URBREATH [101139711]

Systemic Integration of Transformative Technical and Nature-based Solutions to Improve Climate Neutrality of European Cities and Regions and Tackle Climate Change: the URBREATH Approach

D5.2 – Local baseline state and URBREATH revisited requirements and technical framework – V2

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Document description	This document is the second in a series of four reports outlining the joint efforts undertaken within Tasks 5.1, 5.2, 5.4, 5.5, and 5.6 to assess the local baseline state of the URBREATH pilot cities. It covers the identification of functional requirements and their translation into technical specifications, the facilitation of collaboration between pilot cities and technical partners, the development and validation of a Key Performance Indicator (KPI) framework, support of the design, adoption and local use of Local Living Lab (LLL) and Nature based Solutions (NBSs) monitoring tools and simulation models, a gap analysis of local technical infrastructures (including the availability and suitability of tools, models, and datasets), and the mapping and implementation of city-specific customisation needs.

Document revision history

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		Modification Reason	Modified by
V 0.1	November 17th, 2025	TOC, general structure, first input Task 5.4.	VLO, VCS
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V 0.3	November 28th, 2025	Input from the Tasks 5.1, 5.2, 5.4. Addition of Chapters 1, 2 and 3.	VLO, VCS
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V 0.5	December 11th, 2025	Internal review done, update document.	VLO, TAL, UPM
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Disclaimer

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Executive summary

Deliverable 5.2 documents the evolution of Tasks 5.2, 5.4, 5.5 and 5.6 of Work Package 5 (WP5) in the URBREATH project, focusing on the Months 18–24. WP5 aims to advance climate neutrality and resilience in European cities through technical and nature-based solutions (NBS). This period marks the transition from solution design to deployment and evaluation.

- **Task 5.1** (Completed at Month 18) concluded with a comprehensive baseline analysis and requirements mapping for all pilot cities. Functional needs were systematically gathered, prioritised, and translated into technical specifications, forming the foundation for subsequent tool development and pilot implementation. Results from Task 5.1 are now integrated into ongoing activities. No further actions are planned for this task in the current period.
- **Task 5.2** actively facilitates the translation of local requirements into technical solutions. The WP5 team supported iterative tool development, customisation, and continuous feedback between pilot cities and technical partners. Deep-dive workshops and learning-by-doing sessions enabled pilots to validate and refine digital tools, ensuring alignment with operational needs. For the upcoming reporting period, Task 5.2 will continue supporting co-creation, tool adoption, customisation, and local use. Enhance participatory processes and maintain close coordination between pilots and technical teams to address emerging needs and integrate lessons learned.
- **Task 5.4** conducted gap analyses of local data and infrastructure, identified persistent data gaps, and supported the customisation and local implementation of digital tools (e.g., Local Digital Twins, planners, analytical plugins). The team delivered 119 training sessions across nine pilot cities, ensuring capacity building and effective tool use. As next steps, Task 5.4 will focus on resolving data gaps, enhancing tool adoption and standardisation, and promoting tailored tool bundles. Strengthen local integration and interoperability and foster cross-zone knowledge exchange to share best practices.
- **Task 5.5** advanced the design and development of monitoring dashboards for NBS effects and Key Performance Indicator (KPI) tracking. The dashboards aggregate data from various sources, enabling cities to visualise and interpret ecological, social, and climate-resilience impacts. For the next reporting period, Task 5.5 will continue dashboard refinement and integration, validate usability with pilot cities, and prepare for full deployment. Support cities in data collection and ensure dashboards align with participatory decision-making needs.
- **Task 5.6** finalised KPI sets for all pilot cities, developed monitoring protocols, and harmonised baseline data collection. The team coordinated impact workshops to establish Theories of Change and prepared for ex ante impact simulations. As next steps, Task 5.6 will advance monitoring and evaluation frameworks, conduct ex ante and ex post impact assessments, and support cities in ongoing data management and KPI tracking. Promote standardisation and continuous improvement of monitoring protocols.

During Months 18-24, WP5 has made substantial progress in operationalising the URBREATH approach, consolidating technical advances, and embedding participatory processes. The next phase will focus on overcoming data and integration challenges, enhancing tool adoption, and strengthening monitoring and evaluation to support climate-neutral, resilient urban regeneration across Europe.

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List of terms and abbreviations

Abbreviation	Definition
2D, 3D	Two dimensional, three dimensional
AI	Artificial Intelligence
API	Application Programming Interface
BAF	Biotope Area Factor
BIM	Building Information Modelling
CO_2	Carbon Dioxide
COG	Cloud Optimised GeoTIFF
CZ	Climatic Zone
CZML	Cesium Language
D	Deliverable
DoA	Description of Action
DT	Digital Twin
EC	European Commission
EU	European Union
FLC	Follower City
FRC	Front Runner City
GA	General Assembly
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GML	Geography Markup Language
ICT	Information and Communication Technologies
IDEAM	Spatial Data Infrastructure of the Madrid City Council
IDRA	Integrated Data Registry and Access
IT	Information Technology
KPI	Key Performance Indicator
LDT	Local Digital Twin
LL	Living Lab
LLL	Local Living Labs

LST	Land Surface Temperature
M	Month
MIM	Minimal Interoperability Mechanism
NBS	Nature-Based Solution
NGSI	Next Generation Service Interface
PM	Project Management
$PM_{2.5}$	Particulate Matter 2.5 micrometre
REST	Representational State Transfer
SHP	Shapefile
SSPs	Shared Socioeconomic Pathways
T	Task
UHI	Urban Heat Island
UI	User Interface
URL	Uniform Resource Locators
UX	User Experience
VCS	Virtual City Systems
WFS	Web Feature Service
WMS	Web Map Service
WMTS	Web Map Tile Service
WP	Work Package

1. Background and key achievements

1.1 Scope and goal of Deliverable 5.2

Deliverable 5.2 builds directly on the foundations established in Deliverable 5.1, which outlined the methodological approach, early implementation steps, and initial outcomes of Work Package 5 (WP5). While Deliverable 5.1 focused on defining the functional and technical needs of the pilot cities and establishing the frameworks for developing the URBREATH digital toolbox, Deliverable 5.2 shifts the focus to **reporting progress, updates, and refinements achieved across the individual WP5 tasks** during the subsequent project period.

This document is the **second in a planned series of four**, followed by Deliverable 5.3—which will be produced three years after the start of the project—and Deliverable 5.4, which will be delivered at the end of the project (see also Figure 2). *Together, these Deliverables provide a continuous and structured overview of the development, refinement, and operationalisation of WP5 activities throughout the full URBREATH project lifecycle.*

The main objective of Deliverable 5.2 is to **document the evolution of WP5 activities**, showing how the preliminary frameworks, requirements, and methodological processes introduced in Deliverable 5.1 have been further developed, expanded, or validated. This includes updating the status of functional and technical requirement translation, advancing the co-creation processes with pilot cities, and deepening the integration between user needs and emerging technical solutions.

Specifically, Deliverable 5.2 aims to:

- **Provide task-specific progress updates** for Tasks 5.1, 5.2, 5.4, 5.5, and 5.6, demonstrating how each has advanced from the foundations laid in Deliverable 5.1.
- **Report refinements in the functional and technical frameworks**, including adjustments based on lessons learned, new insights from pilot workshops, and interactions with technical partners.
- **Detail ongoing co-creation efforts**, highlighting how cities continue to validate selected tools, simulation models, and processes introduced in the earlier phases.
- **Update the development status of Key Performance Indicators (KPIs), Nature Based Solutions (NBSs) monitoring dashboards, and datasets**, showing progress beyond the initial definitions provided in Deliverable 5.1.
- **Describe continued alignment efforts** with Work Packages 2, 3, 4, and 7, ensuring that the WP5 work remains coherent within the broader URBREATH architecture.
- **Identify emerging challenges, gaps, and next steps**, thereby supporting planning for the next iteration of toolbox development, pilot implementation and use, and monitoring in the upcoming phases of WP5.

While Deliverable 5.1 provided both a blueprint and methodological roadmap and included initial progress reporting, Deliverable 5.2 serves as a **more comprehensive progress report and consolidation document**, capturing how the project has advanced from concept definition to deeper implementation. It demonstrates continuity with the previous Deliverable while clearly articulating the concrete developments achieved since its publication.

Figure 1: Status and timing of the Deliverables series 5.1-5.4.

Deliverable	Version	Due date	Status
Local baseline state and URBREATH revisited requirements and technical framework (VLO)	D5.1 - V1	M18	Submitted
	D5.2 - V2	M24	In progress
	D5.3 - V3	M36	Future work
	D5.4 - V4	M48	Future work

1.2 WP5 goals in relation to the project's objectives

The key **objectives** of the URBREATH project serve as a guiding thread, connecting and aligning the efforts of all Work Packages. Each objective provides direction for both the scientific and operational components of the project, ensuring that activities—from functional analysis and tool development to co-creation, implementation, and policy support—contribute to the same overarching mission. The table below presents an overview of these key objectives, summarising their descriptions and showing how each Work Package is linked to them. This structured mapping helps clarify how the different strands of work reinforce one another and collectively advance URBREATH's systemic approach to urban greening and renaturing.

Table 1: List of objectives of the URBREATH project.

Objective	WPs involved	Content
OBJ-1	*WP2-5-7*	*Creation of a stakeholder group under the concept of a Local Living Lab – identify end users' needs and define requirements for feasible restoration/regeneration measures (NBS at core), based on local needs, policy, climate, and hazard analysis.*
OBJ-2	*WP3-4*	*Establish the necessary Information and Communication Technologies (ICT) tools, methods and participation processes for increased stakeholder participation and wider public (including residents/citizens) participated decision making processes.*
OBJ-3	*WP2-5-7*	*Establish innovative cooperative organisational models ensuring project sustainability and aiming towards systematic adoption of solutions (NBS and hybrid solutions at core) for urban regeneration and climate neutrality.*
OBJ-4	*WP3-4-5-6*	*Develop and demonstrate efficient and effective services, models, and tools for quantitative impact assessment of the climate effects towards climate neutrality, regeneration, and adaptation planning.*

OBJ-5	WP5-6-7	Develop and deploy innovative clustering of NBS and hybrid approaches, for the enhancement of synergy effects of interventions with more effective functionalities towards improved urban/local climate neutrality, resilience, and regeneration.
OBJ-6	WP4-6	Develop an assessment framework for evidence-based evaluation of NBS (URBREATH approach) via extensive monitoring of deployed solutions in the four Front Runner Cities (FRCs) in different European geographical and climatic regions towards optimised future deployments and increased systemic adoption.
OBJ-7	WP7	Replication of the URBREATH methodology and tools through mentoring and coaching in follower cities (FLCs).
OBJ-8	*WP8*	*Support of the adoption of the sustainable URBREATH solutions for the urban/regional planning for regeneration, resilience, and climate neutrality – through extensive public awareness and dissemination activities.*
OBJ-9	WP8	Develop novel business models and strategies for regional climate resilience enhancement.

For the first two years of the project, WP5 aims for:

- **A stepwise in-depth analysis of pilots' functional needs**. OBJ-1
  This involves systematically gathering and structuring the needs of each pilot city through interviews, workshops, and co-creation sessions. The analysis bridges local challenges with the broader URBREATH framework, aligning city-specific requirements with the macro-level functional insights developed in WP2, WP3, and WP4. The outcome is a coherent set of functional requirements, use cases, and user stories that guide tool development.

- **Streamlining the translation to technical solutions and supporting the road to tool & model development**. OBJ-1,2
  Task 5.1 facilitates that functional needs are accurately translated into technical specifications by working closely with the modelling and tool development teams in WP3 and WP4. This includes prioritising functionalities, assessing technical feasibility, coordinating iterations with technical partners, and validating prototypes with cities to ensure that tools and models align with real operational needs.

- **Supporting the setup and implementation of Local Living Labs (LLLs) to co-create in NBS design, implementation, and monitoring**. OBJ-1
  WP5 assists pilot cities in establishing LLLs as participatory spaces where local stakeholders—citizens, experts, authorities—co-create climate-resilient NBSs. This includes providing methodologies, facilitation guidance, digital tools, and templates that enable effective engagement, scenario exploration, and joint decision-making throughout the design, implementation, and monitoring phases.

- **Setting up a KPI monitoring framework & monitoring tools**. OBJ-4,5
  Task 5.1 and 5.6 joined forces to contribute to defining a harmonised set of KPIs that reflect ecological, social, and climate-resilience impacts of NBSs. It supports cities in selecting relevant indicators,

structuring data flows, and using digital dashboards and analytical tools to track progress. This allows consistent evaluation across different pilot contexts.

- **Conducting a data and infrastructure gap analysis. Supporting the local implementation and customisation of developed tools and models. Set up an urban planning workflow for Front Runner Cities (FRCs)**. OBJ-1,2,5
  Task 5.4 evaluated the availability, quality, and accessibility of local datasets required for modelling, scenario planning, and KPI monitoring. It identified missing data, proposed enrichment strategies, and collaborated with cities to prepare the ground for tool deployment. This also includes supporting the local usage and configuration of models, visualisation tools, and digital twins. Additionally, the task initiates the development of a structured urban planning workflow for Front Runner Cities (FRCs), aligning planning processes with URBREATH's technical and analytical capabilities (see Deliverable 5.9 Customised URBREATH decision-making framework for Pilots - V1).

1.3 A combined effort of four WP5 tasks

Task 5.1 was completed after Month 18 of the project.

Deliverable 5.2, therefore, covers the coordinated efforts carried out within WP5 from Month 18 to Month 24, focusing on the activities undertaken in Tasks 5.2, 5.4, 5.5, and 5.6. It integrates the updates of these tasks to provide a coherent and multidisciplinary overview of the activities related to the definition of a KPI framework, monitoring of NBSs and associated KPIs, analysis of local Information Technology (IT) infrastructure and data/model gaps, and the development, documentation, adoption, learning-by-doing, testing, customisation, and local use/implementation of digital tools. Task 5.1, which concluded in Month 18, has now been completed, and a summary of its results is incorporated into this report.

As stated in the Grant Agreement:

Task 5.1 - Analysis of the local baseline state

- M1-M18
- Lead: VLO
- Participants: TAL, MUN, DEDA, URB, BLOX, TEL, OASC, CA, SPG, TRA, BAS, all cities.
- For each city, a baseline evaluation and measurement will be made, explicitly the problems as experienced locally and conducting a data-based analysis enriched with collective intelligence information of the current state. In addition to T2.4, this task will include a data gap analysis and enrichment to allow the measurement and monitoring of the local/ regional and project-related KPIs. In addition, specific **local requirements** will be gathered and shared to **ensure the functionalities and technical requirements** are suited to local policy and engagement-focused usage for local pilot implementation.

T5.2 Alignment of requirements and technical solutions (M6-M48)

- Lead: VLO
- Participants: POLIMI, TAL, ICCS, UPM, ENG, MUN, DEDA, ATC, VCS, URB, DBC, TEL, EXUS, OASC, FIC, MAD, LEU, TLN, CLUJ].
- Support and coordination to ensure that user requirements from local living labs are accurately reflected in the technical solutions developed in WP4. It will involve facilitating communication between the technical team and the local living labs and providing guidance on how to translate user requirements into technical solutions.

T5.4 Customisation and deployment of the URBREATH decision-making framework into pilots (M10-M36)

- Lead: VCS
- Participants: TAL, ICCS, VITO, UPM, VLO, MUN, DEDA, ATC, URB, LAT, TEL, EXUS, FIC, TRA, BAS, MAD, LEU, TLN, CLUJ].
- This task gathers information on the current systems and solutions used in the urban planning process within the cities and identifies the potential for integration or replacement. Based on this, tailoring of the overall framework according to the specific pilots' needs is done, integrating selected components into their existing IT systems. Finally, the task performs the continuous data ingestion, collection and harmonisation to feed KPIs calculation. Activities of this task are performed in strict collaboration with local technical partners.

T5.5 Tools for monitoring, co-creating, deciding and steering (M10-M40)

- Lead: MUN
- Participants: TAL, ICCS, VITO, UPM, VLO, VCS, URB, LAT, BLOX, TEL, EXUS, FIC, MAD, LEU, TLN, CLUJ].
- This task will implement the specific KPI calculation and visualise these to allow local monitoring and policy steering to increase the impact of NBS. Interactive dashboards and decision support systems like digital twins (T5.4) will be used to display the KPI evolutions in a clear and intuitive way. These tools will enable LL participants to view and interpret data related to the selected urban area for a given NBS scenario. It will provide a visual representation of data, allowing LL participants to easily explore and analyse different locally co-created NBS scenarios and identify patterns and trends that may inform the selection or adaptation of the most strategically optimal NBS scenario. KPIs calculation will be done with the impact models developed in WP3. Ex-ante evaluation of the KPIs will be conducted in T5.6 and it will support the co-creation process (T5.2[1]) of NBS scenarios for the FRC. Tools for monitoring, cocreating, deciding, and steering will allow to visualise the simulated impacts on the dashboard developed in T5.3[2].

T5.6 Performance evaluation and impact assessment (M10-M48)

- Lead: IAO
- Participants: LC, USTUTT, TAL, UPM, VLO, DEDA, URB, TEL, CA, FIC, TRA, BAS, all cities].
- This task focuses on evaluating the impact of the implemented solutions.

[1] The reference to “T5.2” in this context is incorrect and should be understood as “T5.3”.
[2] The reference to “T5.3” in this context is incorrect and should be understood as “T5.5”.

