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Urban Planning and design ready for 2030

D3.1 - Transformative pathways roadmaps: strategic integration of solutions and interoperability 1

WP3– UP-SKILLING - Empowering the city's stakeholder ecosystem to co-develop urban planning and design enabled transformation pathways.

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Abstract	**The report is providing the technology road plan for integrating UP2030 solutions in UP2030 cities along with a detailed development and integration strategy for each one of them. The report presents for each solution their goals, objectives, their status of relevant current installations and Technology Readiness Level along with their development and integration strategy, technical specifications, data management and data needs. The report concludes with a general integration and interoperability strategy that includes deadlines, milestones, and descriptions. This would provide seamless interconnection between UP2030 and guarantee a smooth integration process between the suggested solutions in UP2030.**				

Document History

Version	Issue Date	Stage	Description	Contributor
0.1	17/11/2023	Draft	Design of table of contents	DRAXIS
0.2	22/11/2023	ToC draft Review	Review of table of content, executive summary, and alignment	Fraunhofer IAO
0.3	18/12/2023	1st Draft	Implementation of review comments	DRAXIS

0.4	18/12/2023	1st Draft Review	Review of Draft version of document	Fraunhofer IAO
0.5	21/12/2023	2nd Draft	Implementation of review comments	DRAXIS
0.6	21/12/2023	Coordination Review	Final review done by the coordination team	Fraunhofer IAO
1.0	22/12/2023	Final	Final version ready for submission	DRAXIS

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Executive summary

This deliverable presents the technological roadmap towards the integration of the UP2030 solutions in the UP2030 cities. The goal of this deliverable is to provide a clear development and integration plan for each solution.

Each UP2030 solution is presented in a dedicated section including their description and their objectives, relevant existing installations and their Technology readiness level (TRL) status. Additionally, the solutions technical specifications, including an overview of data management among with their data requirements, are provided together with the development and the integration plan.

Finally, a comprehensive section presents an overall integration and interoperability plan with defined dates, milestones, and timelines. This will ensure a smooth integration process between the proposed solutions in UP2030, while at the same time providing seamless interconnectivity between UP2030 subcomponents.

D3.1 is a living document in which information will be updated with further details as the implementation of the UP2030 project progresses and when significant changes occur. An updated version in M24 and M36 will build upon this document and become an updated version of it.

Content alignment with other UP2030 deliverables

The UP2030 project fosters exchange and cooperation among partners and deliverables beyond the work package's structure. Therefore, the content of this document has been developed in alignment with WP leaders and task leaders. The following table lists the deliverables and milestones that were input for this present document and the upcoming ones that could benefit from the content here presented.

Input from	Contributes to
• D1.4 - Data Management Plan 1 • D4.1 - UP2030 Implementation Plan for the Pilot Cities 1	• D3.2 - Transformative pathways roadmaps: strategic integration of solutions and interoperability 2 • D3.3 - Transformative pathways roadmaps: strategic integration of solutions and interoperability 3
• MS3 - Establish the QA & ethical procedures, and the data management protocol	• MS7 - Cities establish user stories

This deliverable, developed during M12 of the project, provides a foundation for all UP2030 City and Technical partners to gain a shared understanding of the technological roadmap required for integrating UP2030 solutions within the UP2030 cities. Liaison partners and task leaders involved in the integration process will benefit most from this deliverable. The document is intended to primarily be shared with the directly involved partners, and subsequently with the entire consortium by distributing it via the UP2030 shared folder. Furthermore, given the public dissemination level of the document, extra third-party stakeholders seeking to benefit from UP2030's solutions and their interoperability could find the document advantageous.

Acronyms

Acronym	Full name
AAD	Algorithm Aided Design
API	Application Programming Interface
BH	Buro Happold
CSV	Comma-separated values
D	Deliverable
DBF	Dbase Database file
DNSH	Do No Significant Harm
DT	Digital Twin
EPW	EnergyPlus Weather Format
ESRI	Environmental Systems Research Institute
EU	European Union
FAIR	Findability, Accessibility, Interoperability, and Reusability
GenA	General Assembly
GIS	Geographic Information Systems
GML	Geography Mark-up Language
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
JSON	JavaScript Object Notation
KML	Keyhole Mark-up Language
KMZ	Keyhole Mark-up Language zipped file
LAA	Learning and Action Alliances
LCA	Life Cycle Assessment

