external solar shading, improving roof reflectance and insulation, strengthening natural and controlled ventilation, and increasing tree shading around exposed façades and courtyards.

Across both case studies, the Veneto pilot confirms the need to guide both public and private transformations. In typical Veneto urban contexts, private spaces play a significant role in climate resilience; therefore, adaptation cannot rely solely on public interventions but should also support awareness, consensus-building, and risk-informed private initiatives.

4.2.5. Lessons Learned and Transferability

The Veneto pilot demonstrated the importance of developing a knowledge-based territorial database built on measurable, updateable and locally specific indicators. The availability of objective data is essential for moving from intuitive assessments to evidence-based decisions and for monitoring the effectiveness of adaptation measures over time.

The pilot also showed that climate risk assessment can support municipal planning by identifying "what is needed, where it is needed". Micro-urban and building-scale analyses proved useful for linking strategic planning with concrete technical solutions. However, the process also highlighted the need for methodologies compatible with local authorities' operational capacities in terms of time, technical expertise, and data availability.

From a transferability perspective, the Veneto experience confirms that the RBE-CE framework can be applied to different urban contexts, including compact urban areas, transport-oriented districts and public buildings. However, a successful application requires local calibration of benchmarks, simplified indicators where data are limited, and strong support from GIS analysis, field surveys and local expert validation.

Scan the QR code or click here to access the full assessment reports for the Veneto Region (Abano Terme and Verona). The report includes calculations, criterion-by-criterion (maps and sources available), and summary tables for vulnerability, exposure, and hazard to determine the overall risk score.

4.3. Municipality of Šibenik (Croatia)

The Croatian pilot territory focused on the Meterize district in the City of Šibenik. The pilot included both neighbourhood- and building-scale assessments; in particular, the RNTool assessment covered 21 criteria for extreme heat and 14 for drought, and the RBTool assessment covered 18 criteria for extreme heat and 12 for drought.

The assessed neighbourhood is a mixed-use but predominantly residential district, while the assessed building is the public Primary School Meterize. The selected hazards were extreme heat and drought, reflecting the main climate-related pressures affecting the area.

The comprehensive criterion-level assessment reports for the Šibenik case study are available via the QR code or link at the end of the pilot summary section. The tables presented in the following sections represent only a selected extract of the full assessment results and are intended to illustrate methodological examples identified during the pilot implementation.

4.3.1. Neighbourhood-scale Assessment (RNTool)

The neighbourhood-scale assessment identified extreme heat as the most significant risk for the Meterize district. The overall risk score for extreme heat was 0.69, classified as rather negative. The weakest urban sector was buildings, with the most critical risk category being damage risk for residential buildings. Examples of the weakest criteria included nature-based solutions, availability of green areas, renewable energy production, and the ratio of vegetated vs. impervious surfaces. Exposure was particularly influenced by population density and lack of cooling urban features, confirming that the neighbourhood is highly exposed to heat stress because of limited vegetation, limited cooling infrastructure, and a dense residential character.

Code	Name	Weight	Risk value
C	Extreme Heat	50.00%	0.69
D	Droughts	50.00%	0.42

Figure 8 Final risk score and weights for the selected hazards. Graph extracted from the SuPeRBE platform.

Exposure to extreme heat was mainly driven by population density and the lack of cooling urban features. These results confirm that heat stress in Meterize is closely linked to the built-up character of the neighbourhood, insufficient green infrastructure, and limited cooling capacity in public and residential spaces.

Table 4 Overall risk score for Extreme Heat at the neighbourhood scale - Šibenik.

Urban sector	Risk value	Weight	Calculation
Buildings	0,88	0,33	0,29
Environment and biodiversity	0,51	0,33	0,17
Health	0,69	0,33	0,23

For drought, the neighbourhood-scale assessment resulted in a neutral risk score of 0.42. Although drought was not classified as critical in the current assessment, the results indicate that it may become more relevant in the future, particularly in light of increasing extreme heat, reduced vegetation resilience, and water scarcity pressures.

Table 5 Overall risk score for Drought at the neighbourhood scale - Šibenik.

Urban sector	Risk value	Weight	Calculation
Environment and biodiversity	0,29	0,33	0,1
Health	0,43	0,33	0,14
Emergency services	0,55	0,33	0,18

4.3.2. Building-scale Assessment (RBTool)

The building-scale assessment focused on the Primary School Meterize. At the building scale, extreme heat resulted in a final risk score of 0.55, classified as neutral. The most affected building systems included the roof, in-built lighting system, ventilation system, sanitary system, location, and occupants. These results indicate that the school is vulnerable to overheating, particularly due to weaknesses in the building envelope, indoor thermal comfort, and cooling capacity.

Table 6 Overall risk score for Extreme Heat at the building scale - Šibenik.

Urban sector	Risk value	Weight	Calculation
Load bearing system	0,53	0,11	0,06
Façade	0,44	0,11	0,05
Roof	0,7	0,11	0,08
In-built lighting system	0,9	0,11	0,1
Energy system	0,35	0,11	0,04
Ventilation system	0,68	0,11	0,08
Sanitary system	0,7	0,11	0,08
Location	0,64	0,11	0,07

Occupants	0,62	0,11	0,07

For drought, the building-scale assessment resulted in a neutral risk score of 0.46. Nevertheless, the sanitary system emerged as the weakest building element. For example, the criterion related to cold water distribution resulted in a risk score of 0.64, with critical values for water leakage alarm, backup water system capacity, and percentage of drinking water replacement. Additional critical weaknesses included the absence of rainwater collection and greywater collection systems. These weaknesses show that, although drought risk is currently assessed as neutral, the building has limited preparedness for future water scarcity scenarios.