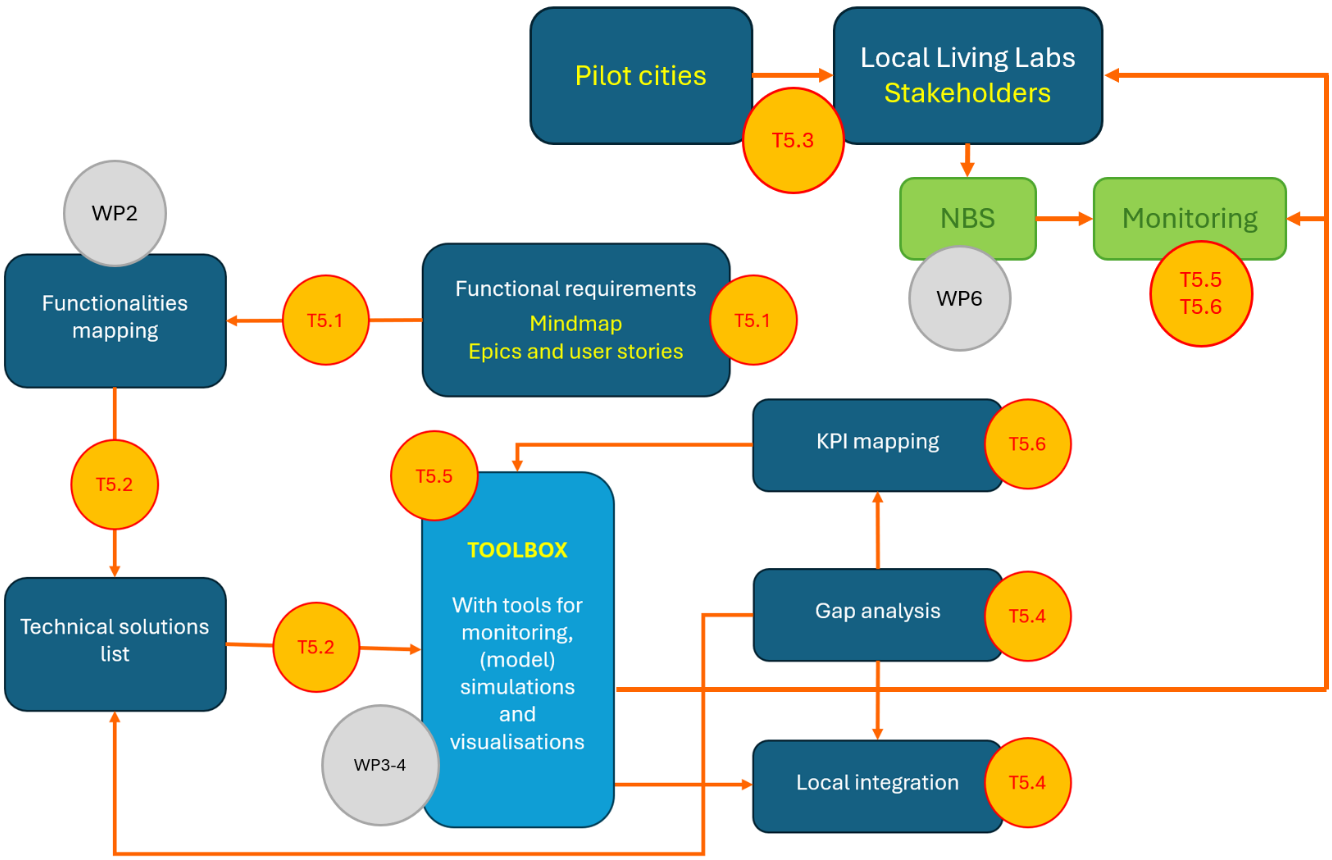
This will include the creation of a common simulation, assessment basis and monitoring protocols based on the expected impacts identified through the LLs activities of the FRC and FLC. This will consolidate the simulation, monitoring, and evaluation work of the URBREATH solutions, the impact assessment framework and tools developed in T5.1 [3] and T5.5. During the co-creation process described in the methodology paragraphs 1.2.2 and 1.2.3, this task will conduct an ex-ante impact simulation of the selected NBS scenarios by using the impact models developed in WP3 and made available to LL participants to the dashboard developed in T5.3 [4] for supporting participatory urban policy decisions and NBS scenario co-creation processes. In the final stage of the demonstration, will be conducted an ex-post assessment of the given KPI, so to inform WP7 and WP8 with evidence-based knowledge and data for scaling the NBS initiatives. Inputs and data gathered from all WP5 and WP6 tasks will be used to conduct an evaluation to assess the level of success of the demonstration activities of the project, enabling comparisons between cities and sectors, and underpinning replication (in direct link with WP7) at five levels, using the EU-CITYKeys framework as a reference: planet, people, prosperity, propagation, and governance.

This task will manage the data gathering and conduct the evaluation assessment to capture the impact and success of the solutions. Each city will be responsible for filling and providing the data requested for conducting the impact assessment activities using quantitative data (based on T5.1) and qualitative impact factors, which would explain the developments and unique elements which contributed or hindered the implementation process of the city. This task will contribute by developing long-term monitoring protocols for the pilots and streamlined monitoring protocols for follower Cities and other cities and regions, in alignment with their proposed roadmap (T7.5). The assessment framework will be developed with the participation of partners who possess complementary expertise in NBS, policymaking, modelling and visualisation, stakeholder/citizen engagement, innovation, and governance, who will work closely with the task leader and city partners in a sustained fashion. Evaluation will be aligned with the project implementation in cities, producing reports in M30 and a final summary in M48.

To clarify the role of each Task within the broader WP5 structure, and to position its activities in relation to the design, planning, implementation, and monitoring of NBSs, an updated process diagram was developed. This visual highlights how Task 5.3 both depends on and supports the other WP5 tasks, reflecting the iterative and interconnected nature of co-creation within LLLs. The diagram also illustrates how insights, tools, and outputs flow between tasks as part of a continuous learning and development cycle.

[3] The reference to "T5.1" in this context is incorrect and should be understood as "T5.6".
[4] The reference to "T5.3" in this context is incorrect and should be understood as "T5.5".

Figure 2: Updated diagram presented at the review meeting of September 25th, 2025, illustrating the interdependencies between Task 5.3 and the other WP5 Tasks and the relation between Task 5.3 and the designing, planning, implementation, and monitoring of Nature-Based Solutions (NBSs).



Within the context of this series of Deliverables, the specific roles and inputs of the relevant WP5 tasks can be summarised as follows:

- **Task 5.1 - Functional and technical requirements analysis.** DONE.
- **Task 5.2 - Co-creation and Living Lab (LL) facilitation**
    - Supports the technical analysis process by ensuring that the perspectives and priorities of local pilots and LLs are accurately captured. DONE.
    - Ensures effective translation of local requirements into technical specifications. ONGOING.
    - Plays a facilitating role in the communication and iterative feedback loops between technical developers and pilot city representatives, including LL coordinators, in different stages of tool development and model integration (development, adoption, documentation needs, testing-by-doing sessions, fine-tuning and debugging, customisation and local use), in close cooperation with technical Work Packages 3 and 4 and Task 5.4. ONGOING.

- **Task 5.4 - Data and infrastructure assessment**
  - Conducts a comprehensive assessment of available data sources and Information and Communications Technologies (ICT) infrastructures within the pilot cities. DONE.
  - Evaluates the feasibility of integrating URBREATH tools and simulation models into the local digital frameworks and supports the customisation process. ONGOING.
  - Coordinates the assessment of tool interest by the pilot cities and coordinates the preconditions for tool customisation and local use of the tools in cooperation with the technical teams (development, adoption, documentation needs, testing-by-doing sessions, fine-tuning and debugging, customisation and local use). ONGOING.
  - Develops an urban planning workflow for FRCs, which will be reported in Deliverable 5.9 Customised URBREATH decision-making framework for Pilots – V1. ONGOING.
- **Task 5.5 - Development of monitoring dashboards**
  - Leads the design and development of digital dashboards for monitoring of NBS effects, whether or not connected to KPIs. ONGOING.
  - Coordinates with Task 5.6 to ensure that indicators are technically feasible. ONGOING.
- **Task 5.6 - KPI mapping and specification**
  - Identifies, defines, structures, and validates KPIs monitoring NBS impacts, in collaboration with the pilot cities. DONE.
  - Provides structured input to support both the technical design of monitoring tools and simulation models and the NBS evaluation framework. ONGOING.
  - Coordinates and supports the pilot cities' baseline measurements of KPIs. ONGOING.

1.4 WP5 Tasks - timing and planning

As presented at the September 25th, 2025, review meeting, Task 5.1 has been completed, marking a significant milestone in the evolution of WP 5.

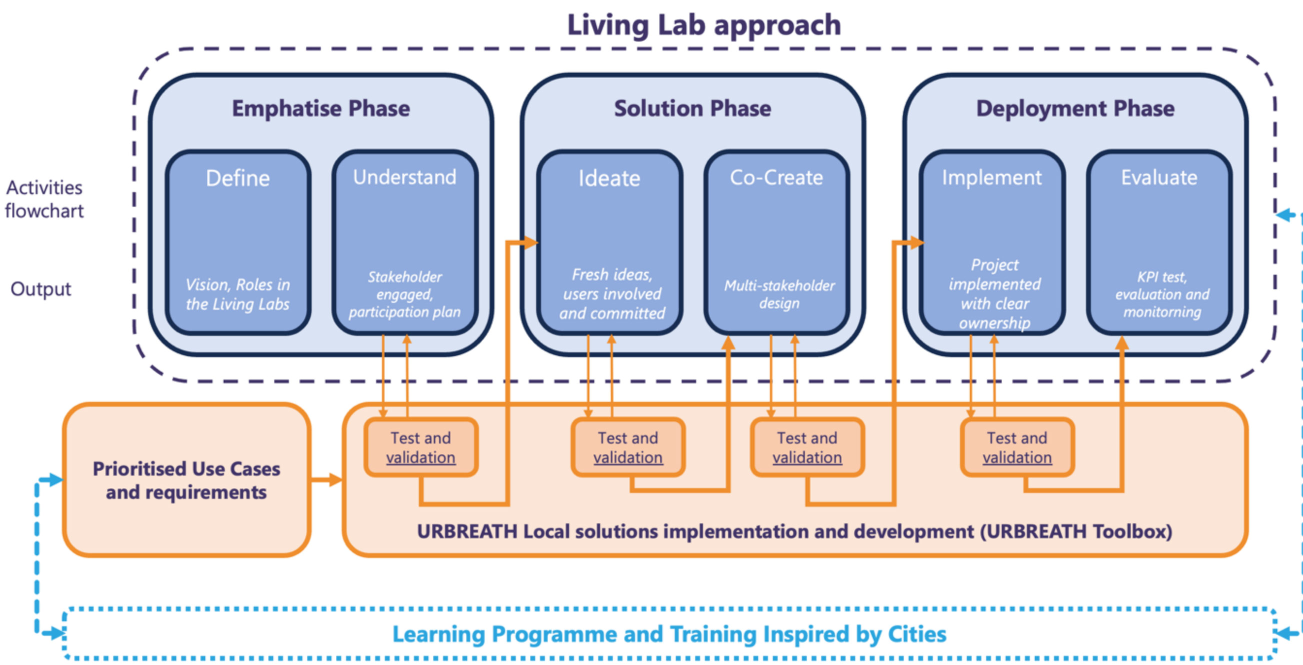
Figure 3 below offers a clear overview of WP5 tasks within the URBREATH project. It highlights the distribution of responsibilities among consortium partners, the main contributors involved, the timeline for each task, and their respective statuses.

Figure 3: Overview of all WP5 tasks, their leading URBREATH consortium partner, the contributors, the timeline and the actual status.

Task	Title	Lead	Contributors	Timeline	Status
Task 5.1	Analysis of the local baseline state.	VLO	TAL, MUN, DEDA, URB, BLOX, TEL, OASC, CA, SPG, TRA, BAS, all cities	M1-18	Completed
Task 5.2	Alignment of requirements and technical solutions.	VLO	POLIMI, TAL, ICCS, UPM, ENG, MUN, DEDA, ATC, VCS, URB, DBC, TEL, EXUS, OASC, FIC, frontrunner cities	M6-48	Ongoing
Task 5.3	Local Living Labs.	VLO	CA, LC, POLIMI, TAL, DEDA, URB, DBC, BLOX, SPG, TRA, BAS, all cities	M1-48	Ongoing
Task 5.4	Customisation and deployment of the URBREATH decision-making framework into pilots.	VCS	TAL, ICCS, VITO, UPM, VLO, MUN, DEDA, ATC, URB, LAT, TEL, EXUS, FIC, TRA, BAS, frontrunner cities	M10-36	Ongoing
Task 5.5	Tools for monitoring, co-creating, deciding and steering.	MUN	TAL, ICCS, VITO, UPM, VLO, VCS, URB, LAT, BLOX, TEL, EXUS, FIC, frontrunner cities	M10-40	Ongoing
Task 5.6	Performance evaluation and impact assessment.	FRAU, USTUTT	LC, USTUTT, TAL, UPM, VLO, DEDA, URB, TEL, CA, FIC, TRA, BAS, all cities	M10-48	Ongoing

The implementation of WP5 within the URBREATH project framework follows a structured and iterative process designed to ensure effective co-creation, technical integration, and capacity building across all pilot cities. This process is organised into three interconnected layers: a timeline of sequential phases and key LLL actions (in relation to the co-designing, implementation, evaluation, and replication of NBSs); the integration and refinement of supporting digital tools and models; and ongoing capacity building among stakeholders. The scheme below (Figure 4), described in detail in Deliverable 5.1, visually represents this integrated framework, highlighting how these layers interact to support the project's objectives from 2023 to 2027.

Figure 4: Schematic representation of the WP5 integrated framework, structured in three layers: (1) the process timeline outlining the sequential phases and key Local Living Lab actions from 2023 to 2027; (2) the digital tool integration layer depicting the iterative development, testing, and refinement of tools and models; and (3) the capacity building layer illustrating the continuous process of strengthening knowledge and skills among local stakeholders.



Between months 18 and 24 of the URBREATH project, we are at a pivotal juncture: the conclusion of the **solution phase** and the onset of the **deployment phase**.

During the **solution phase**, the project emphasised participatory design through two interconnected steps—Ideate and Co-create.

- In the **Ideate stage**, stakeholders from the public sector, academia, industry, and civil society engaged in structured brainstorming and design thinking workshops. These sessions generated a wide array of potential NBSs, encouraged creative exploration, and addressed dilemmas and trade-offs inherent in urban environments. Tools such as stakeholder maps and visual mock-ups were used to structure thinking and stimulate dialogue, ensuring that a diverse range of perspectives shaped the emerging ideas.
- The **co-create stage** then refined these ideas into implementable concepts through collaborative workshops. Here, multi-stakeholder teams translated promising ideas into concrete NBS designs, integrating ecological, technical, and social dimensions. This phase fostered ownership and consensus, with digital tools from the URBREATH Toolbox (such as the Local Digital Twins (LDTs), the storytelling tool, and the e-participation tool), supporting design discussions and participatory decision-making. The outcome was a set of NBS designs that were not only technically feasible but also validated by the community and ready for implementation.

As the project moves into the **deployment phase**, the focus shifts to operationalising these co-created solutions. This phase is structured around two critical stages: **Implement** and **Evaluate**.

- The **Implement stage** transforms the collaboratively developed NBS designs into tangible interventions, involving procurement, resource allocation, and the mobilisation of necessary services.
- The **Evaluate step** systematically assesses the effectiveness of these interventions using a robust set of predefined KPIs, which were established in Milestone 7 at Month 18. These KPIs cover environmental, social, and liveability outcomes, and the evaluation process is evidence-based, drawing on data collected via the digital tools refined during the project.

This transition period is thus characterised by the near-completion of NBS designs and the careful preparation for their real-world deployment and assessment. The project's structured approach ensures that the lessons learned, and frameworks developed during the solution phase directly inform the practical actions and evaluations of the deployment phase, supporting the overarching goal of climate-neutral, resilient urban regeneration.

2. WP5 alignment with its Tasks, other WPs, EU-projects and governmental teams

WP5 thrives as a dynamic, tightly-knit team, where task leads work in perfect harmony—not only coordinating seamlessly within the group but also actively engaging with other work packages. This spirit of collaboration extends beyond the project itself, as WP5 eagerly connects with like-minded initiatives from other EU (European Union) projects in the same EC (European Commission) cluster. The result is a well-oiled, enthusiastic team that embraces knowledge sharing, innovation, and collective progress at every opportunity.

2.1 WP5 internal synchronisation and cooperation

2.1.1 Bi-weekly WP5 meetings

WP5 task leads meet recurrently online every two weeks. The meetings are well prepared and supported by a PowerPoint presentation. An agenda and invite are preceding the meetings, and minutes with action points and main conclusions are sent after each meeting. All WP5 tasks are handled. These open-minded meetings help align all tasks, since they are all connected, and to put them in perspective with other work packages and their related tasks. Task-specific **progress information, announcements, ideas, and best practices can be shared, as well as questions, doubts, bottlenecks, and obstacles that** task leads are facing.

Besides these core activities, these meetings – during this reporting period - are also used for:

- Jointly defining the format, set-up, objectives, content and timing of these meetings.
- Pitching ideas and approaches of the 6-step process towards the tool adoption of Task 5.4.
- Pitching ideas to increase the involvement and interactivity of pilots and technical partners.
- Pitching approaches of LLL train-the-trainer sessions.
- Discussions on the contributions to technical and financial reports.
- Preparing, rehearsing and evaluating (lessons learned) the Month 18 *review meeting* (September 25th, 2005), mutually preparing the presentation of the work done by all.
- Preparing, coordinating, rehearsing and evaluating the *General Assembly* in Tallinn (October 2025), more specifically, the workshops organised by Tasks 5.3, 5.4, 5.5 and 5.6 and the demo café, co-organised by Task 5.2.
- Preparing for participation in the EC Cluster Meetings.
- Preparing the agenda for the Cities Calls.
- Invitation of the WP4 and project leads to work out Task 5.4-related solutions for local implementation and integration of tools, to stimulate the progress of the learning-by-doing sessions by all technical partners.
- Jointly working on the Deliverables due on Month 24.

2.1.2 WP5 Teams channel

A dedicated *Microsoft Teams* channel was set up for all WP5 pilot leads. The channel is used for quick communication (updates, questions, concerns, urgent requests and notifications) and for sharing agendas and other relevant documents.

2.1.3 Contribution to the September review meeting

WP5 *as a team* was involved in multiple aspects of the September 25th, 2025, review meeting. The approach is worked out in more detail in Chapter 4 and Deliverable 5.6.

- Task 5.2 took up the organisation of the 5-minute presentation of all pilot cities' timelines and their progress at the level of NBS and LLL activities. By creating presentation templates and organising multiple rehearsals and feedback moments.
- Tasks 5.2, 5.3, 5.4, 5.5 and 5.6 jointly worked together to report on task-specific activities performed during the first 18 months of the URBREATH project, and to guard the homogeneity of the presentation to make sure to tell a coherent and solid story. Task 5.2 presented and coordinated the reporting of all work done by the WP5 team (all WP5 tasks) in cooperation with all task leads. This includes the Task 5.4 goals of the customisation and local use of technical solutions.

2.1.4 Contributions to the General Assembly in Tallinn

WP5, *as a team*, also contributed to the preparation and content of the General Assembly (GA) in Tallinn in October 2025. The approach is worked out in more detail in Chapter 4 and Deliverable 5.6.

The overarching session with the Task 5.3, 5.4, 5.5, and 5.6 workshops was organised by all corresponding task leads, including preparation, logistics, chairing, moderation, and support for active participation from the whole team.

2.2 Alignment and cooperation with other WPs

2.2.1 Weekly WP task lead meetings

This original WP2, 5, 7 synchronisation meeting grew over time to a meeting with all WP leads, led by the Lisbon Council. This meeting is used to:

- Bring all WP-leads up-to-date with the most recent WP and Task-related updates, developments and realisations.
- To discuss potential synergies and parallels, but also concerns and potential bottlenecks.
- To pitch WP-overarching ideas, plans, good practices, and insights. To brainstorm and trigger/stimulate WP-overarching cooperation, integrated solutions/tools, the readiness and usability (User Interface and User Experience, UI/UX) of solutions/tools, and joint activities.

- To report on dissemination activities and reporting processes (e.g., Deliverables).
- To share ideas to improve communication between technical partners and the pilot cities in both directions. To stimulate, support, and guide pilot-specific active feedback. To synchronise activities with the pilot cities to avoid overwhelming them with tasks.
- To mutually prepare shared activities (review meeting, general assembly, seminars, cluster meetings, etc.
- To streamline opinions and focus and get noses in the same direction.

2.2.2 Monthly Project Management meetings

These monthly meetings address WP leads and city representatives from the URBREATH pilot cities.

During these meetings, WP5 takes the opportunity to present the major updates, plans, and next steps at the URBREATH project level and to pitch high-level concerns or launch a call to action related to pending WP5 tasks.