LULUCF	Land Use, Land-Use Change, and Forestry
NetCDF	Network Common Data Form
OGC	Open Geospatial Consortium
P-GIS	Participatory Geographic Information System
RAF	Resilience Assessment Framework
REST	Representational State Transfer
TRL	Technology readiness level
UCCRN	Urban Climate Change Research Network
UDCW	Urban Design Climate Workshops
UTCI	Universal Thermal Climate Index
VPL	Visual Programming Language
WP	Work package
XML	Extensible Mark-up Language

1 Introduction

1.1 Purpose and Scope

The purpose of this deliverable, developed in Month M12 of the project, is to establish a comprehensive technological roadmap for the integration of UP2030 project solutions within its pilot cities. Its primary aim is to facilitate a shared understanding among all UP2030 cities and Technical partners regarding the necessary steps and requirements for successful integration.

The deliverable is particularly beneficial for liaison partners and task leaders who are directly involved in the integration process. It serves as a foundation for guiding their efforts and ensuring a smooth implementation of the UP2030 solutions. While initially intended for the directly involved partners, the document will eventually be shared with the entire consortium by distributing it through the UP2030 shared folder. This ensures that all stakeholders within the consortium are well-informed and have access to the information outlined in the deliverable.

1.2 Document Structure

The document is organised as follows:

- Section 1 - Introduction: description of the purpose and scope of the document and its structure
- Section 2 to Section 28 – For each of the proposed 27 solutions, a separate section describes the following:
    - A short introduction to the solution
    - A short Description of the solution.
    - The solution’s Objectives.
    - The solution’s relevant existing deployment.
    - The TRL status of the solution as a key indicator that measures the maturity of a certain technology or innovation. It encompasses a scale ranging from 1 to 9, with 1 representing the lowest level of readiness and 9 indicating that the technology is fully developed and ready for commercial deployment. TRL facilitates also effective decision-making and resource allocation by enabling policymakers, funders, and industry stakeholders to identify technologies that are primed for further development or those that need additional research and testing before they can be realized in real-world applications.
    - The solution’s technical specifications.
    - A data-management overview for the proposed solution with its requirements.
    - A comprehensive integration and interoperability plan of the proposed solution. All integration plans presented as Gantt diagrams are related to the implementation within the UP2030 project timeline.
    - Any solution limitations.

  - A short paragraph regarding the solution evaluation
  - A paragraph referring to the mapping of the solution towards UP2030.

- Section 29 – An Overall integration and interoperability plan including all the solutions and other critical milestones of the project.
- Section 30 – A conclusion section for this deliverable.

2 Checks on Climate Impacts / Climate Proofing solution

2.1 Introduction

The Climate Proofing solution is a methodology for the early-stage assessment (e.g., masterplan, design competitions, etc.) of urban development projects at the neighbourhood scale regarding their climate mitigation and adaptation potential and pathways towards climate-neutrality and -resilience. The solution is provided by Buro Happold (BH).

2.1.1 Solution Short Description

The assessment provides quantified early-stage recommendations to cities in their pilot projects on how to set out targets, baselines, and project-specific steps towards a climate-neutral and -resilient neighbourhood development.

The methodology targets municipal stakeholders and local authorities in early planning stages, supporting them to develop an understanding of climate impacts and risks that are related to the assessed medium- to large scale (>100 ha) urban development projects and possible measures that can be implemented to mitigate and reduce them in crucial early stages of project development.

Through interdisciplinary use across the fields of engineering, design, planning, and consulting services, the solution offers a holistic approach to climate mitigation and resilience.

2.1.2 Objectives

The methodology offers guidance and advice on climate mitigation and adaptation assessments to enable the code sign of adaptive pathways for a climate-neutral and climate-resilient urban transformation. Figure 1 shows a graphical illustration of the proposed solution.