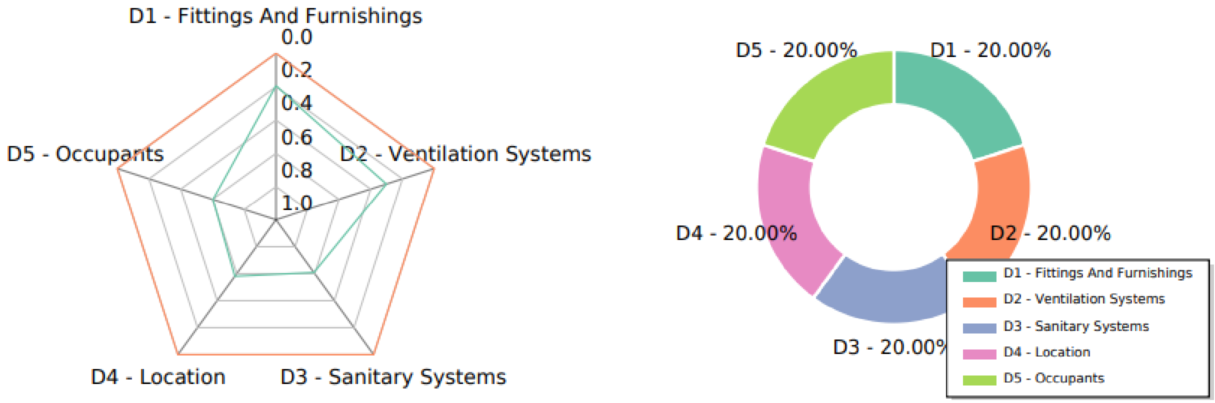


Figure 9 On the left, the level of risk by building component for Drought. On the right, active weights by building components for Drought. Both graphs were extracted from the SuPeRBE platform.

4.3.3. Main Issues Identified

The main issue identified in the Šibenik pilot is the high risk of extreme heat, both at neighbourhood and building scale. This risk is closely connected to the lack of green public spaces, insufficient nature-based solutions, limited vegetation coverage, and the high vulnerability of buildings to overheating.

A second important issue is the potential increase of drought risk in the future. Although drought was assessed as neutral in the current results, the combination of extreme heat, limited green infrastructure, and weaknesses in building-level water management may increase drought-related vulnerability over time.

At the building scale, the Primary School shows specific weaknesses related to water management and overheating, including insufficient rainwater and greywater use, no backup water capacity, and limited passive cooling readiness.

4.3.4. Adaptation Needs and Strategic Recommendations

The main adaptation needed for the Meterize district is to reduce heat stress through the expansion of green infrastructure and nature-based solutions. Priority actions should include planting additional trees, increasing shaded areas, creating more urban green spaces, and, where feasible, reducing the share of impervious surfaces.

At the building scale, recommendations should focus on improving the thermal performance of the Primary School, including roof and envelope upgrades, passive cooling strategies, improved ventilation, and shading measures. Building renovation should also address water resilience by introducing rainwater collection, greywater reuse, leakage monitoring, and backup water capacity.

From a strategic perspective, adaptation planning in Šibenik should treat extreme heat and drought as interconnected risks. Measures to reduce overheating, such as vegetation, shading, and permeable surfaces, can also enhance drought resilience when combined with water-efficient design and irrigation strategies.

4.3.5. Lessons Learned and Transferability

The RBE framework helped identify vulnerabilities at both neighbourhood and building scale and supported the link between assessment results and adaptation priorities.

However, the Šibenik pilot also highlighted several limitations. Data availability was low for several indicators, especially in the RBTool assessment. Using the tool may be difficult for municipal administrators without technical support, particularly when detailed building data or expert interpretation are required. The pilot also showed that common benchmark values may not always fully reflect local climatic and regulatory conditions.

The experience suggests that the framework is transferable to other Croatian and Mediterranean municipalities, but its practical application would benefit from simplified workflows, stronger guidance for municipalities, and locally calibrated benchmarks.

Scan the QR code or click here to access the full assessment reports for Šibenik. The report includes calculations, criterion-by-criterion (maps and sources available), and summary tables for vulnerability, exposure, and hazard to determine the overall risk score.

4.4. Municipality of Schnifis (Austria)

The Austrian pilot territory focused on the Municipality of Schnifis, a small alpine municipality located in the Vorarlberg region. The pilot included both neighbourhood- and building-scale assessments using RNTool-CE and RBTool-CE. The neighbourhood-scale assessment covered a mixed-use settlement area of approximately 0.4 km², comprising around 250 buildings, including residential, public, and community infrastructure.

At the building scale, two public buildings were assessed in detail: the Municipal Office and the Primary School. The selected climate hazards included heavy precipitation, extreme heat, and storms, reflecting the municipality's main climate-related risks.

The comprehensive criterion-level assessment reports for the Schnifis case study are available via the QR code or link at the end of the pilot summary section. The tables presented in the following sections represent only a selected extract of the full assessment results and are intended to illustrate methodological examples identified during the pilot implementation.

4.4.1. Neighbourhood-scale Assessment (RNTool)

The neighbourhood-scale assessment identified heavy precipitation as the most critical climate risks affecting the pilot area, followed by extreme heat which is considered rather positive at the moment, but will increase under climate change. On the other hand, the storm-related risk was classified as non-existent.