In the other direction, the project lead, Lisbon Council, informs the consortium partners about relevant developments in the URBREATH project, dissemination and cooperation opportunities, and cross-cutting initiatives relevant to the project's progress.

For each monthly Project Management meeting, WP5 prepares a PowerPoint presentation with a heads-up, which is validated by the entire WP5 team through the WP5 *Teams channel* and dedicated bi-weekly WP5 meetings. When needed, WP5 Task leads are invited to present specific topics or to trigger a call to action.

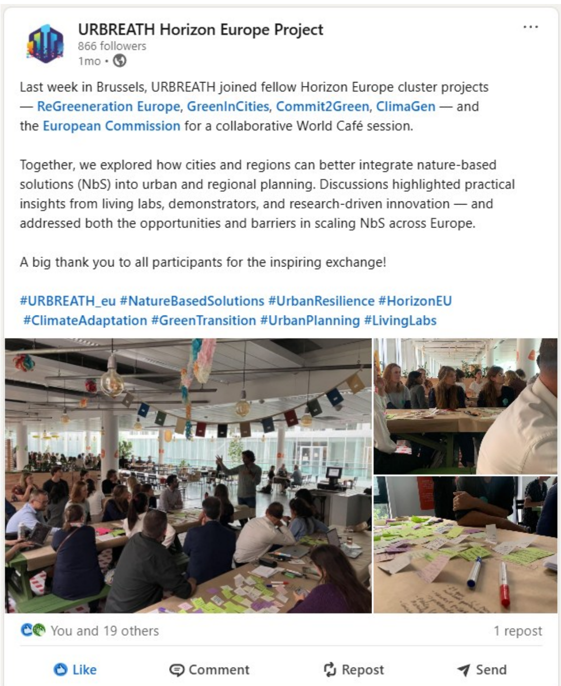
2.3 Alignment and cooperation with other EU projects

The WP5 team actively engages in knowledge-sharing with other EU projects and external experts through interactive monthly urban greening and renaturing cluster meetings, as well as cross-WP and project-wide webinars.

2.3.1 Monthly Urban Greening and Renaturing Cluster meetings

Active participation in the Urban Greening and Renaturing Cluster world café (Nature Network event)

Figure 5: LinkedIn post by the URBREATH project on the Nature Network world café.



On September 17th, 2025, WP5 participated alongside fellow participants in the Horizon Europe cluster projects *ReGreeneration Europe*, *GreenInCities*, *Commit2Green*, and *ClimaGen*, and the European Commission, as coordinator, for a live collaborative World Café session in Brussels.

Together, we explored how cities and regions can better integrate NBSs into urban and regional planning.

Discussions highlighted practical insights from living labs, demonstrators, and research-driven innovation—and addressed both the opportunities and barriers to scaling NBS across Europe. And of course, this was a perfect networking event.

After two general keynote presentations by members of the European Commission, an interactive workshop was held with all participants to exchange ideas and concerns. Three table workshops were organised with alternating group compositions, each working on a different topic :

- Challenges, enabling factors to integrate NBSs in urban planning.
    - What we see as challenges: changes in politics and related budgeting, changes in timing (due to dependency on NBS-installing contractors, contracting procedures, planting season based on NBS choices/designs, ...), conflicting interests/budgets with other departments, ...
    - What we see as enablers: solutions that are overarching, beneficial to all stakeholders. Solutions that grew organically without top-down intervention or steering.
- Challenges and enabling factors enabling NBS implementation (at LLL level).
    - What we see as challenges based on our experience: connecting/involving ALL relevant stake-holders, expectation management, politics, and flexibility in timing.

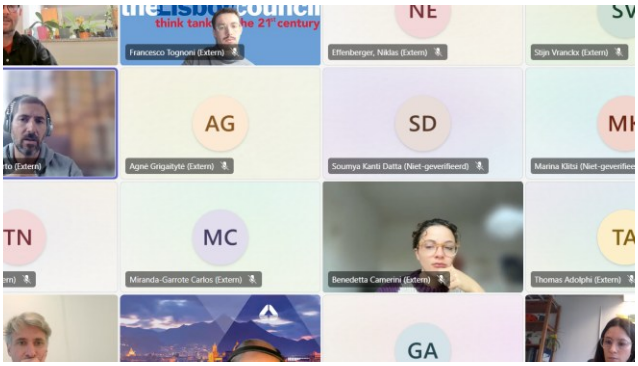
    - Enablers: give a neutral, open and straightforward presentation of the use case and pilot setting, avoid complexity, we recommend the use of LDT scenario visualisations to support a good understanding of NBSs by the local stakeholders, look for additional complementary LLL initiatives to integrate target groups that are difficult to reach, guard the open mindset in your LLL, don't steer.

- The most relevant monitoring framework to measure the impact of NBSs.
    - Our ideas: use a combination of tools in an interactive way. Examples:
        - Integrate model simulations in an LDT where pilot cities can simulate the effects of different NBS scenarios;
        - Make use of citizen science in your LLL to gather data;
        - Combine qualitative analyses done by surveys with AI to analyse a massive amount of open questions and connect to analysing dashboards.

Figure 6: Composition of pictures taken at the Urban Greening and Renaturing Cluster word café, held in Brussels on September 17th, 2025. From the top left to the bottom right: the participants, the URBREATH delegation, a snapshot of the workshop and the Nature Network conference.

Active participation in the dedicated Urban Greening and Renaturing Cluster session on the use of supporting tools

Figure 7: Urban Greening and Renaturing Cluster monthly meeting.



At the Cluster meeting on November 21st, 2025, WP5 and the Project lead, Lisbon Council, presented the status of the tools to fellow cluster projects at the Urban Greening and Renaturing Cluster monthly meeting. WP5 provided a general introduction to the URBREATH project, and the four types of tools/models were presented (LLL-supporting, NBS choice-supporting, NBS implementation-supporting, and NBS evaluation-supporting), each illustrated with examples.

It was interesting and inspiring to learn the approaches of the other projects in the cluster.

2.3.2 Participation in webinars

WP5 also participated in several webinars organised by other work packages and pilot cities that were relevant to its activities. Notable examples include the series of five 1.5-hour cross-cluster webinars on *Innovative Public Procurement in Action* (focused on instruments for urban transformation, held in September and October 2025) coordinated by WP7, as well as the webinar *Understanding NBS: Sustainable Solutions for Urban Resilience* on November 19th, 2025, during which Cluj-Napoca presented its approach within the URBREATH project.

2.4 Alignment within the Digital Flanders Department

Reporting within the Digital Flanders Department is crucial in two ways. By sharing our approach, strategy, best practices, and results from the URBREATH project, we inform and inspire the department's experts. At the same time, learning from similar projects and incorporating feedback allows us to refine and improve our URBREATH approach.

2.4.1 Weekly and monthly internal Digital Flanders meetings

Every Week, the WP5 progress in the URBREATH project is synchronised with the activities of the Digital Flanders Department intergovernmental policy team. It is the ideal moment to exchange ideas and working methods to improve the URBREATH project's approach and to integrate its best practices into the team's daily work.

2.4.2 Departmental level

Each month, a broader Flemish digital strategy division of the Digital Flanders Department is organised, where URBREATH is presented and sometimes showcased in more detail. These meetings provide general input and feedback from specialists on the work packages in which Digital Flanders is involved, with a focus on WP5 activities. Also, the most recent developments in related fields are presented, which are highly valuable for future work and provide useful insights for the URBREATH project.

On **August 14th, 2025**, the URBREATH project in general and the work in WP5 in more detail were presented to the Department, based on a basic slide deck that was part of a generic slide deck covering all EU projects in which the Department is involved, used by all members of the Department when disseminating URBREATH. The presentation goes into depth on the project's goals, the role of Digital Flanders in the project, and its finances.

Figure 8: A selection of slides presenting the contribution of WP5 to the URBREATH project. With explanations of the goals and roles of Digital Flanders, an in-depth view of the functional and technical analyses, the Local Digital Twin progress, and the overarching and Local Living Lab activities organised or supervised by Digital Flanders.

On **October 21st, 2025**, a more general presentation was given, pitching the URBREATH project in its actual state. The most recent progress was outlined regarding the development of Local Digital Twins for the city of Leuven, the LLL activities, and the train-the-trainer sessions organised under WP5. An interesting debate started about the 3-30-300 index maps available in the LDT of Leuven. Since a broader communication had appeared on national news two weeks earlier, showing a higher-level 3-30-300 compliance level at the city and municipal levels, the more detailed URBREATH maps were an interesting topic for discussion among the meeting participants.

Figure 9: Selection of a few slides presented at a high-level department meeting, where the progress of the URBREATH project was demonstrated at levels of Local Digital Twins and Local Living Labs.

2.5 Reporting

2.5.1 Deliverables

WP5, as a team, ensures that all deliverables accurately reflect the work carried out within the work package, so that the information provided can be understood, reused, and serve as a valuable resource for other teams, projects, and stakeholders.

2.5.2 Technical, financial and other progress reports for Months 1-18

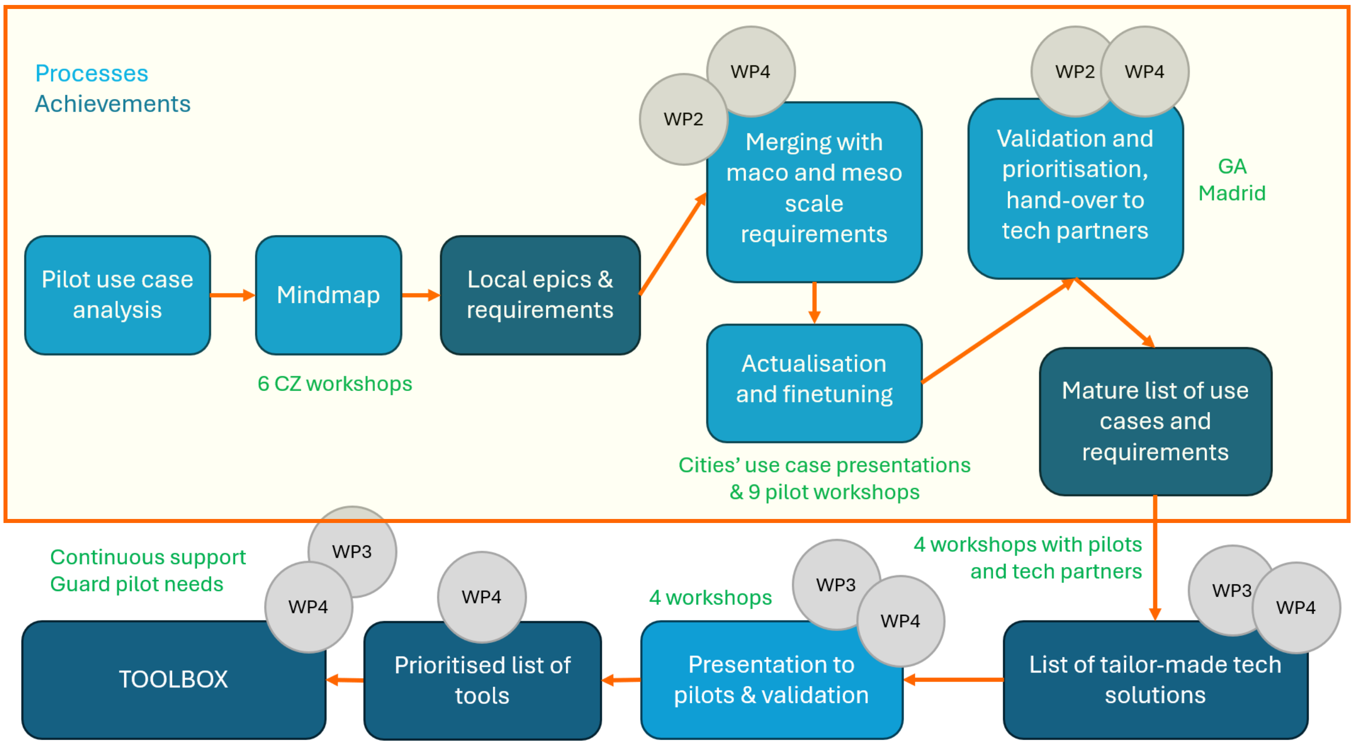
WP5 plays a key role in ensuring consistent reporting on its activities, including those carried out by the pilots. This involves preparing various reports - such as the technical and financial Month 18 reports - for the European Commission, covering aspects such as cross-WP progress, outcomes, and resource allocation:

- The **technical status** (for each WP5 task) at month 18.
- The border between where WP3-4 efforts (tools and models) stop and Task 5.4 efforts (like customisation and implementation) start.
- The **financial state** of the contribution by all WP5 task leads, in sync with the timesheets of all contributors and our internal Accountancy Department.
- The contribution of WP5 to the URBREATH project's **objectives**.
- The coordination of the description **of all WP5 partners' contributions** to the WP5 achievements.
- The contribution of **WP5 partners** to other WPs.
- WP5 **exploitable results**.
- The **contributing scientists**.
- The **end users and citizens** involved.
- And the mapping of **potential risks** related to WP5 activities.

3. Results Task 5.1 - mapping pilots' functional needs

Task 5.1 terminated on Month 18, and all work was reported in Deliverable 5.1. In summary, the following activities were performed, along with the corresponding efforts. Presented during the review meeting. Figure 10 summarises the step-by-step process we followed in creating the LLL and NBSs supporting the Toolbox.

Figure 10: Schematic overview of the WP5 achievements in the processes of mapping pilot cities' functional needs and the subsequent translation to technical solutions in preparation for the Toolbox development. The orange box marks the process of mapping the pilots' functional needs.



After defining the pilot's baseline state and pilot use cases, and analysing them, WP5 created a mind map and a list of local epics and requirements based on all information gathered during two series of workshops with pilots, bundled by Climatic Zone (CZ).

The resulting micro-scale requirements were bundled with the macro- and meso-scale requirements defined by bundled efforts of Work Packages 2 and 4. A subsequent actualisation and finetuning step was added to actualise and finetune all requirements, and the final list was validated, prioritised, and handed over to the technical partners at the General Assembly (GA) in Madrid (October 2nd, 2025).

The end result of this procedure is a **mature list of use cases and requirements**.

4. Results Task 5.2 - aligning requirements and technical solutions

Task 5.2 plays a central role in ensuring that the **pilots' user requirements** are accurately reflected in the **technical solutions** developed within Work Packages 3 and 4. As the connecting interface between the pilot cities and the technical teams, WP5 facilitates clear and continuous communication, helps clarify needs when necessary, and guides the translation of user requirements into concrete, implementable features. In this chapter, we describe in detail how WP5 supported pilot city representatives—including LLL managers—and technical partners between Month 18 and Month 24 in the further development and customisation of tools for the URBREATH Toolbox. Through targeted coordination, sustained dialogue, and ongoing refinement of functional needs, Task 5.2 helps ensure that the evolving technical solutions remain aligned with the priorities and contexts of the front-runner pilots as much as possible.

4.1 Recap - status at Month 18

Before the current reporting period, as reported in Deliverable 5.1, substantial preparatory work was carried out by Work Packages 3, 4, and 5 to establish a solid foundation for the technical development of the URBREATH Toolbox. Following the General Assembly in Madrid (October 2024), WP3 and WP4—supported by WP5—conducted a detailed feasibility assessment of the prioritised use cases of the front-runner cities. This work ensured that early conceptual designs were firmly anchored in the user requirements gathered during the initial co-creation workshops. In parallel, WP5 coordinated the creation of a cross-referenced overview of all involved WPs, clarifying roles, enhancing interdisciplinary alignment, and ensuring that functional and technical inputs could be coherently integrated across the project.

Throughout October 2024, each front-runner pilot city participated in weekly WP3–WP4 brainstorming sessions. Task 5.2 moderated these discussions, simultaneously consolidating emerging technical solution directions and safeguarding the pilots' interests by ensuring their needs remained at the centre of all decision-making. Building on this, WP5 (under Task 5.2) organised four 120-minute deep-dive sessions starting mid-November, during which technical partners presented refined solution concepts to the pilots. These sessions were instrumental in gathering additional pilot insights and in progressing the ongoing data and model availability mapping under Task 5.4.

Based on the feedback collected during this entire process, WP5 compiled a comprehensive and consolidated list of required technical functionalities addressing all prioritised front-runner use cases. This marked a key milestone for Task 5.2, completing the trajectory from co-creative mapping of user needs to the translation of those needs into an actionable technical development plan. The finalised list, delivered to technical partners in December 2024, also served as the core reference for Task 5.4's data inventory work.

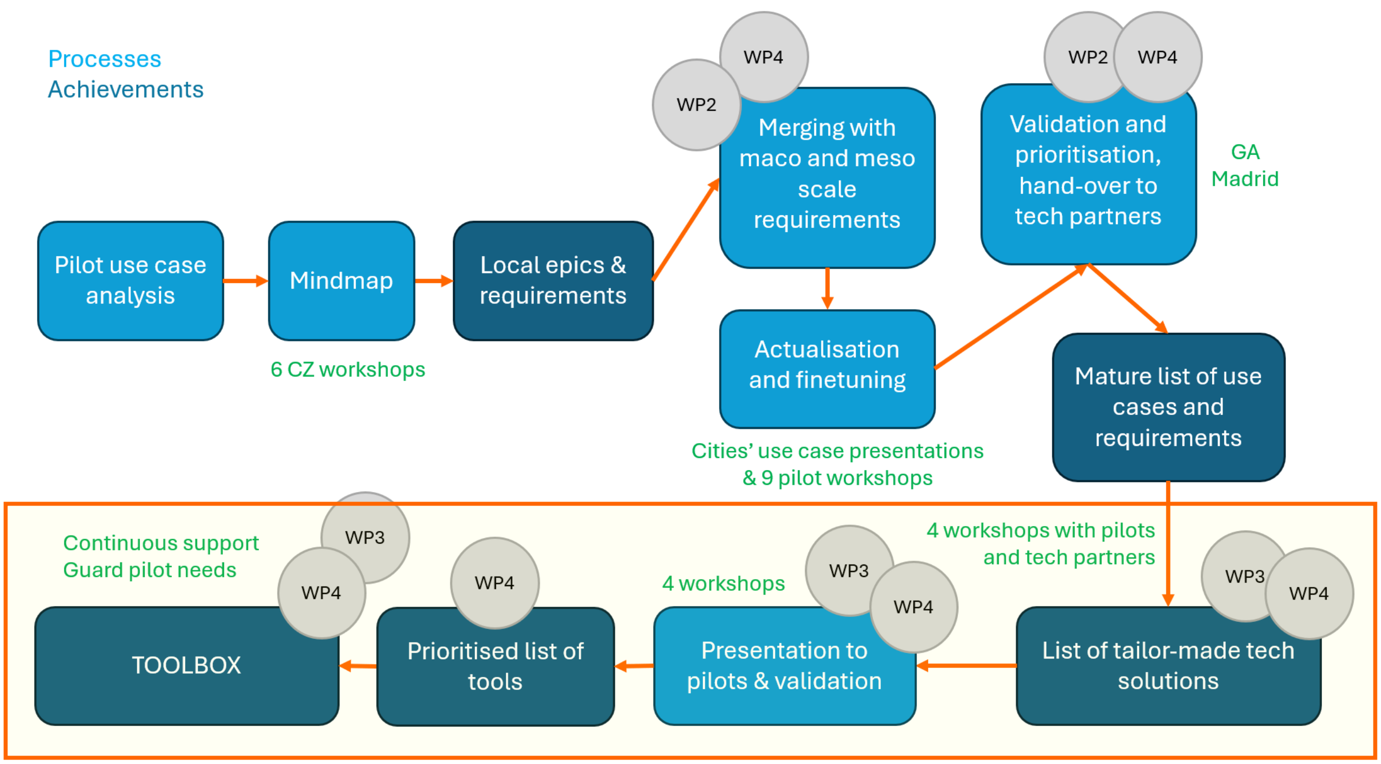
With this preparatory phase completed, WP3 and WP4 launched the actual development of the tools in the first half of 2025 that form the URBREATH Toolbox.