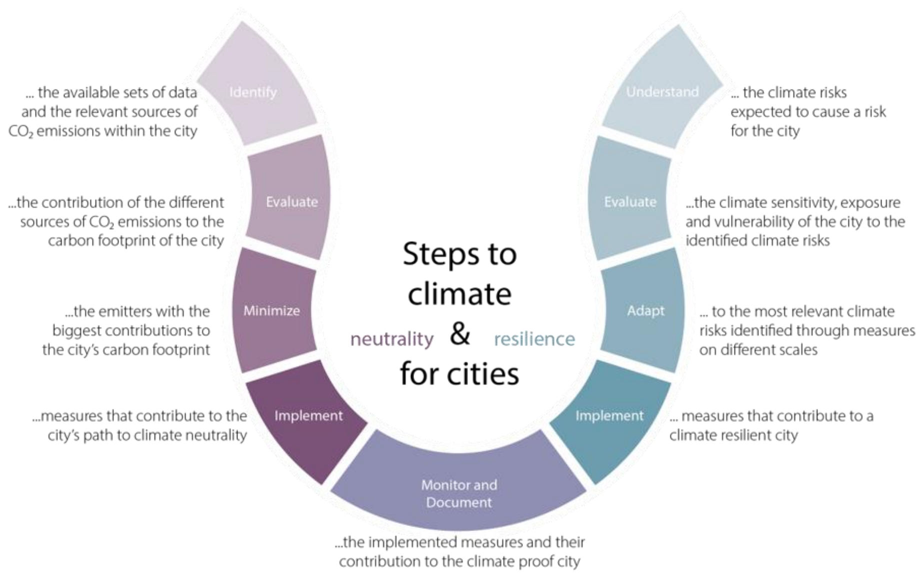

Figure 1 Graphical Illustration of the Methodology of Climate Proofing © Buro Happold

In a first step, aspirations and goals of the city are identified and translated into project and sector specific targets. Existing policies, regulations and guidelines are reviewed. Second, the cities are supported in how to assess existing data, identify gaps, and potential substitutes for missing data – e.g., reference data or industry experience.

Based on the gathered data and information, cities are guided on how CO_2-emissions from different sectors are assessed (e.g., building operation, embodied carbon, mobility, carbon sinks). Additional tools from UP2030 might be integrated in the quantification process to support these assessments, as there are several tools supporting CO_2-assessments on embodied carbon or operational carbon. Likewise, the methodology integrates aspects on climate adaptation with a focus on impacts of prolonged heat periods on neighbourhoods. Also here, links with other (software-)tools are possible.

Finally, recommendations are given regarding measures and pathways to reduce carbon emissions in the respective sectors, as well as strategies for reducing impacts of climate change (e.g., heat island effect). The proposed measures aim to ideally support each other or at least do no significant harm in any of the considered aspects. This would then translate into recommendations to be applied through formal or informal planning instruments in the subsequent planning phases.

2.1.3 Existing Installation

The solution has been used in (Burohappold, n.d.)and is currently further developed using projects of different scales and phases of development.

2.1.4 TRL status

The TRL level of this solution will be defined in the following up months of the project.

2.2 Technical specifications

The following table represents the actions and sub-steps from a technical view that needed to be taken when using the on-climate checks / climate proofing solution.

Table 1: Actions and sub-steps for the on-climate checks / climate proofing solution.

Actions	Sub-steps
• Data gathering	• Define project benchmarks and ambitions. • Identify available project data. • Definition of reference data where project specific information is not available.
• Evaluation and quantification	• Evaluation of main sources of CO_2 emissions within a project • Evaluation of climate risks relevant to a project
• Development of Pathways for Minimization and Adaptation	• Assessment of main drivers for carbon emissions and climate vulnerability in the project

	• Development of project specific mitigation and adaptation pathways to minimize climate impacts. • Identification of mitigation/adaptation measures
• Implementation of Pathways	• Implementation of the climate proofing pathways through specific strategies and measures in formal/informal planning instruments

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 2: Technical aspects of the Checks on Climate Impacts / Climate proofing solution

Technical Aspect	Description
Versioning information	Not applicable
License	Not applicable
Online-documentation	Not applicable
Programming Language	Not applicable

2.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Climate Impacts / Climate proofing solution.

Table 3: Data inputs and outputs for the Check Climate Impacts / Climate proofing solution.