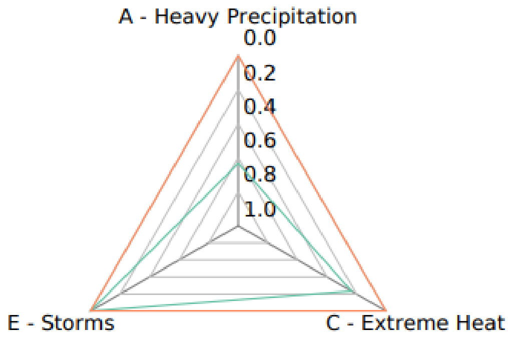


Figure 10 Level of risk by hazard. Graph extracted from the SuPeRBE platform.

For heavy precipitation, the final neighbourhood-scale risk score reached 0.63, corresponding to a rather negative risk level. The assessment highlighted high vulnerability and exposure conditions linked to building density, population exposure, road network exposure, and the concentration of exposed buildings and critical facilities. Vulnerabilities were particularly associated with buildings and transport infrastructure, reflecting the sensitivity of the settlement structure to intense rainfall events and surface runoff. The hazard value was assessed at 0.84, reflecting the increasing frequency and intensity of heavy precipitation events within the regional climatic context.

Table 7 Vulnerability value for Heavy Precipitation at the neighbourhood scale - Schnifis.

Urban sector/Risk categories	Vulnerability class	Normalized score	Weight	Value
Buildings	Critical	0,34	0,5	0,17
Transport	Critical	0,50	0,5	0,25
Total VV for Hazard Heavy Precipitation				0,42

Table 8 Exposure value for Heavy Precipitation at the neighbourhood scale - Schnifis.

Urban sector/Risk categories	Exposure class	Normalized score	Weight	Value
A1.1.-E.1 - Building Density	Critical	1,00	0,25	0,25
A1.1.-E.2 - Population Exposure	Critical	1,00	0,25	0,25
A1.1.-E.5 - Building Entrances Below Grade	Optimal	0,00	0,25	0,00
A2.2.-E.1 - Road Network	Critical	1,00	0,25	0,25
Total EV for Hazard Heavy Precipitation				0,75

On the other hand, extreme heat resulted in a rather positive neighbourhood-scale risk score of 0.23. This result does not fully reflect the expected increase in heat-related risks under future climate scenarios. The assessment identified major vulnerabilities related to buildings, health, and environmental conditions, particularly limited vegetation coverage, insufficient shading, and reduced cooling capacity of public spaces and built surfaces. Exposure analysis further highlighted the relevance of environmental and biodiversity-related indicators, as well as the exposure of sensitive population groups to overheating conditions.

Storm-related risk resulted in an optimal score of 0.00, meaning that Schnifis presents no significant risk related to storm events. Nevertheless, the assessment identified vulnerabilities linked to the energy sector, building exposure, and the road network, indicating the suggested need for continued monitoring and preparedness measures, especially considering the alpine context and exposure to wind and precipitation events.

The RNTool assessment combined GIS analyses, orthophotos, cadastral information, field observations, and local expert input. The assessment workflow also included the production of maps, spatial overlays, site plans, and visual analyses supporting the identification of exposed areas and vulnerable urban sectors.

4.4.2. Building-scale Assessment (RBTool)

The RBTool assessment focused on two public buildings: the Municipal Office and the Primary School. Both buildings were assessed against the selected climate hazards of heavy precipitation, extreme heat, and storms through a criterion-based evaluation process integrating hazard, vulnerability, and exposure components.

For the Municipal Office, the heavy precipitation assessment resulted in a final risk value of 0.56, classified as neutral. The most vulnerable systems were identified as the façade, roof, landscaping elements, and occupant-related criteria. The assessment highlighted weaknesses related to limited façade protection, absence of rainwater harvesting systems, low vegetation integration, and insufficient green infrastructure.

The extreme heat assessment for the Municipal Office resulted in a final risk value of 0.63, classified as rather negative. Key vulnerabilities were associated with roof performance, occupant thermal comfort, and overheating risks affecting the building envelope and indoor conditions.

Storm-related risk for the Municipal Office was classified as neutral, with a final score of 0.45. The main vulnerabilities concerned façade resilience, waterproofing, and long-term exposure of building components to wind-driven precipitation.

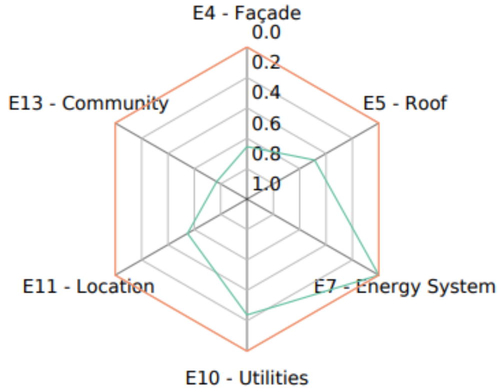


Figure 11 Level of risk by building component for Storm. Graph extracted from the SuPeRBE platform.

The Primary School showed similar patterns of vulnerability. Heavy precipitation resulted in a rather negative risk score of 0.63, with vulnerabilities concentrated in the roof, façade, outdoor areas, and occupant sensitivity. The extreme heat assessment resulted in a neutral score of 0.58, highlighting vulnerabilities related to roof systems, thermal comfort, and passive cooling capacity. Storm-related risk was also classified as neutral with a score of 0.54, with vulnerabilities affecting the energy system, roof, façade, and community exposure.

The building-scale assessments integrated architectural documentation, field observations, technical drawings, photographic surveys, climate datasets, and expert judgement. The assessments were progressively integrated within the SuPeRBE platform environment, supporting the testing of both the methodological workflow and the digital implementation process.

4.4.3. Main Issues Identified

The pilot assessments identified several recurring vulnerabilities affecting both the neighbourhood and building scales. The most critical issues were associated with heavy precipitation and extreme heat.