A selection of tools and simulation models was first demonstrated in their early form in May 2025 during the GA in Cluj-Napoca and later documented in a more advanced form at the end of Month 18 as part of technical Deliverables.

*In early July 2025, Tasks 5.2 and 5.4 jointly developed a **six-step approach** to deploy the tools to the pilot cities (see Chapter 5.5.1 for details).*

The current reporting period builds on this established foundation, providing updates on progress made since these earlier milestones.

Figure 11: Schematic overview of the WP5 achievements in the processes of mapping pilot cities' functional needs and the subsequent translation to technical solutions in preparation for the Toolbox development. The process of translating the pilots' functional needs into technical solutions within the URBREATH toolbox is highlighted in the orange box.



4.2 Facilitating and boosting technical development processes

Task 5.2 continues playing a pivotal role in facilitating the translation of pilot-specific functional needs into actionable technical developments across Work Packages 3 and 4 (WP3-WP4). Task 5.2 remains actively involved at multiple stages of the process, supporting the technical teams to ensure that the co-development of tools and simulation models stays firmly aligned with the contextual realities, priorities, and requirements of each pilot city.

To start, Tools were grouped by purpose. Each of the **four tool groups** requires its own tailored approach and involves a different combination of consortium partners. Moreover, the tool groups correspond to distinct stages in the URBREATH project, reflecting the stepwise progression from design to implementation and monitoring.

1. **Tools supporting the LLL process**
   These tools assist the Local Living Labs throughout the co-creative and participatory design phases of NBSs—particularly during the *empathise* (define, understand) and *solution* (ideate, co-create) stages, as illustrated in Figure 4. Some of these tools are also used during the *deployment* phase. For example, citizen science approaches can help gather data that will later feed into the *monitoring and evaluation* of NBS performances.
   Examples:
   - *E-participation tool* enabling LLLs to communicate, engage participants, and share information & documentation.
   - *Local Digital Twins* supporting scenario exploration with immersive visualisation capabilities.
   - *Citizen science supporting tools.* Such as biodiversity-monitoring tools, where biodiversity data can be collected in the field by citizens participating in an LLL.

2. **Tools and models supporting decision-making**
   LLLs contribute to the evaluation and selection of NBSs, but tools and simulation models provide an objective complement. They help assess ideas, guide decision-making with evidence-based insights, and support pilot cities in prioritising and implementing NBSs.
   Examples:
   - *Climate simulations* helping identify suitable species (e.g., Mediterranean trees resilient to future temperature scenarios).
   - *Flooding and heat-stress* analyses informing decisions on measures such as wadis or desealing.
   - *Infrastructure maps* showing cables and pipes to support safe and efficient installation of NBSs.

3. **Tools supporting NBS monitoring**
   URBREATH systematically monitors the effects of NBSs. The Toolbox plays a central role here, grounded in a set of 64 KPIs across eight categories, developed under Task 5.6 along with the associated evaluation methodology.

Examples:

- *Qualitative analyses* via e-participation tools (e.g., surveys for citizen feedback on perceived NBS impacts).
- *Quantitative analyses* using predictive models combined with visualisation, interpretation tools, and monitoring dashboards.

4. **General, overarching, and supporting tools**
These tools provide cross-cutting support to pilot cities, facilitating access to data, improving coordination, and ensuring coherence across the Toolbox.
Examples:
   - *Data and model catalogues* that centralise, organise, and disseminate datasets and models across regions.
   - *An NBS registry map* enabling pilot cities to find comparable NBS examples and share their own.
   - *A unified user interface* bringing all Toolbox components together into a coherent, user-friendly environment.

4.2.1. Active engagement in WPs 3-4 activities and meetings

Task 5.2 made a significant contribution to translating pilot city requirements into operational technical developments by actively participating in WPs 3-4 coordination meetings and related activities. This work included:

- Representing and safeguarding the functional interests of the pilot cities, ensuring that their specific requirements were accurately communicated and consistently integrated into the technical development process.

- Chairing, participating and contributing to events such as the *review meeting* (September 2025) and the *demo Café* during the General Assembly in Tallinn (October 2025), showcasing the actual state of the tools and simulation models.

- Providing WPs 3-4 technical teams with a dedicated space during the monthly Cities Call to demonstrate new tool features, share progress updates, discuss challenges, present alternative solutions, and request feedback. Task 5.2 takes the lead in planning and organising these contributions.

4.2.1.1 Active participation in bi-weekly WPs 3-4 meetings

Task 5.2 participates in the bi-weekly WPs 3-4 meetings, where it plays an active role by:

- Providing targeted feedback on the development progress of tools and simulation models, ensuring that the concerns, needs, and expectations of the pilot cities—as well as the broader project objectives—are accurately reflected. This feedback is gathered through both the overarching Cities Calls and direct bilateral contacts.

- Encouraging enhancements in user-friendliness, applicability, and interactivity to increase the likelihood that the pilot cities will adopt and effectively use the developed tools.
- Task 5.2 helps Task 5.3 by supporting the development of tools that will be used within the LLLs, and contributes to Task 5.4 by helping shape approaches for bringing tools and simulation models to the pilot cities and encouraging their adoption, customisation, and local uptake. In addition, Task 5.2 provided input to Tasks 5.5 and 5.6 on dashboard development needs and on KPI integration and follow-up.

4.2.1.2 Active support of learning-by-doing sessions

For each tool, learning-by-doing sessions are organised by the technical partners for all pilot cities that express interest, coordinated by **Task 5.4**. These sessions are designed to let pilot cities actively explore the tool or simulation model themselves. When necessary, user accounts are created, and a guiding scenario with basic tasks is provided to help demonstrate the tool's added value in a hands-on manner. This approach enables pilot cities to understand the tool's functionality better while also giving technical teams practical insights into potential improvements to enhance usability and interactivity.

Task 5.2 participates in these sessions to facilitate communication, ensure mutual understanding, and support the interaction between pilot cities and technical partners. More information on the Task 5.4 approach is provided in Chapter 5.

4.2.1.3 Active WP3-4 support in review and General Assembly meetings

Through its participation in bi-weekly WP3–WP4 meetings, a series of dedicated coordination sessions, and multiple rehearsal moments, Task 5.2 actively supported several aspects of tool development and demonstration activities.

- **Review meeting preparation and support**

  Task 5.2 contributed to the preparation of the review event by helping to define and structure the content, align contributions across work packages, design the sequence and timing of presentations, and support the organisation of live demonstrations. The goal was to ensure a coherent narrative, avoid overlap between work packages, and present the WP5 approach as a source of inspiration.

  Key preparation moments included the WP3–WP4 meeting of August 29th, the WP-lead call of September 2nd, the written instructions sent out on September 12th, the finalisation of the guiding PowerPoint on September 16th, the general rehearsal with pilots and WP leads of 24 September 24th, the review meeting itself on September 25th, and the follow-up evaluation meetings held on September 30th and October 3rd.

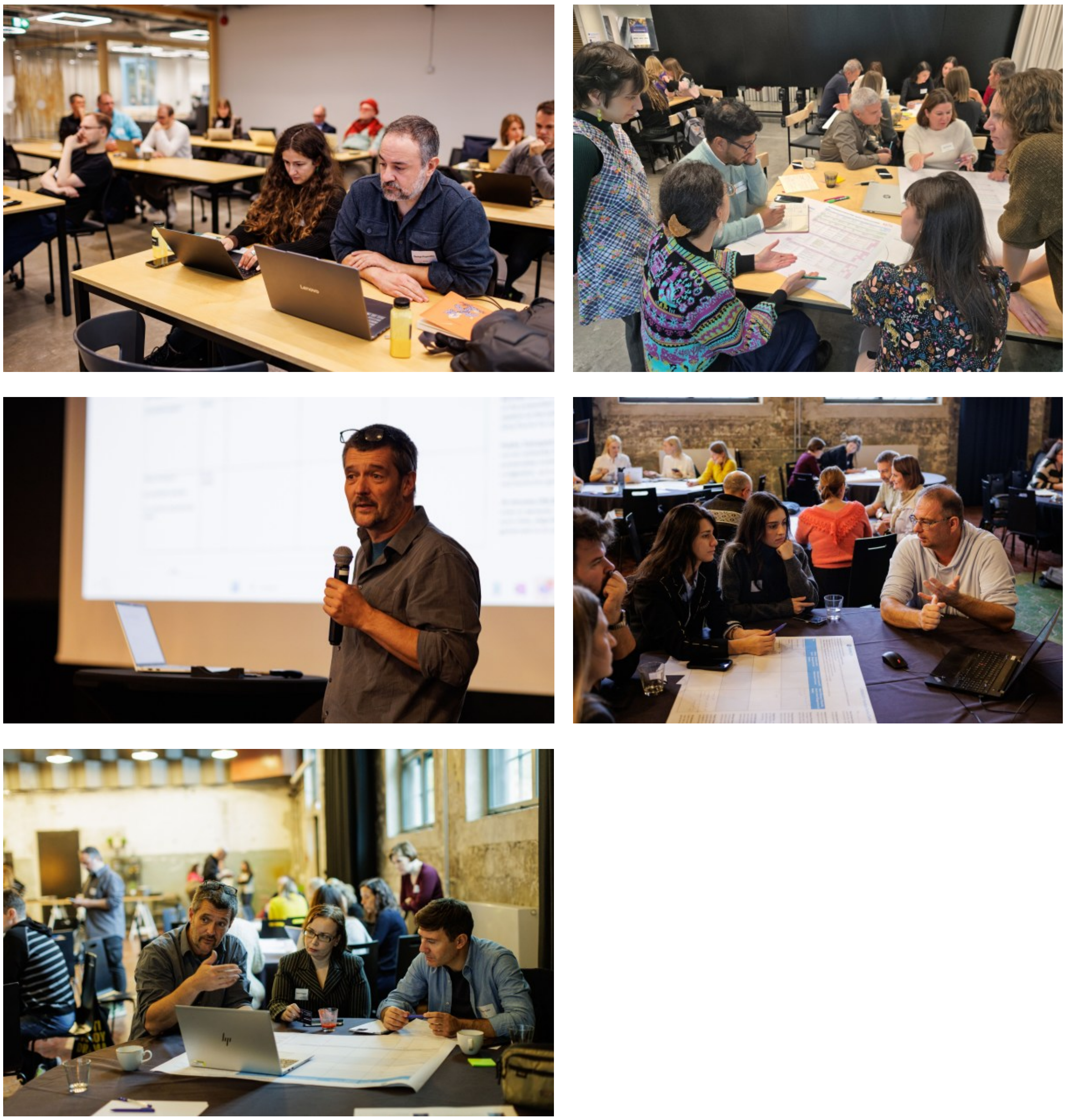
- **General Assembly (October 15th and 16th)**

  At the General Assembly, Task 5.2 played an active and coordinating role:

  - Participating in the technical session with all technical partners.

- Conceptualising, preparing (October 7th, 8th and 10th), chairing, and coordinating the **Demo Café** in close collaboration with WP3-4 and the Lisbon Council. Task 5.2 also demonstrated several tools—such as the geocacher, data/model catalogues, and KPI manager (developed by Engineering)—to the pilot cities.

Figure 12: Task 5.2 contributions to the GA in Tallinn. Pictures taken during the technical WP3-4 meeting, the four workshops organised by Tasks 5.3, 5.4, 5.5 and 5.6, and the WP3-4 Demo Café.



4.2.1.4 Active support of Task 5.4

Task 5.2 actively supports Task 5.4 in customising tools and identifying opportunities for their local use, implementation, and integration.

- **Joint adoption strategy**
  Starting in July 2025, Task 5.2 and Task 5.4 jointly developed a **six-step roadmap** to guide the adoption of tools within the pilot cities. This approach includes structured documentation and learning-by-doing training sessions led by the technical teams. Task 5.2 helps disseminate the roadmap and monitors progress through City Calls, Project Management Calls, WP5 meetings, and WP3–WP4 coordination sessions. *See also Chapter 5.5.1*.

- **Continuous alignment**
  Task 5.2 maintains regular contact with the Task 5.4 lead to synchronise ideas, suggestions, and proposed interventions, ensuring a coordinated approach.

- **Active participation**
  Task 5.2 also takes part in the bi-weekly Task 5.4 meetings organised by the task lead, contributing to discussions on tool customisation and pathways for local adoption.

4.2.2. WP5 engagement in pilot support and linking pilots and developers

4.2.2.1 Connecting pilots and tech partners in the Cities Calls and facilitating discussions

The idea of organising dedicated *Cities Calls* emerged organically and was further developed by WP5 together with the pilot cities, who jointly defined the format and focus. Within the context of tool and simulation model development, Task 5.2 uses these calls to bring pilots and technical teams together, encouraging them to exchange ideas, raise concerns, ask questions, and discuss progress.

- **A platform for technical partners** to present new developments, highlight challenges, or request feedback on tools and simulation models.

- **A space for pilot cities** to update the group on the status of their use cases and to express specific needs or desired improvements.

- **An opportunity for other WPs** to introduce pilot-related topics, ensuring that tool development and adoption are viewed in a broader project perspective.

- **Organisational support from Task 5.2**, which prepares agendas, sends invitations, structures the content, and facilitates or moderates the discussions.

Since many core elements of the City Calls fall under Task 5.3, a full account of activities for this reporting period is provided in **Deliverable 5.6**.

4.2.2.2 Active pilot support in review and GA meetings

- For the **review meeting**, Task 5.2 took on the role of coordinator for the pilots, reporting on the progress of their use cases at the levels of NBS progression, LLL activities, tool use, and planned steps.

  In order to tell a coherent story, a general PowerPoint template was developed and fine-tuned. The pilots were instructed to prepare a 5-minute presentation for the review meeting based on their presentations. Their input was timed and adjusted where needed during the first rehearsal during a Cities Call organised by Task 5.2 (September 19th, 2025), and finally during the rehearsal (September 24th, 2025), the day before the review meeting on September 25th, 2025.

- Concerning the **GA meeting in Tallinn**, Task 5.2 contributed to the pilot-oriented Task 5.3 workshop on how LLLs and supporting tools can be used to collect citizen-generated data for KPI evaluation as part of citizen science activities. And in the organisation and chairing of the Task 5.4, 5.5, and 6.6 workshops with all pilot cities, where they learned to make flyover movies in their LDTs, create concrete dashboards, and follow up on KPI monitoring.

4.2.3 Provision of technical and methodological support

Task 5.2 additionally assisted the technical teams by implementing organised approaches to project and workflow management, with particular emphasis on the following methods:

- In the preceding Deliverable 5.1, we described how Task 5.2 supported technical teams by introducing structured project and workflow management mechanisms, notably through the setup and implementation of a **JIRA-based project management platform**. This included collaborative JIRA training workshops, the development of technical tasks as JIRA stories, and the establishment of a comprehensive registry of JIRA accounts for all technical partners. The platform was configured for sprint planning, customised workflows, and ticketing to support agile project management across WP5.

  Due to recent changes, we have decided to discontinue support for JIRA implementation. This decision was made because WP4 has adopted a project management approach that does not use agile methodologies. Instead, WP4 will rely on alternative tools and processes that better fit its operational needs. As a result, JIRA is no longer compatible with WP4's way of working, and it will not be used to monitor development activities in the future.

  This decision ensures that our project management tools remain consistent with the working methods of all involved work packages, supporting effective collaboration and avoiding unnecessary complexity.

- **Contributing to UI and UX design processes**

  Task 5.2 collaborated with technical partners to ensure end-user needs were reflected in the development of intuitive mock-ups and functional prototypes. This included structuring the URBREATH Toolbox landing page (in cooperation with partner ATC) and developing UI/UX approaches for simulations (with partners ATC and VCS).

- Sharing our WP5 **General Data Protection Regulation (GDPR) related expertise** in the context of setting up test environments, including the implementation of GDPR-compliant test accounts and the formulation of appropriate legal disclaimers for the Toolbox landing page. These activities were carried out in close collaboration with partners DBC Diadikasia, ENG, and TEL to ensure full adherence to data protection regulations and ethical standards.

5. Results Task 5.4 - Gap analyses, customisation and local implementation support

This section outlines the essential groundwork undertaken in Task 5.4 to establish the digital infrastructure, analyse data availability, customise LDTs, and provide capacity building necessary for integrating the URBREATH technical solutions across the pilot cities. The foundational effort began in the second half of 2024 by assessing the existing data landscape against future simulation needs. This resulted in the development of a centralised, dynamic Data Inventory Framework in February 2025, which defines the required datasets, Application Programming Interfaces (APIs), data streams, modelling infrastructure for technical solutions and KPI monitoring. The project integrated standardised datasets, including the 3-30-300 rule, the Urban Heat Island (UHI) Assessment, the Walkability/15 min city index, and long-term Climate forecasts, across multiple LDTs. However, local adoption varied by specific needs.

Despite these standardisation efforts, the analysis consistently identified significant data gaps across the pilot cities, including a persistent lack of necessary data, challenges in accessing data from partners or government sources, and difficulties related to data fragmentation, rigid administrative processes, and formatting issues. These persistent gaps directly impact the feasibility of KPI monitoring and simulation modelling. The LDT implementation, which relies on Virtual City (VC) Map to ingest and render heterogeneous datasets using standards such as *3D Tiles, Web Map Service (WMS), Web Feature Service (WFS), GeoJSON*, and *Cloud Optimised GeoTIFF (COG) layers*, highlighted the highly varied nature of municipal data infrastructure. For instance, Madrid uses 29 COG raster layers for high-resolution climate analysis, while Aarhus relies primarily on 14 WMS layers focused on hydrogeological data.

The core LDT framework, built on VC Map leveraging *CesiumJS* and *OpenLayers*, provides a hybrid approach for 3D global visualisation and 2D local Geographic Information System (GIS) precision across all nine LDTs. Custom implementation focused particularly on Nature-Based Solutions (NBS) planning through a suite of specialised tools. Key tools include *VC Planner*, which facilitates planning tasks and the virtual planting of 26 tree species; Shadow analysis, which simulates shadow coverage vital for KPI CR-KPI10 (Increase Shaded areas); Growing Trees, which simulates linear tree growth and Carbon Dioxide (CO_2) sequestration, linking to KPI BIO-KPI7 (Increase share of NBS area covered by tree canopy); and Small-scale BAF calculation, which computes the Biotope Area Factor relevant to KPI BIO-KPI2.

While pilot cities already employ sophisticated tools such as ArcGIS and AutoCAD, the URBREATH Toolbox is designed as a modular suite that adheres to Minimal Interoperability Mechanisms (MIMs) and MIM+ guidelines to ensure flexibility and interoperability. Tool adoption analysis revealed that Data Visualisations and Dashboards received the highest level of interest, marked in green for all nine cities. High demand was also noted for the KPI Manager (eight cities) and the NBS Registry (eight cities). However, advanced simulation tools, such as Growing Trees and Small-scale Biotope Area Factor (BAF), primarily attracted targeted interest from Leuven and Athens. Critical for localised use is the Dynamic Layer Tool, which enables users to flexibly add external geospatial data

(*WMS*, *GeoJSON*, *3D Tiles*) without configuration, dynamically enriching the map environment for tailored analysis.

Initial demonstrations integrated standardised Climate forecasts and Urban Heat Islands Assessment into the LDTs, allowing visualisation using time sliders for temporal analysis. Real-time monitoring capability is provided via plugins such as *OpenAQ*, which integrates air quality data (e.g., Particulate matter (PM) 2.5 in Plzeň), and *Telraam*, which integrates multimodal traffic segment data, offering contextual insights directly within the LDT environment. To ensure effective use, Task 5.4 prioritised comprehensive capacity building, delivering structured training via *GoTo webinars*, an open learning platform, and a series of personalised one-on-one workshops. By the end of June 2025, a total of 119 training sessions had been completed across the nine pilot cities, with Madrid, Leuven, and Parma receiving the most significant investment, ensuring the digital tools are meaningfully embedded within the local urban planning and governance contexts.

5.1 Analysis of data across pilot cities

The analysis of data across pilot cities within the URBREATH project, primarily managed under Task 5.4 (Gap analyses and local implementation support), involved a structured approach to identify available datasets, pinpoint gaps, and ensure the necessary data were harmonised to feed the LDTs and KPI calculations.

5.1.1 Methodology and data inventory

The foundational work began in the second half of 2024 by assessing the existing data landscape against the defined future needs for simulation models and tool applications.

- **Data Inventory Framework**: A centralised data inventory framework was developed in February 2025 and is maintained as a dynamic, continuously updated living document.
- **Purpose**: This inventory defines the required datasets, APIs, data streams, and modelling infrastructure necessary for technical solutions targeting prioritised use cases and KPI monitoring.
- **Addressing Gaps**: When required datasets were unavailable locally, Task 5.4 explored alternative solutions, such as leveraging satellite imagery or proxy data with lower granularity, to ensure analytical continuity. The inventory was revised accordingly whenever new tools or functionalities were integrated.
- **Data Categories**: The relevant data categories addressed in the analysis include sensor-derived data, geospatial and environmental datasets (like GIS layers), sociological and participatory datasets, urban infrastructure and activity data specifically required for KPI definition, calibration, and monitoring.

5.1.2 Standardised datasets integrated across cities

The project generated several standardised datasets intended for integration across multiple LDTs, although adoption varied according to local needs and interests:

Table 2: Standardised datasets integrated across cities.

Dataset / Tool	Integrated Cities	Purpose
3-30-300 rule / index	Leuven, Madrid, Tallinn, Cluj-Napoca	Strategic guidelines for assessing urban greenery, accessibility, and environmental resilience. The model serves as a framework to assess urban green infrastructure at multiple spatial scales (individual, neighbourhood, and city-wide).
Urban Heat Islands (UHI) Assessment	Leuven, Madrid, Tallinn, Cluj-Napoca	Identifies and quantifies areas with significantly higher surface temperatures using satellite-derived Land Surface Temperature (LST) data, expressed as a severity index. Since these relate to selected months and years, they can be visualised with a time slider in the LDT.
Walkability / 15 min city index	Leuven, Aarhus, Parma, Athens, Cluj-Napoca, Plzeň	Evaluates the accessibility of essential services (e.g., groceries, healthcare, parks) within walking or cycling distance, aligning with the "15-minute city" concept. Results are presented using a hexagonal grid classified into proximity zones (e.g., 15-minute zone, 30-minute zone).
Climate forecasts (long term)	Leuven, Madrid, Tallinn, Cluj-Napoca	Provides projections on key environmental variables, such as mean annual temperature, across three time periods (historical, mid-century, and end-of-century) under different socio-economic and emission scenarios (SSPs).

5.1.3 Local Digital Twin data profiles and formats

The implementation of each LDT relies on VC Map, a hybrid web-based mapping solution using *CesiumJS* and *OpenLayers*, designed for the ingestion, processing, and rendering of heterogeneous urban datasets using standards such as *3D Tiles, WMS, WFS, GeoJSON*, and *COG layers*.

- **Madrid (FRC)**: Emphasises raster data, using 29 *COG Layers* for high-resolution analysis of climate and heat vulnerability, including multiple entries for UHIs and annual heatwave risk maps (2021-2023). It is complemented by vector layers (*GeoJSON* and *VectorTile/FlatGeobuf*) for built areas and planning context.
- **Leuven (FRC)**: Integrates multiple formats to support climate and hydrological studies. It uses *GeoJSON* layers for different water infiltration scenarios (spring, summer storm, winter rain) and COG Raster Layers for monthly UHI intensity derived from Sentinel-2 imagery.

- **Tallinn (FRC)**: Uses a rich combination of *COG, GeoJSON*, and *WMS layers*. The datasets focus heavily on environmental monitoring, including layers for the 3-30-300 rule, temporal heat island data (2023-2024), and an extensive set of *WMS layers* providing highly granular noise mapping (segmented by source, such as highway, railway, industry, and flight paths) and flood hazard information.
- **Cluj-Napoca (FRC)**: Features an extensive range of *VectorTile* layers covering demographics (population distribution/projection), infrastructure (roads, railways, metro, bike routes), environmental data (forest gain/loss, land cover), and specialised geographical indicators (Mai index, network analysis). It also includes *GeoJSON* isochrones for walking times to essential services.
- **Plzeň (FLC)**: Integrates several WMS layers that serve as the backbone for monitoring critical utility infrastructure, including wastewater, drinking water, telecommunication networks, district heating, and power supply. These are combined with *GeoJSON* layers for green areas and sensor data (*OpenAQ* for air quality).
- **Aarhus (FLC)**: Primarily relies on 14 WMS layers focused on hydrogeological data, such as groundwater monitoring, drilling locations, and water supply/quality assurance.
- **Athens & Parma (FLCs)**: Data profiles emphasise vector formats (*GeoJSON* and *VectorTile*) focused on mobility and accessibility metrics, including the walkability index and delineated NBS sites and districts.
- **Kajaani (FLC)**: Data emphasises cold climate urban management, including *GeoJSON* and *VectorTile* layers identifying potential snow pile deposit locations and detailed road networks.

5.1.4 Challenges and gaps in data collection

Despite ongoing efforts, the analysis consistently identified significant data gaps across the pilot cities:

- **Lack of data**: There is a persistent lack of data across multiple pilot cities, which directly impacts the feasibility and functionality of the KPI framework and monitoring dashboards.
- **Access issues**: Accessing necessary data, even from local technical partners or central government sources, proved challenging for pilots.
- **Quality and formatting**: Data integration was often complicated by issues related to data fragmentation, rigid administrative processes, and difficulties in data formatting and structuring.
- **Impact on KPIs**: The data gaps highlighted during assessments directly relate to missing inputs needed for KPI monitoring, simulation modelling, and tool development. The urgency of resolving these gaps was reiterated at project events, such as the General Assembly in Cluj-Napoca.

The continuous effort involves targeted one-to-one consultations and cross-city coordination meetings to validate dataset availability, resolve formatting issues, and advance localisation strategies tailored to each pilot context.

The analysis of data across pilot cities shows that while standardised analytical tools provide a unifying layer (like the 3-30-300 index), the reality of local infrastructure requires integrating a rich and highly varied mix of data formats—from Madrid's reliance on COG raster layers for climate analysis to Aarhus's use of WMS layers for hydrogeology—highlighting the bespoke nature of each digital twin implementation despite persistent challenges with data fragmentation and availability.

5.2 Analysis of local infrastructure and custom implementation of tools

The core of the Local Digital Twin (LDT) framework is built upon VC Map. This hybrid web-based mapping solution uses *CesiumJS* and *OpenLayers* to manage the disparate requirements of 3D global visualisation and 2D local GIS precision. This robust, standard-compliant approach ensures the ingestion, processing, and rendering of heterogeneous urban datasets. The foundation of each LDT comprises geospatial and infrastructure data, represented as 3D Tiles or Building Information Modelling (BIM) derived models, forming the digital canvas for buildings, terrain, and infrastructure. Roads, parks, and underground networks can be visualised as extruded geometries or vector tiles, enabling user interactions such as showing utility corridors beneath the surface. For example, underground analysis of the below-ground infrastructure has been conducted at Leuven's LDT. Critical infrastructure for cities, such as wastewater, drinking water, telecommunication networks, district heating, and power supply, is often represented through WMS layers for service-based infrastructure monitoring, as seen in the Plzeň LDT.

The LDT Viewer offers a suite of advanced analysis tools that collectively enhance spatial understanding and planning capabilities. These tools, which go beyond traditional measurement and drawing functionalities, are available across all nine LDTs, ensuring consistent access to analysis capabilities regardless of the specific city.

Custom implementation of tools is focused on NBSs planning and the URBREATH initiative. Key specialised tools include:

- **VC Planner**: This tool is the starting point for several analyses, enabling users to structure planning tasks, integrate GIS layers and BIM models, and manage object libraries. It facilitates the virtual planting of new trees, with a selection of 26 different tree species available in various age classes.
- **Shadow Analysis**: This tool simulates sunlight movement and calculates shadow coverage at user-defined intervals (e.g., every 15, 30, or 60 minutes). It is vital for assessing the impact of planned measures, such as new trees, on shading levels and temperature changes. The outcome of this tool relates to the KPI CR-KPI10 (Increase Shaded areas).
- **Growing Trees**: This plugin simulates the linear growth of urban trees over a user-defined number of years, producing detailed outputs on canopy coverage, oxygen production, CO_2 sequestration, and biomass. The results can be used for comparative analysis between the "now" state and a projected "in 5 years" state. This tool relates to the KPI BIO-KPI7 (Increase share of NBS area covered by tree canopy).

- **Small-scale BAF calculation**: This plugin computes the BAF, which measures the proportion of ecologically effective surfaces relative to total land area. This tool is relevant to the KPI BIO-KPI2.
- **Dynamic Layer Tool**: This critical tool allows pilots to flexibly add and manage external geospatial data layers, supporting formats like *WMS, WFS, GeoJSON*, and *3D Tiles* without requiring prior configuration. This allows pilots to incorporate external datasets not statically integrated into the viewer, dynamically enriching the map environment for tailored and context-specific analysis.

In addition to NBS-specific tools, the LDTs integrate sensor readings for real-time monitoring: the *Telraam* plugin integrates multi-modal traffic segment data, colour-coding road segments by car counts per hour and provides dynamic information on cars, bikes, heavy vehicles, and speed. The *OpenAQ* plugin integrates air quality measurement data, offering visualisation and contextual insights for parameters such as PM2.5 in cities like Plzeň. These sensor integrations illustrate the LDT's role as an interactive environment that merges static infrastructure models with the city's dynamic, living pulse.

The analysis of local infrastructure and the custom implementation of tools within the LDTs reveals a foundational strategy built on leveraging existing municipal digital maturity while enhancing capabilities through a modular, custom-tailored framework. Prior to URBREATH integration, pilot cities were already utilising sophisticated GIS tools such as *ArcGIS, AutoCAD,* and *Revit* for spatial analysis and design. Cities like Madrid and Tallinn maintain public Geoportals (e.g., *Spatial Data Infrastructure of the Madrid City Council (IDEAM), Tallinn Planning Registry*) and leverage Representational State Transfer (REST) APIs for data access, signalling strong existing infrastructure. Data exchange often relies on standardised geospatial formats *(Shapefile (SHP), GeoJSON, Geography Markup Language (GML))* and open web services (*WMS, WFS*).

The URBREATH Toolbox is introduced as a modular suite of digital services designed for flexibility and interoperability with this varied infrastructure. It is currently deployed in a centralised, cloud-based environment for testing and co-evaluation, with cities accessing components via shared development platforms, as local deployment into municipal IT systems is yet to be implemented.

Custom Implementation and tool adaptation are primarily centred on the LDT environment, which is customised for each pilot city and serves as a central access point for data visualisation and planning. The LDT embeds several analytical components that assist in NBS planning:

- **Static Baseline Data**: Layers such as UHI zones, BAF calculations, 3-30-300 indicators, 15-minute city index, and climate projection areas are preloaded and visualised as static data to assess current environmental conditions and prioritise NBS areas.
- **The Planner Tool**: allows users to make spatial and visual interventions within their area of interest, upload 2D and 3D data formats, and explore scenarios, effectively linking planning input to analytical baseline data.

Cities expressed interest in integrating specialised analytical modules tailored to local needs, including Heat Stress Analysis, Shadow Analysis, Water Infiltration Model, and Optimal Locations to Deposit Snow for seasonal management. These custom tools are linked directly to KPIs; for example, the Virtual City Systems (VCS) Growing Trees tool contributes to BIO-KPI7 (Share of total area covered by tree canopy), integrating analysis directly into the evaluation framework.

To ensure seamless integration and futureproofing, URBREATH promotes data harmonisation using open standards and web services (WMS, WFS, Next Generation Service Interface (NGSI)-LD). The tools are designed to follow the MIMs and MIM+ (version 8.0) guidelines, ensuring compatibility, data exchange, and vendor-neutral deployment. However, the sources note that local adoption faces barriers, including data fragmentation, rigid administrative processes, and the need for additional capacity building and training for sustained use.

The following overview details the interest level of the nine pilot cities (Leuven (LEU), Aarhus (AAR), Tallinn (TAL), Kajaani (KAJ), Cluj-Napoca (CLU), Plzeň (PIL), Madrid (MAD), Parma (PAR), and Athens (ATH) in the URBREATH tools. Green cells indicate interest in the tool, while red cells indicate no interest.

5.2.1 Cities' interest matrix for Digital Twin & environmental simulation tools

This group includes core planning tools and specialised analytical plugins, many of which have already been implemented or have produced results so far and are generally KPI relevant.

Table 3: Tools interest matrix by all URBREATH pilot cities for data analysis & processing.

Tool name	LEU	AAR	TAL	KAJ	CLU	PIL	MAD	PAR	ATH
15 minutes city (proximity index)	green	green	red	red	green	green	red	green	green
3-30-300 Analysis	green	green	green	green	green	green	red	green	red
Adaptive Rainfall-Infiltration Tracking (Water infiltration model)	red	red	red	red	green	red	red	red	red
Biotope Area Factor	green	red	red	red	green	red	red	green	red
Climate forecasts (long term)	red	green	red	red	green	green	green	green	red
Climate tools	red	green	red	red	green	red	green	red	red
crime statistics	red	red	red	red	red	red	red	red	red
green gentrification/property prices	red	red	red	red	red	red	red	red	red
Growing Trees	green	green	red	green	green	green	red	green	red
Heat Stress Analysis	red	green	red	green	green	red	green	green	red
Liveability index	red	green	red	red	red	red	red	red	red
Nature Value Explorer	red	red	red	red	red	red	red	red	red
Optimal locations to deposit snow	red	red	green	green	red	red	red	red	red
Public Transport Accessibility Analysis	red	green	red	red	red	red	red	red	red

Seasonal forecasts (1-6 months)									
Sensors / FROST sever or similar									
Shadow plugin									
Short term weather forecasts (0-15 days)									
Small scale BAF (Biotope Area Factor)									
snow pile sim									
Urban Heat Island									
Water Discharge and Flooding prediction model (under design)									

5.2.2 Cities' interest matrix for data management, data visualisation, and e-participation tools

This group includes tools focused on data management, KPI tracking, and citizen engagement.

Table 4: Tool interest of URBREATH pilot cities for data management, data visualisation, and e-participation tools.

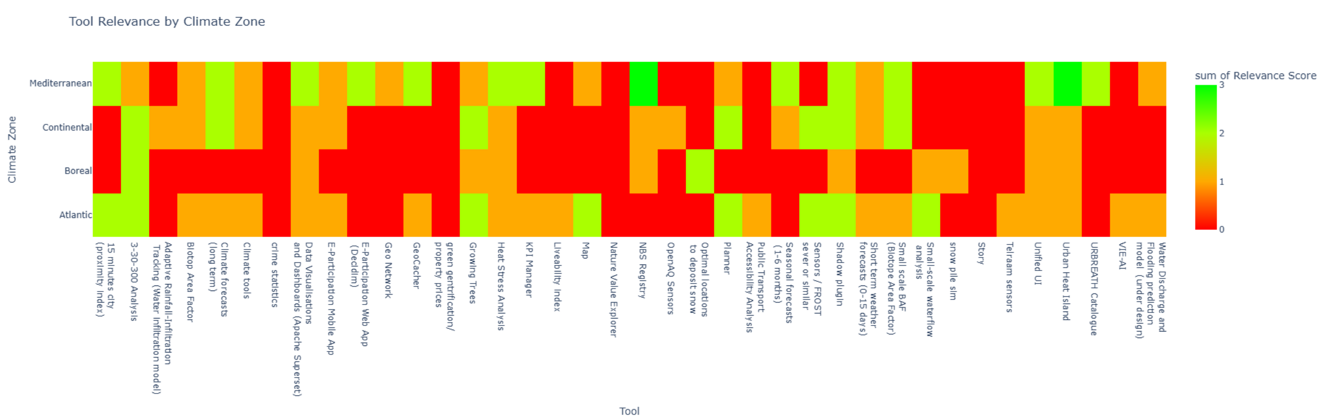
Tool name	LEU	AAR	TALL	KAJ	CLUJ	PIL	MAD	PAR	ATH
Unified UI									
GeoCacher									
VIE-AI									
Data Visualisations and Dashboards (Apache Superset)									
Map									
OpenAQ Sensors									
Planner									
Small-scale waterflow analysis									
Story									
Telraam sensors									
E-Participation Web App (Decidim)									
E-Participation Mobile App									
Geo Network									
URBREATH Catalogue									
KPI Manager									
NBS Registry									

5.2.3 Key results on tool interest by the pilot cities

Across all cities, Data Analysis and Processing overwhelmingly dominate tool usage, accounting for approximately 72% of total interactions, followed by City Data Visualisation at around 18%. In comparison, e-Participation and NBS Planning together account for less than 10%. This confirms that analytical capabilities form the backbone of URBREATH's architecture, with visualisation acting as the primary interface for operationalising insights.