At the neighbourhood scale, the main weaknesses included limited green-blue infrastructure, low vegetation coverage, moderate surface permeability, absence of natural flood defence buffers, and insufficient cooling capacity within public spaces. These conditions increase exposure to surface runoff, overheating, and urban heat accumulation.

At the building scale, the assessments identified weaknesses related to roof performance, façade protection, drainage systems, absence of rainwater harvesting systems, limited façade greening, and insufficient passive cooling strategies. Several public buildings also showed vulnerabilities associated with occupant thermal comfort and exposure of sensitive users during extreme events.

The pilot also highlighted data-related and methodological challenges, including limited data availability for certain indicators, the need for extensive manual calculations, and the reliance on qualitative assessments and expert interpretation for several criteria.

4.4.4. Adaptation Needs and Strategic Recommendations

The assessment results highlighted the need for both short-term and long-term adaptation measures addressing heavy precipitation, extreme heat, and storm resilience.

- Recommended short-term measures included the identification of small infiltration areas, increased tree planting and shading, local drainage improvements, and strengthening of façade and roof protection systems.
- Medium-term recommendations focused on increasing permeable surfaces, implementing nature-based solutions such as rain gardens, bioswales, vegetated berms, and sustainable urban drainage systems (SUDS), as well as increasing façade and roof greening in public buildings. Additional recommendations included the integration of passive cooling strategies and improvements to stormwater retention capacity.
- Long-term recommendations included integrating the assessment findings into municipal climate adaptation planning, progressively transforming the pilot area towards a “sponge city/site” approach, strengthening green-blue infrastructure networks, and incorporating public buildings into broader resilience and adaptation strategies.

4.4.5. Lessons Learned and Transferability

The Schnifis pilot demonstrated that the RBE-CE framework can be successfully applied within small municipalities and alpine territorial contexts, while also highlighting several methodological and operational challenges.

One of the main lessons learned concerned the strong dependence of assessment quality on local data availability and technical capacity. The pilot showed that many criteria require extensive manual calculations, GIS processing, and expert interpretation, particularly where local datasets are incomplete or not standardised.

The pilot also highlighted the importance of local contextualisation. Several benchmark values and assessment thresholds required adaptation to better reflect local climatic, topographical, and geological conditions. The experience further demonstrated the importance of involving local experts and municipal stakeholders throughout the assessment process, particularly for validating qualitative indicators and the interpretation of results.

From a transferability perspective, the pilot confirmed that the RBE-CE framework is adaptable to both neighbourhood and building scales and can be transferred to municipalities with different climatic and territorial characteristics. However, the experience also demonstrated the need for simplified workflows, clearer guidance for qualitative indicators, and more calibrated benchmark ranges to improve usability, comparability, and operational implementation across different contexts.

Scan the QR code or click here to access the full assessment reports for Schnifis. The report includes calculations, criterion-by-criterion (maps and sources available), and summary tables for vulnerability, exposure, and hazard to determine the overall risk score.

4.5. City of Prague (Czechia)

The Prague pilot focused on the Nový Barrandov residential development in Prague 5, specifically the area around Hugo Haase and Vítové streets. At the neighbourhood scale, the assessment covered a newly developed residential area, while at the building scale, it focused on Building D, a multi-residential building considered representative, given that the rest of the residential buildings are very similar in design. The selected hazards were heavy precipitation and extreme heat.

At the neighbourhood scale, the RNTool assessment covered 25 criteria for heavy precipitation and 24 criteria for extreme heat. At the building scale, the RBTool assessment covered 17 criteria for heavy precipitation and 22 criteria for extreme heat.

The comprehensive criterion-level assessment reports for the Prague case study are available via the QR code or link at the end of the pilot summary section. The tables presented in the following sections represent only a selected extract of the full assessment results and are intended to illustrate methodological examples identified during the pilot implementation.

4.5.1. Neighbourhood-scale Assessment (RNTool)

At the neighbourhood scale, both assessed hazards resulted in a neutral overall risk classification. Heavy precipitation showed relatively favourable results, with an overall risk score of 0.49, mainly due to the presence of retention measures and compliant drainage infrastructure already present in the selected neighbourhood. Nevertheless, weaknesses were identified in infiltration capacity, green infrastructure, and exposure of the mobility system.

Extreme heat was also classified as neutral at the neighbourhood scale, with a final risk score of 0.55. However, the assessment identified several important heat-related vulnerabilities. The most problematic criteria included very low shading of paved surfaces, low reflectivity of paved materials, strong solar exposure of façades and roads, limited mature vegetation, and lack of irrigation access for trees. Only 7.7% of paved surfaces were shaded during peak summer conditions, while dark surface exposure reached 51.5%.

Table 9 Vulnerability value for Extreme Heat at the neighbourhood scale – Prague.

Code	Urban sector	Vulnerability class	Normalized score	Weight
C1	Buildings	Neutral	0.58	60%
C7	Environment and Biodiversity	Rather positive	0.32	20%
C8	Health	Rather positive	0.35	20%
Total VV for Extreme heat			0.48	

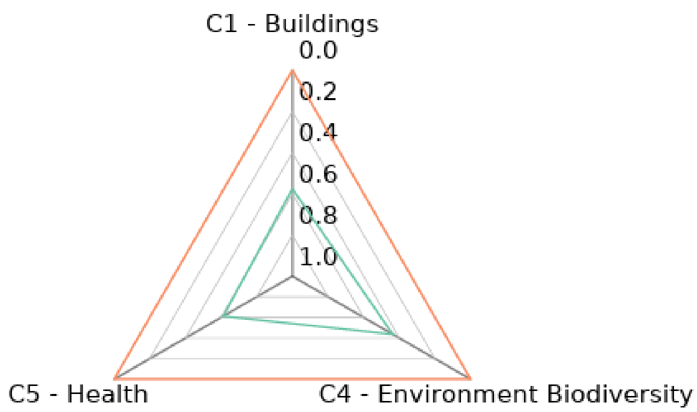


Figure 12 Level of risk by urban sector for Extreme Heat. Graph extracted from the SuPeRBE platform.