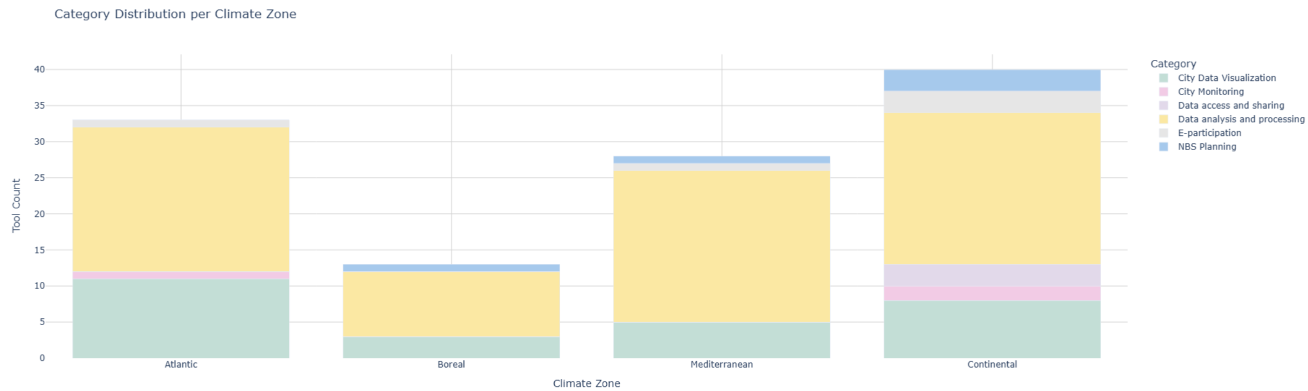
When broken down by climate zone (compare Figure 13 and Figure 14), the Atlantic zone (Leuven and Aarhus) registers about 33% of total tool usage, with Data Analysis and Processing contributing nearly 70% of that share. Boreal cities (Tallinn and Kajaani) account for 13%, where water infiltration models and snow management tools dominate, reflecting adaptation to precipitation and freeze-thaw cycles. Continental cities (Cluj-Napoca and Pilsen) account for 28%, with a strong emphasis on heat stress analysis and urban heat island modelling, which together account for more than 60% of their analytical workload. Mediterranean cities (Madrid, Parma, Athens) lead with 40% of total usage, heavily skewed toward climate forecasting and NBS registries, which collectively exceed 65% of their zone-specific activity.

Figure 13: Tool relevance overview, sorted by climatic zone.



Trend analysis reveals that Mediterranean cities are the most tool-intensive, likely due to their vulnerability to heat and drought. In contrast, Boreal cities show the lowest engagement, suggesting a narrower but highly specialised toolset.

Figure 14: Tool categories by climate zones.



Visualisation tools such as dashboards, planners, and sensor-based platforms consistently appear across all zones. Still, their proportional share remains secondary to analytical tools, reinforcing the URBREATH principle that data-driven insights precede participatory and planning layers.

For contextual linkage, these insights align directly with the URBREATH Tools Catalogue, where categories such as Data Analysis and Processing, City Data Visualisation, and e-Participation are structured as modular components of the architecture. The dominance of analytical tools across zones validates the catalogue's emphasis on environmental intelligence. At the same time, the presence of visualisation and participatory platforms ensures that technical outputs translate into actionable governance and citizen engagement.

5.2.4 Recommendations

Moving forward, Task 5.4, together with WP3 & 4, will focus on encouraging broader adoption of tools that currently show moderate uptake—such as 15-Minute City Index and Climate Forecasts—as these could play an essential role in strengthening climate adaptation strategies.

It will also be beneficial to explore the possibility of promoting the standardisation (if available) of core tools, including Unified UI and VCS plugins, across all participating cities. This step could support interoperability and ensure a more consistent user experience throughout the network.

In addition, Task 5.4, together with WPs 3-4, will consider identifying opportunities to enhance categories that appear less represented, particularly Security and Process Orchestration. Strengthening these areas may contribute to improved governance and operational resilience. Finally, fostering the broader use of e-Participation tools could be an essential task for the future, as these tools may help increase citizen involvement in planning and decision-making processes, thereby supporting more inclusive and collaborative urban development.

5.2.5 Future Tasks

- Assess climate-specific needs to ensure tools like Heat Stress Analysis and UHI Assessment are fully leveraged in Mediterranean and Atlantic cities. In contrast, Boreal cities may benefit from enhanced deployment of Sensors and Climate Forecasts.
- Promote cross-zone knowledge exchange, enabling cities to share best practices for adapting tools to local conditions.
- Develop tailored tool bundles aligned with climate characteristics, supporting coherent and efficient implementation strategies.
- Monitor adoption gaps and provide technical support to cities for integrating underused tools that may offer climate resilience benefits.

5.3 Initial demonstrations and local integration plans of Toolbox tools

The LDT Viewer within the Virtual City Map platform incorporates several key tools and datasets to enable initial demonstrations and localised integration for Nature-Based Solutions. The LDT Viewer within the Virtual City Map platform incorporates several key tools and datasets to enable initial demonstrations and localised integration for NBS planning. This framework is built on a robust, standard-compliant approach using VC Map, which is designed for the ingestion and rendering of heterogeneous urban datasets.

The Dynamic Layer Tool (see D4.2 Chapter 2.2.1) is a critical component for local integration, enabling users to flexibly add and manage external geospatial data layers without requiring prior configuration. This tool supports a wide range of formats, including OGC standards like *WMS, Web Map Tile Service (WMTS), WFS*, as well as *3D Tiles, GeoJSON*, and Cesium Language (CZML). The tool supports dynamic enrichment of the map environment, enabling more tailored and context-specific analysis, even when certain data layers are not available by default. The tool is structured with a Catalogues Tab that provides access to preconfigured data catalogues *(e.g., Piveau, GeoNetwork, Integrated Data Registry and Access (IDRA))* and is relevant for pilots as it supports integration with the NBS registry. The tool also lists all added layers, allowing users to view metadata, adjust parameters like opacity and style, and remove layers.

Climate Information is integrated into the LDTs through both standardised URBREATH-created datasets and specific visualisation tools. Climate forecasts (see D4.2 Chapter 2.1.1.4) are essential for understanding how key environmental variables may evolve under different socio-economic and emission scenarios. These forecasts, based on CMIP6 simulations and Shared Socioeconomic Pathways (SSPs), focus on projected changes in mean annual temperature across three time periods: the historical reference period (1985-2014), mid-century (2036-2065), and end-of-century (2071-2100). The results are available on their own webpage, showing boxplots for each variable and SSP, and are also integrated directly into the LDT viewer for cities like Leuven, Madrid, Tallinn, and Cluj-Napoca, as demonstrated by the integrated climate projection shown in Tallinn's LDT. Additionally, the UHI Assessment (see D4.2 Chapter 2.1.1.2), which uses satellite-derived LST data to identify and quantify areas with significantly higher surface temperatures, is integrated into the LDTs for several cities (Leuven, Madrid, Tallinn, Cluj-Napoca). Since these datasets relate to specific months and years, they can be visualised alongside a time slider in the LDT (e.g., Figure 18), making it easy for the user to select another period and view the corresponding dataset.

Dashboard Integration and real-time monitoring are achieved via several plugins that integrate live data streams. The *OpenAQ* plugin (see D4.2 Chapter 2.2.3) integrates air quality measurement data into the LDT application. This plugin offers users an interactive way to discover and visualise recent pollution observations directly on the map. When clicking an air quality point, a compact information panel appears, identifying the location and the type of measurement (e.g., PM2.5), and displaying a simple chart of recent readings. This integration model facilitates staying within the map environment without consulting external sources and supports rapid comparison between different locations, as demonstrated in the Plzeň LDT with PM2.5 readings. Similarly, the *Telraam* sensor readings plugin (see D4.2 Chapter 2.2.2) integrates multi-modal traffic segment data into the LDT, colour-coding road segments by car counts per hour using a graduated legend. The *Telraam* plugin registers a custom declarative style and provides a Feature Information view that presents dynamic, context-aware inspection of traffic modes (cars, bikes, heavy vehicles, pedestrians, speed). These real-time data integrations support analysis and decision-making for mobility planning and environmental monitoring.

5.4 Customisation of the Local Digital Twin

The customisation of LDTs is achieved through a tailored integration of city-owned and URBREATH-generated datasets, combined with the flexible implementation of advanced analytical tools, all built upon the VC Map hybrid mapping solution. The primary customisation goal is to adapt the 3D model to each FRC and report on its use by LLLs to compare the simulated effects of NBS measures in participatory scenarios.

5.4.1 Data-driven customisation

Each LDT is customised by integrating diverse geospatial and infrastructure data, forming the digital canvas for buildings, terrain, and infrastructure. This involves leveraging a robust, standard-compliant framework for the ingestion, processing, and rendering of heterogeneous urban datasets. The data foundation relies on three main components:

- **Standardised datasets created for URBREATH**: These datasets provide crucial comparative and analytical context and are integrated into the LDTs based on city interest and relevance. Examples include the 3-30-300 rule/index (integrated into Leuven, Madrid, Tallinn, and Cluj-Napoca LDTs, see Figure 15 as example), the UHI Assessment (integrated into the LDTs of Leuven, Madrid, Tallinn, Cluj-Napoca, and others), and Climate forecasts focusing on mean annual temperature projections (integrated into Leuven, Madrid, Tallinn, and Cluj-Napoca LDTs). Additionally, the 15-minute city index is integrated into the LDTs of Leuven, Aarhus, Parma, Athens, Cluj-Napoca, and Plzeň (see Figure 16 as an example). These analytical datasets are often visualised using features such as time sliders to select specific periods, thereby enhancing temporal analysis.

Figure 15: Tallinn's Local Digital Twin - 3-30-300 rule map.

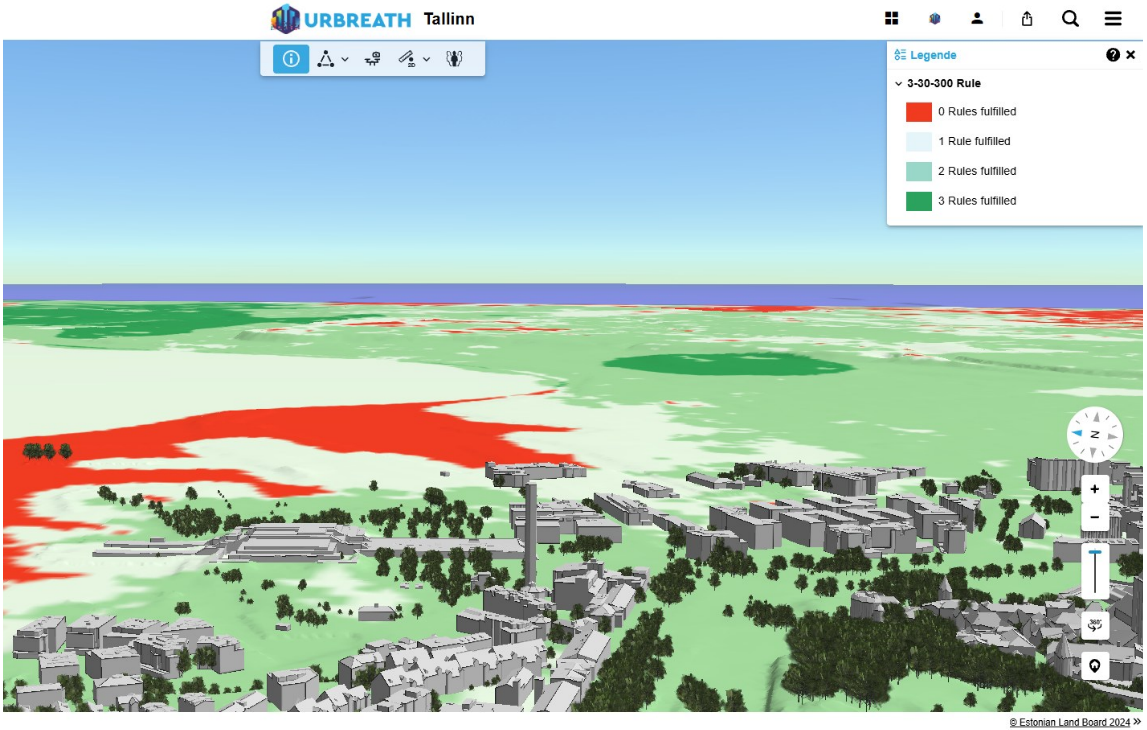
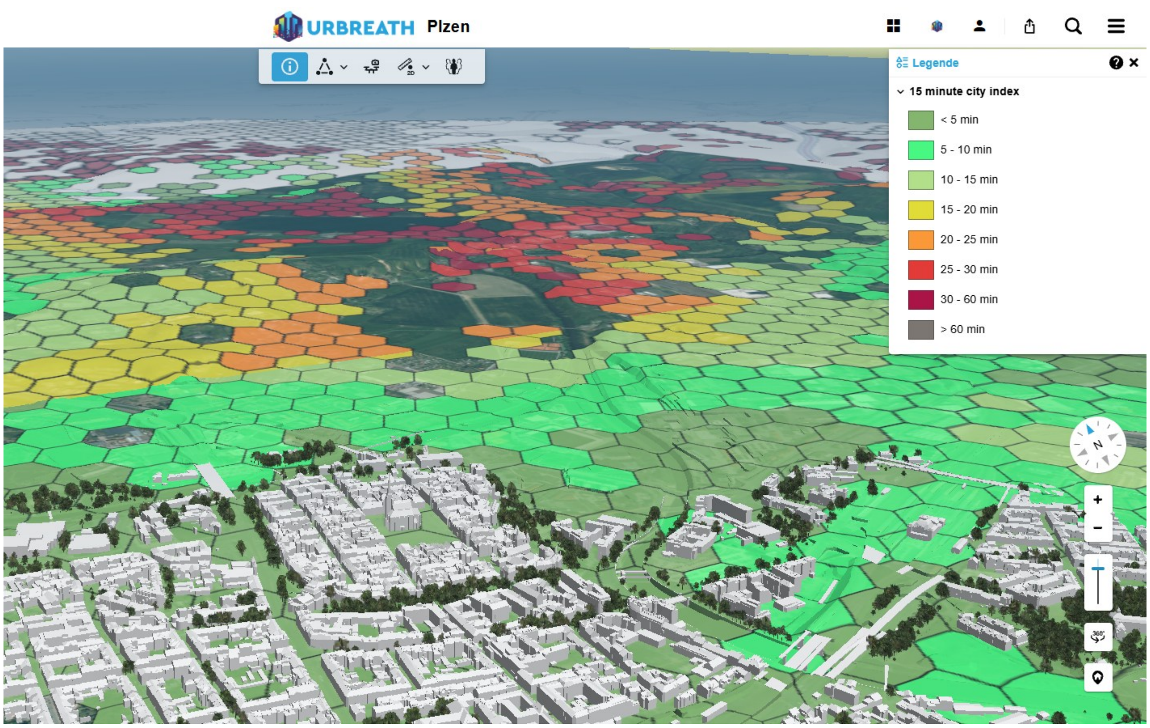
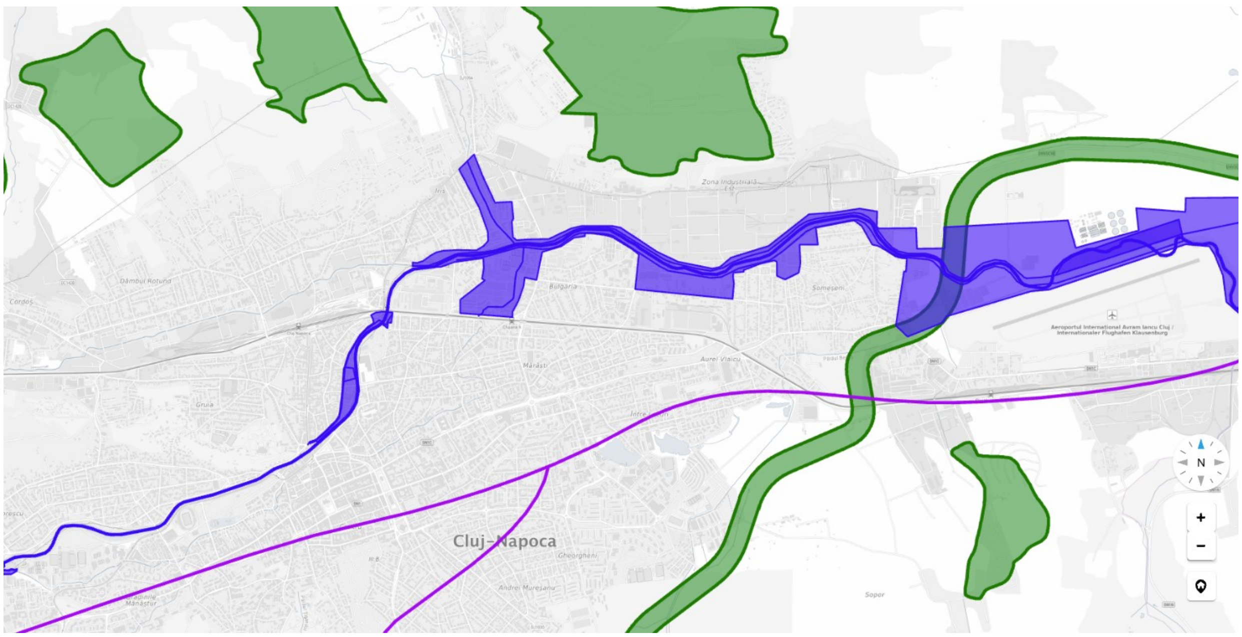


Figure 16: Plzen's Local Digital Twin - 15-minute city index for entertainment map.



- **City-owned datasets**: These datasets are pivotal in shaping local planning and are integrated into the LDT viewer to provide specific contextual information (see Figure 17). These layers often span themes such as land use, traffic, noise pollution, and utilities. The integration allows decision-makers to visually intersect policy layers (like zoning regulations) with environmental or demographic data. The format of this data dictates accessibility, with common standards including *GeoTIFF, GeoJSON, WMS*, and *WFS services*.

Figure 17: Cluj-Napoca - major cycling routes (purple), green proposals (green) and Somes river corridor (blue) in the Local Digital Twin.



- Data Format Profiles (Examples): The actual mix of formats is tailored to local priorities. Madrid emphasises Cloud Optimised GeoTIFF (COG Layers, see Figure 18 as an example) for high-resolution raster analysis, using 29 *COG Layers* for annual heatwave risk and urban heat island observations. Aarhus focuses heavily on 14 WMS layers to support hydrogeological studies, monitoring groundwater and water supply. Cluj-Napoca utilises extensive *VectorTile* layers for demographics, infrastructure, and land cover, alongside *GeoJSON* for detailed walking-time isochrones. Plzeň integrates multiple WMS layers specifically for monitoring critical utility infrastructure (see Figure 19), including wastewater, drinking water, and power supply.

Figure 18: Madrid - heat wave risk provided as time-dependent datasets (2021- 2023).