A key observation is that Nový Barrandov is a new development with recently planted vegetation. As trees and shrubs mature, several heat-related indicators are expected to improve over time, particularly shading, cooling capacity, and vegetation-related performance.

4.5.2. Building-scale Assessment (RBTool)

At the building scale, heavy precipitation was classified as rather positive, with an overall risk score of 0.37, indicating that the building performs relatively well in terms of drainage and rainwater-related protection. However, some weaknesses remain, particularly the absence of rainwater harvesting and greywater reuse systems.

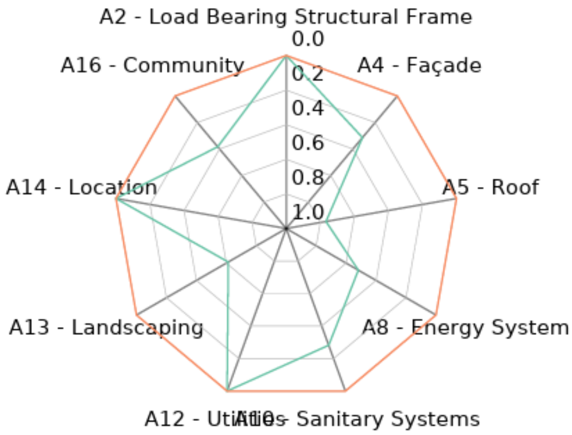


Figure 13 Level of risk by building components for Heavy Precipitation. Graph extracted from the SuPeRBE platform.

Extreme heat was identified as the main building-scale challenge, with a final risk score of 0.66, classified as rather negative. The most vulnerable categories included sanitary systems, landscaping, occupants, roof exposure, ventilation systems, and load-bearing/envelope-related exposure. The assessment showed that, although the building benefits from modern technical systems and a relatively efficient envelope, climate resilience is limited by overheating risks, façade exposure, insufficient passive cooling strategies, and limited mature landscape shading.

Table 10 Exposure value for Extreme Heat at the building scale - Prague.

Code	Building part	Exposure class	Normalized score	Weight	EV
C2	Load-bearing system	Critical	1.0	10%	1*0.1
C4	Façade	Rather positive	0.35	10%	0.35*0.1
C5	Roof	Critical	1.0	10%	1*0.1
C8	Energy system	Neutral	0.50	10%	0.5*0.1
C9	Ventilation system	Critical	1.0	10%	1*0.1
C10	Sanitary systems	Neutral	0.50	10%	0.5*0.1
C13	Landscaping	Critical	1.0	10%	1*0.1
C14	Location	Rather negative	0.74	20%	0.74*0.2
C15	Occupants	Neutral	0.50	10%	0.5*0.1
Total EV for Extreme heat					**0.73**

The building has some positive features, including integrated greenery and outdoor cooling elements. Around 41.1% of the outdoor area is covered by cooling elements, and approximately 55% consists of vegetated or permeable surfaces. However, the lack of rainwater reuse, greywater reuse, and mature tree-based shading limits its overall resilience.

4.5.3. Main Issues Identified

The main issues identified in the Prague pilot relate primarily to extreme heat. At the neighbourhood scale, the most important weaknesses are low shading capacity, high exposure of paved and façade surfaces, limited mature vegetation, compacted or low-permeability soils around trees, no identified irrigation network, and very high population density.

At the building scale, the main weaknesses include overheating risk, limited façade shading, moderate passive cooling, exposed paved outdoor areas, no rainwater harvesting, no greywater reuse, no battery backup system, and limited operational data.

The assessment also highlighted important data limitations. For the RBTool, detailed as-built documentation, operational data, water consumption data, irrigation schedules, maintenance information, and thermal simulation outputs were missing. For the RNTool, the assessment relied strongly on GIS analysis, public maps, spatial interpretation, and expert judgement.

4.5.4. Adaptation Needs and Strategic Recommendations

- Short-term recommendations include installing temporary shading elements, improving irrigation and maintenance schedules, and increasing monitoring of runoff and soil absorption capacity.
- Medium-term recommendations include expanding tree canopy coverage, retrofitting reflective and permeable materials, improving passive cooling strategies, and introducing rainwater harvesting and greywater reuse systems.
- At neighbourhood scale, priority measures include street tree planting, urban forests, pocket parks, cool pavements, reflective materials, soil decompaction, improved rooting conditions, and smart irrigation systems. At building scale, recommended measures include external shading devices, reflective façade or roof materials, green façades, vegetated pergolas, passive cooling optimisation, smart ventilation, and rainwater-fed irrigation.

From a governance perspective, the assessment results indicate the need to strengthen cooperation between the municipality, developers, and technical experts. Climate resilience assessment could also be integrated into planning workflows and used as a requirement for future development projects.

4.5.5. Lessons Learned and Transferability

The Prague pilot confirmed that GIS analysis is highly valuable for understanding spatial climate risks, especially at neighbourhood scale. On-site inspection was also essential for verifying data, collecting missing information, and interpreting the results realistically.

The assessment showed that building-scale evaluation requires more detailed technical documentation than neighbourhood-scale assessment. Several criteria had to be assessed qualitatively due to missing data or overly complex calculation requirements. Local benchmark calibration was also essential, as some thresholds were too strict or insufficiently adapted to local conditions.