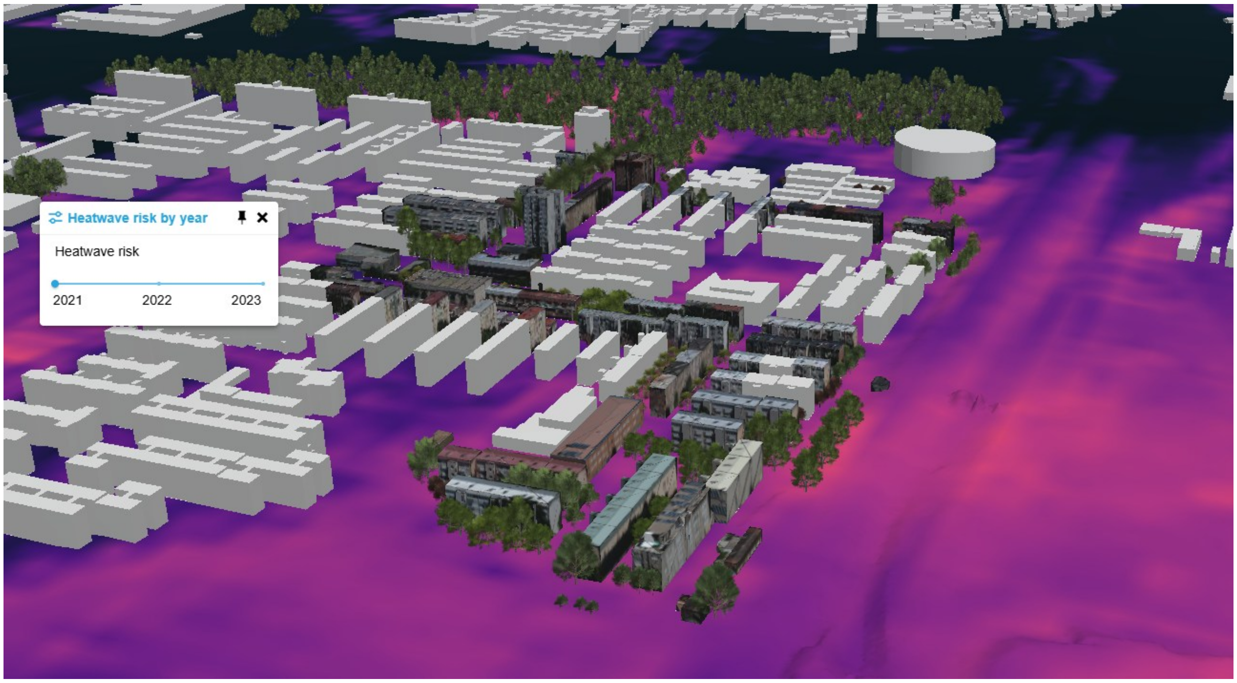


Figure 19: Leuven Local Digital Twin - 3D underground infrastructures.

- **Customisation by improving data:** For some cities (Leuven, Madrid), some improvement tests were done, trying to visually enhance the appearance of the provided 3D city model, at least for the NBS site.

For Leuven, a manual texturisation approach was performed using hand-made photos. The texturisation was performed in Blender using the CityGML LOD2 data (generated by VCS BREC, Pointcloud data, and building footprints). Since the manual texturisation approach is very time-consuming, only the front sides of the buildings were textured. A more automated or semi-automated texturing approach failed due to missing or poorly accessible data (such as oblique imagery covering the entire NBS site). The results of the manual texturing approach are shown in Figure 20.

Figure 20: Result of manual texturisation of buildings in Leuven.

For the city of Madrid, some free downloadable oblique images were used to texturise the NBS buildings. Since no photogrammetrically relevant data could be obtained for each image, the images must be georeferenced manually by setting more than 8 pass points per image (4 images per wind direction). The result shows that more images need to be downloaded and georeferenced to achieve a better visual result (see Figure 21).

Figure 21: Textured buildings at Madrid’s Nature-Based Solution intervention site.

During the GA meeting in Tallinn (October 2025), VCS suggested to the pilots that they take photos of the front of each building on their NBS sites for a manual texturisation approach.

5.4.2 Customisation based on tools

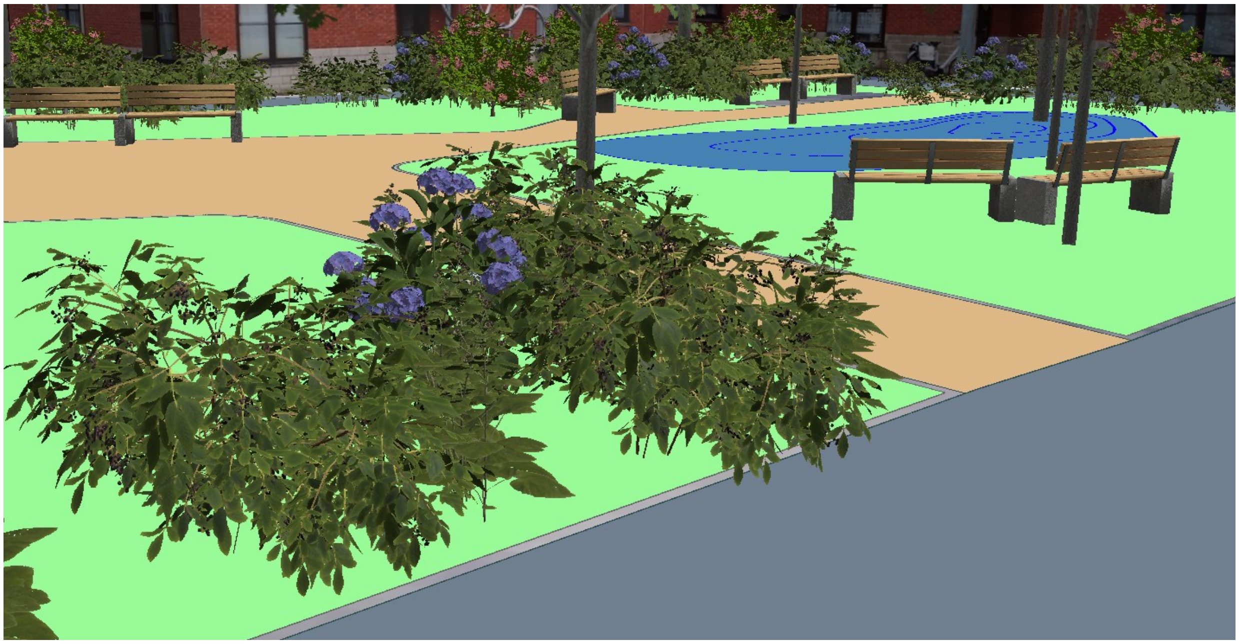
While several fundamental tools (e.g., Drawing tool, Measurement tool, Line-of-Sight analysis) are available across all nine LDTs, customisation primarily occurs through the integration of specialised analysis plugins and real-time data connectors to support NBS planning:

- **VC Planner**: This serves as the starting point for NBS scenario creation, enabling users to manage planning tasks, integrate spatial datasets, and access object libraries, such as the NBS catalogue. With the Planner, pilots can virtually plant new trees (selecting from 26 species in various age classes), import 2D and 3D CAD drawings and define surfaces for BAF calculations.

Figure 22: Leuven - 3D Nature-Based Solution planning using the VC Planner and 3D underground infrastructure.

To better support the NBS planning, three object libraries for the VC Planner were created. Such libraries allow users to draw BAF areas using the NBS object library, plant new trees and calculate tree canopy growth using the NBS tree library, and finally add visual scene content like bicycles, persons, flowers, etc., using the landscape library.

Figure 23: Visually enhanced Nature-Based Solution planning in Leuven's Local Digital twin - using the VC Planner landscape library.



- **NBS Analysis Plugins**: Three core NBS tools are integrated into the LDT framework: the Shadow Analysis tool simulates sunlight movement and calculates shadow coverage to assess shading impact; the Growing Trees plugin simulates linear tree growth over time, producing outputs like canopy coverage and CO_2 sequestration, which can then be used to perform follow-up shadow analyses for projected future states; and the Small-scale BAF Calculation plugin computes the Biotope Area Factor to measure ecologically effective surfaces.

Figure 24: Result of baseline analysis (Tree Canopy) for the Nature-Based Solution area in Leuven.

Tabelle der durchnschnittlichen Baumhöhen

Baumart	Variante	Anzahl	durchschnttl. Höhe [m]
Acer_platanoides	middle	47	12.20
Acer_platanoides	young	11	6.72

Tabelle der berechneten Kronenflächen

Baumart	Variante	Anzahl	Kronenfläche [m²]
Acer_platanoides	middle	47	3066.98
Acer_platanoides	young	11	176.51

Gesamtanzahl Bäume: 58

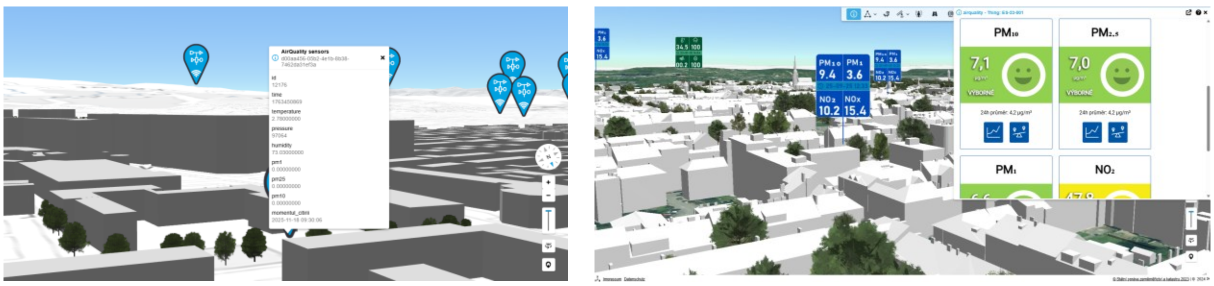
Kronenfläche [m²]: 5.029,18 m²

Gesamte Fläche [m²]: 11.574,93 [m²]

Kronenflächenanteil [%]: 43,45 %

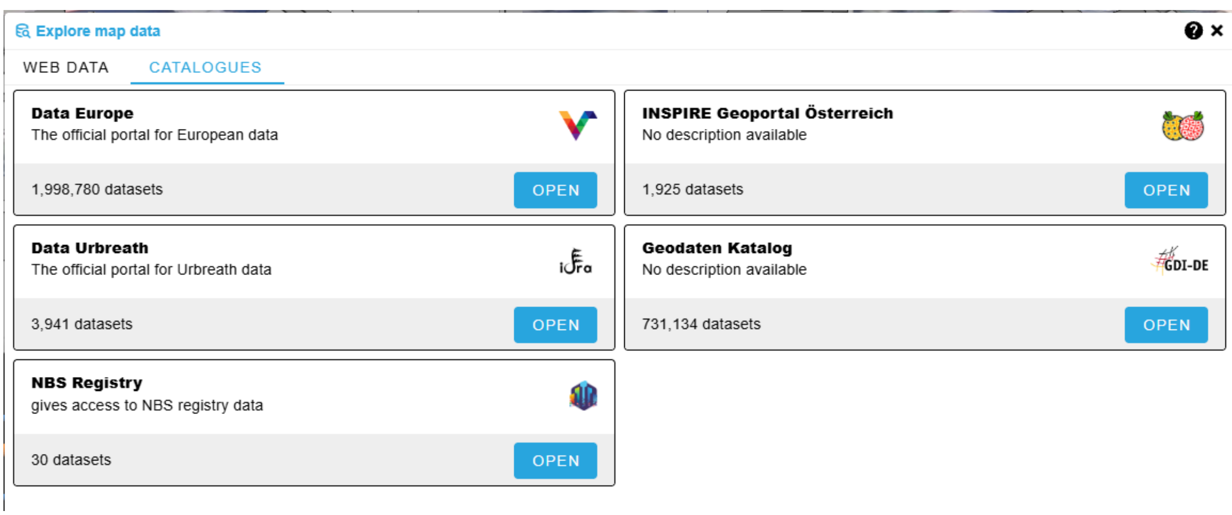
- **Dynamic Data and Sensor Integration**: The Dynamic Layer Tool provides a critical customisation mechanism, allowing pilots to flexibly add and manage external geospatial data layers via Uniform Resource Locators (URLs) or preconfigured catalogues (including the NBS registry), enabling dynamic enrichment for tailored analysis. Furthermore, specific plugins integrate real-time data streams, such as the *Telraam* plugin for multi-modal traffic data (demonstrated in Leuven), and the *OpenAQ* plugin for visualising air quality measurements directly on the map (demonstrated in Plzeň and Cluj-Napoca).

Figure 25: Air quality sensor visualisation in Cluj-Napoca (left) and air quality and weather stations readings in Plzen (right).



Using the Dynamic layer plugin and customised access to IDRA (URBREATH data catalogue) as well as the access to URBREATH NBS registry, datasets produced by URBREATH tools, as well as URBREATH NBS cases, can be visualised in each LDT.

Figure 26: Available catalogues in the Dynamic Layer plugin of the Local Digital Twin viewer, at least the Data Europe, Data URBREATH and Nature-Based Solution Registry are relevant for pilots.



5.5 Capacity building and customisation through training and technical support

The provision of structured training and capacity-building activities is an essential component of the local implementation of URBREATH digital tools, primarily driven by Task 5.4. This effort involves organising a series of targeted learning-by-doing training sessions and fostering a decentralised learning environment designed to empower both technical partners and the pilot cities. To facilitate knowledge transfer, multiple *GoTo webinars* were organised, and an open training platform was established, allowing technical partners, city representatives, and their associated LLLs to initiate and host webinars autonomously for continuous learning, see below the 6-step plan.

5.5.1 The six-step plan for tool deployment in pilot projects

Table 5: The six-step plan for tool deployment in the URBREATH project.

Step	Description	Next Step
1. Update data inventory	Expand data inventory with relevant tools and models; attach documentation; designate contact persons; incorporate feedback.	↓
2. Clustering of tools and simulation models	Systematically group tools and simulation models to streamline management and deployment.	↓
3. Add documentation & contact information	Provide comprehensive documentation and contact information for each tool/model, including draft and simplified versions.	↓
4. Present approach & assign homework to tech partners	Outline methodology during PM call; assign tasks to technical partners for completion before the next Cities Call.	↓
5. Homework for pilot cities	Pilot cities complete assigned homework to support deployment and customisation.	↓
6. Organise 1:1 testing and learning-by-doing trainings	Conduct personalised one-on-one workshops and training sessions for hands-on support and technical skill development.	**End**

This flowchart illustrates the sequential process for deploying URBREATH digital tools in pilot projects, ensuring comprehensive preparation, knowledge transfer, and capacity building.

1. **Update the data inventory**
   The first step involves expanding the data inventory by including all relevant tools and simulation models. Any existing documentation should be attached, and efforts made to complete any missing sections. Additionally, a contact person should be designated for each pilot project. Feedback from pilot cities must be collected and systematically incorporated into the inventory to ensure continuous improvement and relevance.

2. **Clustering of tools and simulation models**
   Tools and simulation models are to be systematically grouped as part of the activities under Task 5.2 and Task 5.4. This clustering facilitates more effective management and deployment of resources within the pilot projects.

3. **Add documentation and contact information**
   Comprehensive documentation and relevant contact information should be provided for every tool and simulation model. This includes submitting both a draft version and a simplified version of the Deliverable 4.7 WP4, as prepared by Task 5.4 and WP4. This step ensures that all stakeholders have access to the necessary supporting materials.

4. **Present approach and assign Tasks to technical partners**
   The implementation methodology should be outlined during the Project Management (PM) call. Technical partners are expected to complete their assigned tasks before the next scheduled Cities Call, set for September 25th, 2025. This structured approach ensures accountability and maintains project momentum.

5. **Homework for pilot cities**
   Pilot cities are required to update their interests by reviewing the provided documentation ahead of the September 25th, 2025, Cities Call. They should also review, add, replace, or remove tools as appropriate to ensure alignment with local requirements and project goals.

6. **Organise one-to-one testing and learning-by-doing training sessions**
   Where necessary, test accounts should be set up to allow pilot cities to gain practical experience with the tools. These hands-on sessions are supported by technical teams, who provide ongoing guidance and support. Participant feedback is to be collected using evaluation forms. Collaborative meetings are held to group tools, and related tables are updated with workshop dates and colour codes for tracking purposes. Once tools evolve and improve trainings need to be repeated to showcase the capabilities to pilots.

5.5.2 Structural training activities

Following the still ongoing 6 step plan (Step 6 is an iterative step showing the improvements of tools), several structured training activities have been conducted, including an external webinar on the Virtual City BREC platform (for simplified generation of *CityGML* datasets) and a dedicated training session on the use of the VCS Storytelling Tool.

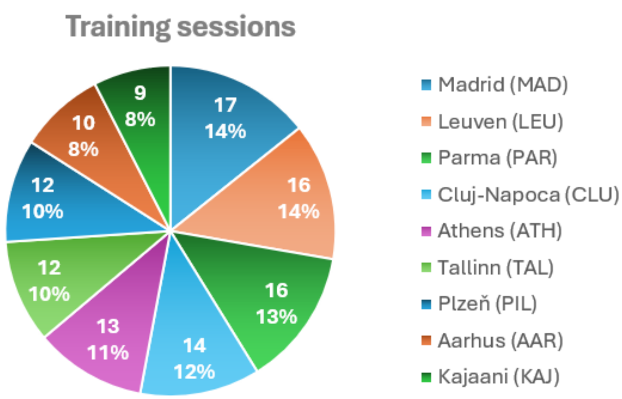
A series of three URBREATH **webinars** covered the Virtual City Map platform overview, the application of the Virtual City Planner for the design and simulation of NBSs within the LDT environment, and the procedures for dynamically adding and managing spatial data layers. The LDT expert training extended to specific tool demonstrations, with training scheduled for the VCS Shadow plugin and VCS Growing Trees tools in June and July 2025, and the VCS Small-scale BAF tool also in mid-2025.

Additionally, at the General Assembly in Tallinn (October 2025), VCS organised a workshop where pilots learned step-by-step to make **fly-over movies** in their LDTs to be used in LLL settings to present NBS scenarios in an immersive setting. Moreover, the training was used to showcase customisation of LDT's by plantings and peoples as well.

Figure 27: Local Digital Twin workshop organised by VCS in Tallinn to create immersive fly-over movies.

In addition to group formats, Task 5.4 launched a series of one-on-one workshops with pilot cities to provide hands-on support for LDT functionalities. These personalised sessions involved end users sharing their screen while performing the full procedure under expert supervision. For example, one two-hour workshop involved training an end user to import external *AutoCad* files, develop an NBS ground plan including different tree species, apply the tree planting and growth simulator, generate shaded area simulation reports, and use the BAF tool for simulation and reporting, along with creating high-quality flyovers for dissemination. Furthermore, Task 5.4 conducted personalised one-to-one technical consultations to configure and refine the LDTs and adapt storytelling elements to reflect local objectives. All webinar recordings were made publicly accessible to ensure open knowledge dissemination.

Figure 28: Tools training sessions done between June 2025 and November 2025.



Quantitatively, the data inventory confirms that a total of 119 trainings has been completed across the nine pilot cities by the end of June 2025. This involved significant investment in cities such as Madrid (17 trainings), Leuven (16 trainings), and Parma (16 trainings), as well as Cluj-Napoca (14 trainings) and Athens (13 trainings). These combined group and tailored training activities ensure that the digital tools are effectively implemented and meaningfully embedded within the local urban and governance contexts of each URBREATH pilot city.

6. Results Tasks 5.5 and 5.6

6.1 Monitoring and evaluation framework planning under Tasks 5.5 and 5.6

In December 2024, a preliminary draft plan of approach for Task 5.6 was developed and subsequently discussed with the WP5 leads to establish a strategic framework for monitoring the implementation and performance of NBSs across the URBREATH pilot cities. Building on this foundation, Task 5.6 led to a refined and expanded approach, finalising a comprehensive work plan by mid-January 2025. This plan comprises four complementary subtasks, which will continue throughout the project's duration. Over the past six months (since Deliverable 5.1 in Month 18), these subtasks have been further refined in both scope and timeline (see below).