The pilot demonstrated that the RBE-CE framework is transferable to the Czech context, but its practical application requires local contextualisation and support from external experts. A key lesson is that modern building standards alone do not guarantee climate resilience, particularly regarding overheating, outdoor thermal comfort, and long-term vegetation performance.

Scan the QR code or click here to access the full assessment reports for Prague. The report includes calculations, criterion-by-criterion (maps and sources available), and summary tables for vulnerability, exposure, and hazard to determine the overall risk score.

5. Comparative Analysis Across Pilot Territories

The pilot activity implemented within the SuPeRBE project provided the opportunity to test the RBE-CE framework across a diverse range of territorial, climatic, and governance contexts. The pilot territories included alpine municipalities, coastal cities, dense urban neighbourhoods, transport-oriented districts, suburban residential areas, and public buildings of different typologies and ages. Despite these differences, the assessments revealed several recurring climate risks, shared vulnerabilities, and common implementation challenges.

The comparative analysis demonstrates that the RBE-CE framework can support a harmonised and comparable assessment process across different territorial contexts while still allowing local contextualisation of hazards, benchmarks, and assessment priorities. The pilot activities also contributed to validating the methodological structure, the aggregation logic, and the operational applicability of the SuPeRBE platform environment.

5.1. Common Climate Risks Across Territories

The pilot assessments confirmed that extreme heat and heavy precipitation are the most recurrent and relevant climate hazards across Central European territories. These two hazards were selected in nearly all pilot territories and consistently produced the highest overall risk values at both neighbourhood and building scale.

The analysis of selected Key Risk Categories (KRCs) shows that, at neighbourhood scale, heavy precipitation was addressed by 8 pilot applications, while extreme heat was addressed by 9 pilot applications. At building scale, the same hazards were also dominant, with heavy precipitation assessed in 8 pilot applications and extreme heat in 9 applications.

Although the same hazards were assessed across most territories, their local manifestations differed significantly:

- in the coastal area of Šibenik, extreme heat and drought represented the dominant climate pressures;
- in dense urban areas, such as Prague and Verona, heat accumulation and impermeable surfaces increased both overheating and runoff-related risks;
- in alpine and mountainous territories, such as Schnifis, heavy precipitation and storms represented the most critical hazards;
- in suburban and mixed-use districts, such as the Piedmont pilots, both extreme heat and heavy precipitation generated combined vulnerabilities affecting buildings, mobility systems, and public spaces.

The assessments also demonstrated strong interconnections between hazards. For example, increasing extreme heat was frequently linked to drought stress, vegetation degradation, and reduced cooling capacity of urban greenery, while heavy precipitation was strongly associated with runoff, flooding potential, and drainage system overload.

5.2. Recurrent Vulnerabilities and Weaknesses

Despite the pilots' territorial diversity, several recurrent vulnerabilities emerged across the assessments.

At the neighbourhood scale, the most frequent weaknesses included: (i) high percentages of impervious surfaces; (ii) insufficient urban greenery and tree canopy coverage; (iii) limited shading of public spaces and pedestrian routes; (iv) low infiltration and stormwater retention capacity; (v) fragmented or incomplete drainage infrastructure data; (vi) exposure of vulnerable population groups; (vii) insufficient integration of nature-based solutions into urban planning.

At the building scale, recurrent weaknesses were identified in: (i) roof systems and roof reflectance; (ii) façade protection and openings; (iii) insufficient external shading; (iv) absence of green roofs and vegetated systems; (v) limited stormwater retention and rainwater reuse; (vi) overheating risk and insufficient passive cooling; (vii) incomplete technical documentation and monitoring systems.

Several governance and implementation challenges also emerged repeatedly:

- fragmented datasets and inconsistent data availability;
- limited access to technical building documentation;
- insufficient GIS-ready information;
- lack of climate-oriented monitoring systems;
- high dependence on expert judgement for complex indicators;
- limited operational capacity within smaller municipalities.

5.3. Comparison Between Building and Neighbourhood Scale

The pilot activities demonstrated that the combined application of RNTool-CE and RBTool-CE provides a more comprehensive understanding of climate resilience conditions than the use of either scale independently. While the two tools share the same conceptual framework and risk assessment logic, they address different dimensions of climate vulnerability and therefore generate complementary types of information for planning and decision-making processes.

The neighbourhood-scale assessments carried out through RNTool-CE proved particularly effective for understanding the spatial distribution of climate risks and identifying broader territorial patterns affecting urban resilience. The RNTool applications enabled the analysis of relationships between urban morphology, land use, mobility systems, green-blue infrastructure, and environmental conditions. Through GIS analyses and spatial indicators, the assessments highlighted how the structure and configuration of urban areas influence the accumulation of climate-related vulnerabilities.

In several pilot territories, the neighbourhood-scale assessments clearly demonstrated the influence of imperviousness, lack of vegetation, limited shading, and insufficient stormwater retention capacity on both heavy precipitation and extreme heat risks. For example, the Prague, Verona, and Piedmont pilots showed that large paved surfaces, dense urban morphology, and low tree canopy coverage significantly increased overheating conditions and runoff vulnerability at district scale. Similarly, the Šibenik pilot highlighted how limited cooling urban features and insufficient public green infrastructure contribute to elevated heat exposure for the local population.

At the same time, the building-scale assessments carried out through RBTool-CE provided a much more detailed understanding of the technical and operational vulnerabilities affecting individual buildings. The RBTool applications enabled the evaluation of specific building systems and components. Compared to RNTool, the RBTool assessments required more detailed technical documentation, building-specific information, and direct site inspections.

The RBTool assessments frequently revealed vulnerabilities that could not be fully captured at neighbourhood scale alone. For example, buildings located within neighbourhoods showing overall neutral risk values often still presented rather negative or critical building-scale results due to specific technical weaknesses such as poor roof reflectance, insufficient external shading, lack of passive cooling measures, limited stormwater retention systems, or vulnerable façade and opening systems. This situation emerged clearly in several pilots, including Prague, Verona, and the Piedmont municipalities.

The comparison between scales also highlighted strong interconnections between urban and building-level vulnerabilities. In many cases:

- neighbourhoods characterised by high imperviousness and low vegetation coverage also contained buildings exposed to overheating and limited outdoor cooling capacity;
- areas with poor infiltration and stormwater retention capacity frequently corresponded to buildings lacking rainwater management systems or permeable surroundings;
- districts with limited tree canopy and shading often included buildings with high façade and roof exposure to solar radiation;
- neighbourhoods with vulnerable population groups frequently contained schools, public buildings, or residential buildings with insufficient thermal comfort resilience.

The pilot activities therefore demonstrated that neighbourhood-scale and building-scale assessments should not be considered as independent exercises, but rather as interconnected layers of the same resilience evaluation process. The RNTool assessments were particularly useful for strategic planning, territorial prioritisation, and identification of spatial hotspots, while the RBTool assessments supported the definition of targeted technical adaptation measures at building level.

Another important finding concerns the difference in data requirements and operational complexity between the two scales. The RNTool assessments relied heavily on GIS datasets, orthophotos, land-use analyses, demographic information, and spatial interpretation, making them more suitable for large-scale screening and planning applications. In contrast, the RBTool assessments required more detailed technical inputs, including construction documentation, material specifications, drainage layouts, maintenance information, and system-level data. As a result, building-scale assessments often required stronger expert involvement and more extensive site inspections.

Despite these differences, the pilot implementation confirmed the added value of combining both tools within a unified methodological framework. The integration of neighbourhood-scale and building-scale assessments enabled pilot territories to connect strategic urban adaptation priorities with concrete technical interventions, supporting a more holistic understanding of climate resilience across multiple spatial scales.

5.4. Framework Robustness and Applicability

The pilot implementation demonstrated that the RBE-CE framework is sufficiently robust and flexible to be applied across different territorial, climatic, and governance contexts.

The framework proved capable of: (i) integrating multiple climate hazards; (ii) combining quantitative and qualitative indicators; (iii) supporting both strategic and technical assessments; (iv) enabling comparison across territories; (v) adapting to locally contextualised benchmarks and priorities.

The normalised 0–1 scoring system and the aggregation methodology enabled consistent comparison of results across very different pilot contexts. The use of common methodological principles also supported transnational comparability while allowing local flexibility in hazard selection and data integration.

However, the pilot activities also identified several methodological and operational limitations: some indicators were highly data-intensive; several municipalities lacked the technical resources required for advanced GIS or modelling activities; expert interpretation remained necessary for a number of criteria; benchmark calibration requires further refinement for different climatic regions; some assessment workflows were considered too complex for routine municipal application without external support.

The pilots also highlighted the importance of the SuPeRBE platform environment in supporting the operational implementation of the methodology. The progressive integration of assessment inputs, calculations, and outputs into the platform improved consistency and transparency of the workflow, although several functionalities were still under development during the pilot phase.

5.5. Contribution to Local Planning Processes

The pilot activities demonstrated that the RBE-CE framework can provide significant support for local climate adaptation planning and resilience-oriented decision-making. The assessments helped municipalities and local stakeholders to:

- identify the most critical climate risks;
- prioritise adaptation interventions;
- visualise vulnerability and exposure patterns;
- support evidence-based planning processes;
- improve understanding of cross-scale climate interactions;
- strengthen communication between technical experts and decision-makers.

Several pilot territories highlighted the value of the framework for integrating climate resilience considerations into: (i) urban planning processes; (ii) municipal adaptation strategies; (iii) building renovation planning; (iv) public space design; (v) nature-based solution implementation; (vi) participatory governance processes.

The pilot activities also contributed to awareness raising and capacity building through workshops, dissemination events, and stakeholder discussions. In many cases, the pilot assessments represented the first structured climate resilience assessments carried out simultaneously at the neighbourhood and building scales within the participating municipalities.

6. Link with WP3 and Adaptation Planning

The pilot assessment activities implemented within WP2 provided the analytical foundation for the climate adaptation planning activities developed in WP3. The RNTool-CE and RBTool-CE applications generated structured evidence on climate hazards, exposure conditions, vulnerabilities, and resilience gaps at both neighbourhood and building scale, supporting the identification of adaptation priorities and the development of locally tailored resilience pathways.

The transition from assessment to planning followed the methodological logic defined within the SuPeRBE climate adaptation planning framework and the “Guideline for Climate Action Plans using SuPeRBE instruments” developed in A3.5. The guideline establishes a structured process linking the ex-ante diagnosis produced through RNTool and RBTool with the definition of adaptation targets, intervention strategies, implementation measures, governance arrangements, financing schemes, and monitoring procedures.

Within this process, the pilot assessments represented the evidence-based “diagnosis phase” of the adaptation planning cycle. The results generated through the pilot activities enabled municipalities and stakeholders to: (i) identify the most relevant climate hazards affecting each territory; (ii) determine the most vulnerable urban sectors, buildings, and exposed population groups; (iii) identify recurring weak criteria and resilience gaps; (iv) prioritise adaptation needs at neighbourhood and building scale; (v) support the definition of measurable resilience targets and adaptation objectives.