- **Subtask 1:** Development of a performance evaluation and impact assessment framework *(ongoing till M30)*
    - *M18 - M30:* Finalisation of the city's individual KPI sets (ongoing closure of remaining gaps resulting from the fact that not all NBS plans were available at that date).
    - *M20 - M22:* Development of monitoring protocols for collecting baseline.
    - *M20 - M22:* Development of individual city data management plans.
    - *M22 - M24:* Collection and harmonisation of baseline data.
    - *M24 - M30:* Development of a method for impact evaluation.
- **Subtask 2:** *Ex ante* impact simulations *(M24 - M30)*
    - *M22:* Conducting an impact workshop at the GA in Tallinn, where the pilot cities were asked to describe the impact they expect from implementing the NBS.
    - *M23:* Coordination of further steps with project coordination and relevant partners from WP5, WP4 and WP3.
- **Subtask 3:** Monitoring of NBS implementation *(M30 - M42)*
    - *M30:* Development of a precise procedure and timeline for monitoring data collection.
    - *M31 - M32:* Adaptation of monitoring protocols so that they go beyond the collection of baseline data.
    - *M38 - M42:* Data collection towards the end of the monitoring period to gather data after NBS implementation that can be compared with the baseline state.
- **Subtask 4:** *Ex post* performance evaluation *(M37 - M48)*
    - Evaluation of baseline and monitoring data to assess the impact of the NBS.

The results of subtasks 1 and 2 will be presented in Deliverable 5.11 *(Month 30)*. The results from subtasks 3 and 4 follow in Deliverable 5.12 *(Month 48).*

6.2 KPI maturation and validation: iterative coordination with pilot cities

In the previous phase of Task 5.6, the team developed and refined a comprehensive KPI framework for monitoring NBS implementation and performance across URBREATH pilot cities. The initial KPI compilation drew from diverse sources, including EU Horizon projects and international standards, and was enriched through bilateral consultations with pilot cities.

Following a formal briefing in early March 2025, the KPIs were organised into eight thematic categories:

1. Mobility
2. Biodiversity
3. Climate resilience
4. Environment and pollution
5. City quality and liveability (former liveability/social justice/equity)
6. Knowledge and awareness
7. Governance and participatory planning
8. Local Economy

City-specific draft KPI sets, based on the LLLs approach, were delivered by the end of March 2025. The validation process encountered delays because cities needed additional time to set targets. In response, Task 5.6 revised the engagement strategy in mid-May 2025, providing preliminary target value suggestions and enhancing bilateral support. Following reassessment at the Cluj-Napoca General Assembly (May 21st, 2025), the KPI validation deadline was extended to June 6th, 2025.

6.2.1 KPI finalisation and baseline data collection

As of the current reporting period, all KPIs have been selected and confirmed by the pilot cities. Only minor gaps remain regarding target values, primarily where final NBS designs are still under development. These gaps are being continuously addressed through ongoing close collaboration with the cities.

In Month 20, standardised monitoring protocols were developed to capture baseline state data. These protocols were strategically designed to integrate data management plan queries, thereby consolidating information gathering into a single process and minimising administrative burden on the pilot cities. This approach ensures cities are contacted only once rather than through multiple separate requests. Table 6 below presents an exemplary excerpt from the monitoring protocol structure.

Table 6: Excerpt from the monitoring protocol, Kajaani.

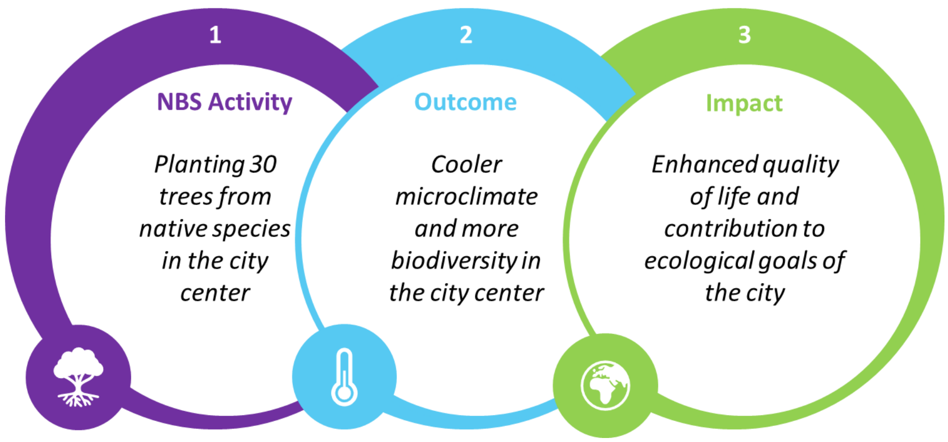
Kajaani-BIO-KPI2	
Target Trend	Increase
Metric	Total area freed from invasive plant species
Scale	NBS surrounding area
Calculation	Measurement
Unit	Square meters (m^2)
Target Value by end of 2027	100 m^2
Baseline Data Collection	
Baseline Value	0 m^2
Baseline Date	May 2025
Data Management	
Data Source	Citizen science
Digital Availability	☐ No ☒ Yes
	Data Format: XLS
Data Collection Method	A specific mobile application is used to measure the m^2 of invasive species eradicated.
Frequency of Data Collection	Annually
Data Storage	**Storage Location:** City of Kajaani, department of environmental technology
	Data retention period: End of 2028
Responsible for Data Collection	Horticulturist H.P.

The collected data and information are currently being reviewed until Month 24. The information will be systematically transferred into the comprehensive KPI master spreadsheet and harmonised to ensure consistency and comparability across all pilot cities. This harmonisation process will establish a robust foundation for subsequent monitoring phases and impact assessment activities.

6.2.2 Preparatory work for the ex ante impact simulations

To provide a basis for ex ante impact simulations Task 5.6 leads organised a dedicated impact workshop during the GA in Tallinn in October 2025. The workshop's primary objective was to collaboratively develop "Theories of Change[5]" for each pilot city's NBS. This methodological approach establishes explicit causal pathways linking NBS activities to expected outcomes and broader impacts. The Theory of Change framework follows a three-stage logic model:

Figure 29: Theory of Change model.



During the workshop, city representatives were grouped by pilot city and tasked with collaboratively completing Theory of Change templates for their respective impact categories. Participants were encouraged to align their Theories of Change with the previously established KPIs, though not required to develop a separate framework for each individual indicator. Instead, cities were asked to focus on the most significant and transformative NBS interventions.

To facilitate this process, supporting materials were provided, including exemplary Theories of Change and relevant information from the baseline monitoring templates. This exercise not only clarified the expected impact pathways but also enabled cities to articulate their strategic intentions and identify potential monitoring priorities for the upcoming implementation and evaluation phases.

[5] https://op.europa.eu/en/publication-detail/-/publication/d7d496b5-ad4e-11eb-9767-01aa75ed71a1

Figure 30: Task 5.6 workshop held at the General Assembly in Tallinn, October 2025.

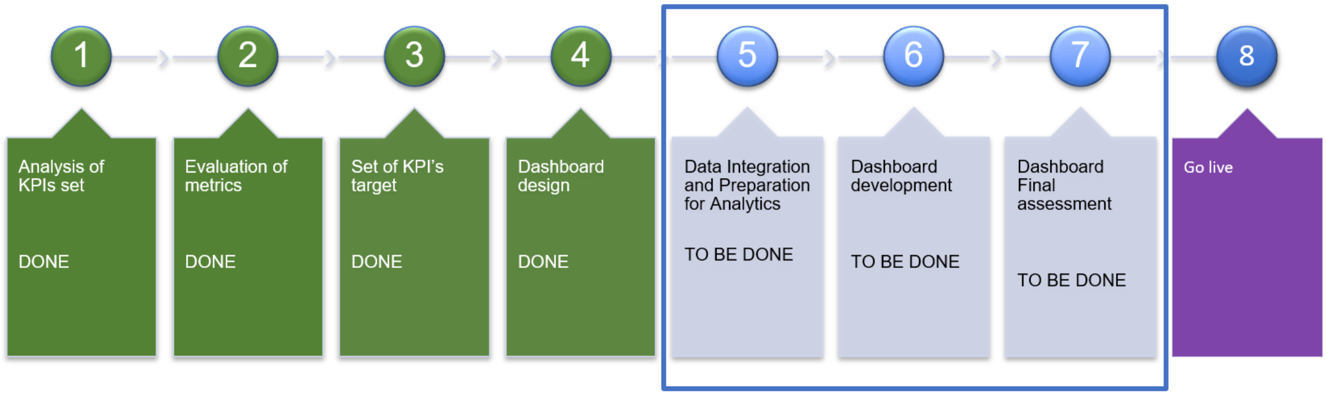
The further development of the ex ante impact simulations and the necessary consolidation of WP3 impact models will be coordinated in Month 23 with the relevant partners from WP5, WP4 and WP3.

6.3 Monitoring dashboards of Task 5.5.

The development of the monitoring dashboards under Task 5.5 has evolved through a structured multi-step process that is deeply interconnected with the KPI definition and validation work carried out in Task 5.6. Because dashboards serve as the primary tool for visualising NBS performance, trends, and impacts, their design has necessarily depended on consolidating the KPI set, defining related metrics, and assessing data availability across cities.

This interdependency resulted in a tightly coordinated workflow in which the advancement of Task 5.5 followed the progressive maturation of the KPIs. As illustrated in the ***dashboard development sequence***, the completion of steps 1-4 (analysis of KPI sets, evaluation of metrics, definition of KPI targets, and dashboard design) has been enabled largely by the contributions of Task 5.6. In the current reporting phase, the work of Task 5.5 is transitioning into steps 5-7, which relate to data integration, dashboard development, and assessment, while step 8 (go-live) is planned for a later stage.

Figure 31: The dashboard development workflow as defined by Task 5.5.



Phase 1 - Identification of digitally monitorable KPIs (DONE)

The first phase consisted of analysing the KPI set produced by Task 5.6 to determine which indicators could be monitored through existing digital data sources. This step was crucial in mapping:

- KPIs for which pilot cities already store relevant digital data (e.g., databases, sensors, GIS layers),
- KPIs requiring new monitoring methods,
- KPIs depending on the upcoming NBS implementation and therefore not yet measurable.

This mapping aligns directly with the dashboard development workflow of Figure 31, steps 1-3. It provided the foundation for selecting the subset of KPIs feasible for early dashboard implementation.

Phase 2 - Establishment of a structured dashboard development process (DONE)

Based on the available KPIs and their associated metrics, Task 5.5 developed the initial dashboard design framework (step 4 in the dashboard development workflow of Figure 31). This included:

- visualisation principles that ensure comparability across cities,
- hierarchical organisation of indicator categories,
- user-centric navigation aligned with Living Lab needs,
- preliminary integration pathways for simulation outputs from WP3.

This process also required close coordination with Task 5.4 to understand local ICT infrastructures and the feasibility of integrating the necessary data streams.

Phase 3 - Data Integration and Preparation for Analytics (ONGOING)

The core technical work of Task 5.5 begins in step 5 of the dashboard development workflow of Figure 31, which consists of building the data layer that will feed the dashboards. Based on the structures shown in the second slide, this phase includes four essential components:

1. **Data Sources** – Dashboards will aggregate information from internal city databases, sensor networks, external providers, and APIs. The quality and governance of these sources are critical to ensuring meaningful KPI reporting.
2. **Extraction and Transformation Process** – Before being used for analytics, data must be extracted, cleaned, validated, and standardised. This guarantees consistency across cities and enables reliable comparison and aggregation.
3. **Database Views & Modelling** – Structuring the data into optimised database views supports efficient queries, scalable performance, and accurate KPI calculations. This modelling step also ensures compatibility with simulation outputs generated in WP3.
4. **API Integration Strategy** – Secure and resilient API connections will enable automated or real-time data flows, particularly for KPIs connected to dynamic environmental or mobility indicators.

This technical architecture forms the backbone of the upcoming dashboard development.

Phase 4 - Dashboard development (ONGOING)

Following data preparation, Task 5.5 will proceed to the development phase (Step 6 of the dashboard development workflow, Figure 31).

The first dashboards will visualise:

- validated KPIs for which digital data is already available,
- baseline values collected through the monitoring protocols of Task 5.6,
- preliminary trends where historical data exists,
- placeholders for future ex-ante simulations (Task 5.6 Subtask 2) and ex-post evaluation outputs.

This phased implementation ensures that dashboards evolve as the project's data ecosystem matures.

Phase 5 - Dashboard assessment and refinement (TO BE DONE)

In step 7 of the dashboard development workflow (Figure 31), dashboards will undergo validation with pilot cities and Living Lab stakeholders. This phase will assess:

- usability and interpretability,
- suitability of visualisations for participatory decision-making,
- alignment with local governance needs,
- coherence with the KPI monitoring framework.

Feedback from this process will guide refinements before dashboards move to the go-live phase.

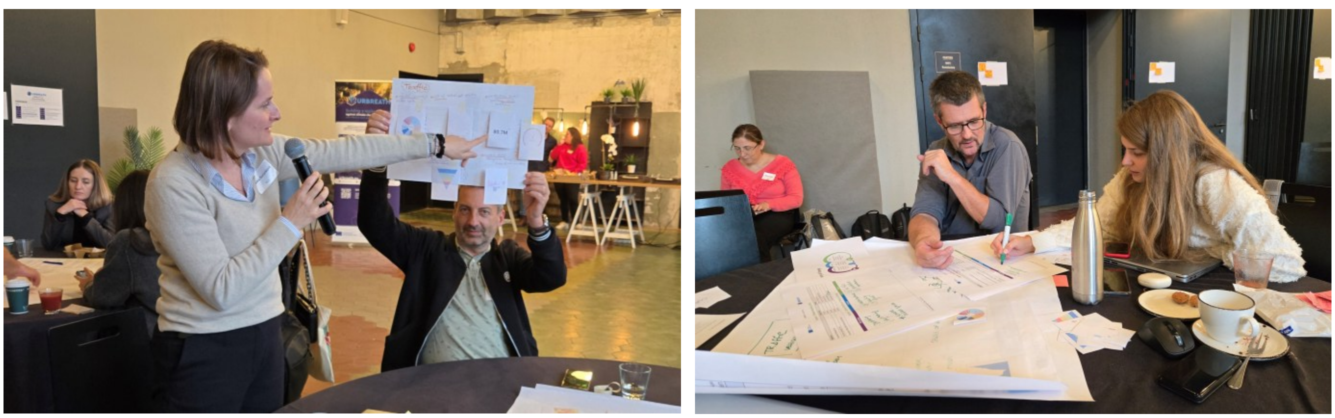
Phase 6 - Go-live (PLANNED)

The final deployment (step 8 of the dashboard development workflow, Figure 31) will take place once data pipelines, visualisation components, and user interactions have been validated and the required datasets are consistently available.

Overall, the development of the monitoring dashboards is progressing through a structured and interdependent process, directly informed by the KPI work of Task 5.6 and by the technical insights generated through Task 5.4. As KPI validation and baseline data harmonisation advance, Task 5.5 will transition into the data integration and implementation stages, setting the foundation for a functional, city-relevant monitoring system that will support evidence-based decision-making and NBS impact interpretation across the URBREATH pilot cities.

During the GA in Tallinn, the Task 5.5 lead hosted a workshop to help pilot cities understand how dashboards can be designed and interpreted. The session included an exercise where each pilot selected a KPI to monitor and built a custom dashboard using data visualisation types and techniques best suited to their needs.

Figure 32: Task 5.5 workshop on the cocreation of dashboards best fitting KPI monitoring objectives.



7. Further activities and further steps

- **Task 5.1** (Completed at Month 18) concluded with a comprehensive baseline analysis and requirements mapping for all pilot cities. Functional needs were systematically gathered, prioritised, and translated into technical specifications, forming the foundation for subsequent tool development and pilot implementation. Results from Task 5.1 are now integrated into ongoing activities. No further actions are planned for this task in the current period.
- **Task 5.2** will maintain its active support for co-creation, tool adoption, and customisation by continuing to facilitate workshops, learning-by-doing sessions, and iterative feedback between pilot cities and technical teams. This approach ensures that local needs are consistently translated into technical solutions and that digital tools are adapted to operational realities. The team will also enhance participatory processes, keeping stakeholders engaged and fostering ownership of outcomes. Regular coordination meetings and open communication channels will be used to address emerging needs and integrate lessons learned, ensuring that the project remains responsive and that improvements are continuously incorporated into both methodology and tool development. In addition, Task 5.2 will continue to support Task 5.4 in terms of customisation and the local use of tools and simulation models.
- Further activities and further steps focus primarily on enhancing tool adoption, promoting standardisation, finalising the monitoring framework, and conducting required performance evaluations across the pilot cities. To improve tool integration and efficacy, **Task 5.4**, in collaboration with WP3 and WP4, should focus on encouraging the broader adoption of certain tools, such as the 15-Minutes City Index and Climate Forecasts, which currently show moderate uptake but could strengthen climate adaptation strategies. It is also recommended to explore the possibility of promoting the standardisation (if available) of core tools, including the Unified UI and VCS plugins, across all participating cities to support interoperability and ensure more consistent user experience. Future technical tasks include assessing climate-specific needs to ensure tools like Heat Stress Analysis and Urban Heat Islands are fully leveraged in Mediterranean and Atlantic cities, while Boreal cities may benefit from the enhanced deployment of Sensors and Climate Forecasts. To create coherent and efficient implementation strategies, tailored tool bundles aligned with specific climate characteristics should be developed. Furthermore, it is important to promote cross-zone knowledge exchange, enabling cities to share best practices for adapting tools to local conditions, and to monitor adoption gaps while providing technical support to cities for integrating underused tools that could offer climate resilience benefits. Task 5.4, WP3, and WP4 will also consider identifying opportunities to enhance categories that appear less represented in the toolbox, particularly Security and Process Orchestration, as strengthening these areas may contribute to improved governance and operational resilience. Finally, fostering the wider use of e-Participation tools is identified as an important future task that may help increase citizen involvement in planning and decision-making processes, thereby supporting more inclusive and collaborative urban development. In terms of data visualisation and customisation, VCS suggested during the General

Assembly meeting in Tallinn (October 2025) that pilots take photos of the front side of each building in their NBSs site to facilitate a manual texturisation approach for the Local Digital Twins.

- Regarding the monitoring and evaluation framework, **Task 5.5** will proceed to the Dashboard assessment and refinement phase (Step 7). This assessment will involve validation with pilot cities and Living Lab stakeholders to check the usability, interpretability, suitability of visualisations for participatory decision-making, and alignment with local governance needs and the KPI monitoring framework. This feedback will guide necessary refinements before moving to the final deployment stage, Go-live, which is planned once data pipelines, visualisation components, and user interactions are validated, and the required datasets are consistently available.
- **Task 5.6** has outlined future subtasks that include the Monitoring of NBS implementation (Subtask 3), scheduled from Month 30 to Month 42. This involves developing a precise procedure and timeline for monitoring data collection (Month 30) and adapting monitoring protocols to go beyond the collection of baseline data (Months 31-32). Data collection towards the end of the monitoring period (Months 38-42) is necessary to gather data after NBS implementation that can be directly compared with the baseline state. The final step is the Ex post-performance evaluation (Subtask 4), running from Months 37-48, which focuses on evaluating the baseline and monitoring data to assess the overall impact of the implemented NBSs.