The pilot implementation demonstrated that the assessment results can directly support the preparation of Local Adaptation Plans by identifying which urban systems, public spaces, infrastructures, and buildings require priority intervention. The assessments also highlighted the interconnections between urban-scale vulnerabilities and building-scale weaknesses, confirming the importance of integrated adaptation planning approaches combining public-space interventions, nature-based solutions, building retrofits, water-sensitive urban design, and social preparedness measures.

The adaptation planning process developed in WP3 adopted a cross-scale and backcasting-oriented logic. Rather than focusing exclusively on current risk conditions, the process aimed to define desirable future resilience scenarios and then identify the operational pathways, investments, governance actions, and implementation measures required to progressively achieve those objectives. In this context, the RNTool and RBTool assessments were used not only to analyse present conditions, but also to support the definition of ex-post resilience targets and expected future performance levels.

An important contribution of the SuPeRBE methodology is the possibility of using the SuPeRBE platform not only for the assessment of the current (ex-ante) situation, but also as a decision-support tool for future adaptation scenarios. The assessment results generated through RNTool-CE and RBTool-CE can be progressively updated within the platform to simulate the expected effects of proposed adaptation measures and evaluate alternative resilience pathways. This enables municipalities and local stakeholders to define target resilience levels together with local authorities and assess how specific adaptation solutions may influence future vulnerability, exposure, and overall risk scores.

Through this iterative approach, the platform supports the comparison between ex-ante and ex-post assessment conditions, allowing users to estimate the potential effectiveness of adaptation measures before implementation. For example, interventions such as increasing permeable surfaces, improving stormwater retention systems, adding green roofs, increasing urban tree canopy, upgrading façade and roof performance, or improving shading and passive cooling strategies can be translated into modified assessment inputs and recalculated within the framework. The resulting changes in vulnerability and risk values help municipalities evaluate which adaptation strategies produce the most significant resilience improvements.

Across the pilot territories, the assessment results from A2.5 will be translated into proposed adaptation strategies.

The pilot implementation also contributed to identifying practical barriers affecting adaptation planning and implementation. Common challenges included fragmented datasets, limited technical documentation, lack of monitoring systems, funding constraints, governance fragmentation, and limited technical capacities within municipalities. These findings informed the WP3 activities by highlighting the need for adaptation pathways that integrate not only technical interventions, but also governance structures, stakeholder coordination, financing mechanisms, communication strategies, monitoring procedures, and long-term implementation frameworks.

Another important contribution concerns the possibility of using the RBE-CE framework as a monitoring and reassessment tool over time. The methodology supports repeated application of RNTool and RBTool after implementation of adaptation measures, enabling municipalities to track resilience improvements, evaluate the effectiveness of implemented actions, and progressively update adaptation priorities and investment strategies.

Overall, the integration between WP2 and WP3 therefore represents a core component of the SuPeRBE methodology, supporting municipalities and stakeholders in moving from vulnerability diagnosis towards measurable, evidence-based, and locally contextualised resilience pathways.

7. Conclusions

The implementation of A2.5 represented a key validation phase of the SuPeRBE project, enabling the practical application and testing of the RBE-CE framework across multiple territorial and climatic contexts within Central Europe. Through the coordinated implementation of pilot assessments in Italy, Croatia, Austria, and Czechia, the project demonstrated the feasibility of applying a harmonised climate resilience assessment methodology at both neighbourhood and building scale while maintaining sufficient flexibility for local contextualisation.

The pilot activities confirmed that the combined use of RNTool-CE and RBTool-CE provides a comprehensive framework for identifying climate vulnerabilities, exposure patterns, and resilience gaps affecting the built environment. The methodology proved capable of supporting both strategic territorial analysis and detailed technical evaluation of buildings and infrastructures. The assessments also demonstrated the importance of integrating spatial, environmental, technical, and socio-economic dimensions within a unified resilience assessment process.

The pilot implementation demonstrated that climate resilience assessment can provide practical support for municipal planning, climate adaptation strategies, building renovation processes, and evidence-based decision-making. The generated outputs, including GIS analyses, thematic maps, visualisations, technical reports, and platform-based assessment workflows, contributed not only to the validation of the methodology itself but also to strengthening local awareness and stakeholder engagement regarding climate adaptation challenges.

At the same time, the pilot activities identified several methodological and operational challenges that should be addressed in future development phases. These included fragmented data availability, limited access to technical documentation, inconsistent quality of local datasets, high dependence on expert interpretation for complex indicators, and varying technical capacities among municipalities. Several pilots also highlighted the need to simplify selected assessment workflows, reduce the complexity of highly technical indicators, and further calibrate benchmark values to better reflect local climatic and regulatory contexts.

An important achievement of the pilot phase was the progressive validation of the SuPeRBE digital platform as a supporting operational environment for resilience assessment and adaptation planning. Although some functionalities may still need to be changed/improved, the platform demonstrated significant potential for supporting data integration, indicator calculation, risk visualisation, and future scenario evaluation. The possibility of comparing ex-ante and ex-post resilience conditions also represents a valuable contribution for long-term monitoring and adaptation pathway development.

The pilot implementation further confirmed the importance of linking assessment activities with adaptation planning processes. The results generated within WP2 provide a strong analytical basis for the climate adaptation pathways and resilience-oriented planning activities developed in WP3. The methodology therefore supports not only the diagnosis of current climate vulnerabilities but also the definition of measurable resilience objectives and future adaptation scenarios.

Future development of the RBE framework should focus on improving usability, simplifying operational workflows, expanding benchmark libraries, strengthening interoperability with GIS and planning systems, and supporting long-term institutional uptake beyond the project duration.