Data Input	Data output/results

Depending on availability:
• **Local/Municipal policies, targets, frameworks, strategies, for example:**
  ○ Climate mitigation action plans
  ○ Climate resilience and adaptation action plans
  ○ Energy efficiency, renewable energy use legislation
  ○ Development strategies, local area masterplans
• **Project specific, depending on the project's planning stage:**
	• Enabling cities to address their emissions and setting a foundation to build local capacities for tackling climate mitigation and adaptation.
	• Methodology for integrating data on environmental impacts in early-stage decision-making processes, including the identification of which data is needed and which reference data is valid.
	• Defining baseline and mitigation scenarios

○ development frameworks, masterplans ○ early-stage urban designs ○ early-stage landscape/outdoor area concept ○ site specific area indicators: total area, gross floor area, FAR, etc. ○ any other early design concepts and studies ○ mobility strategy ○ energy concepts ○ material concepts (e.g., on structural designs, outdoor surfaces)	• Outcomes can be integrated into the further development and the following decision-making process.

2.3.1 Data requirements

The data requirements for the implementation of the solution requires information on planned areas and uses in the project as well as information on building types and urban layouts. Further, data on location specific surface conditions and climate risks are beneficial for the assessment of project specific climate vulnerability.

With the methodology targeting projects in early planning phases, where only a limited amount of information is available, evaluations on climate impacts can be made based on the use of reference information in case project data is not available.

For the development of project specific targets, municipal policy documents and frameworks are reviewed.

2.4 Integration and interoperability plan

Figure 2 shows the integration Gantt diagram of the proposed solution.

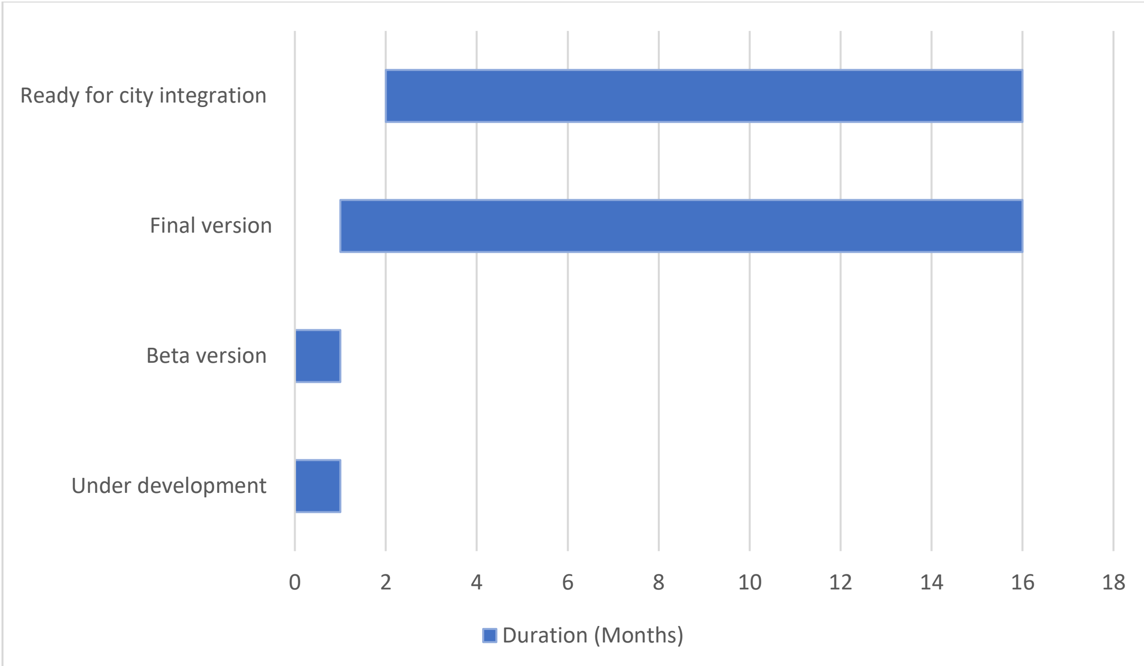

Figure 2. Integration Gantt diagram for the Check Climate Impacts / Climate proofing solution

The methodology of Climate Proofing has been developed and tested in (Burohappold, n.d.) project and is currently being refined in further projects. It is now ready for integration into cities. However, the aim is to further enhance the methodology during the UP2030 project and in collaboration with pilot projects.

2.5 Solution limitations

The tool aims to support municipal stakeholders in early planning stages, as crucial decisions are already made at competition stage, or even earlier. Therefore, limitations are mainly referring to lack of data from the side of municipalities.

2.6 Solution Evaluation

The evaluation of this solution will be defined in the following up months of the project.

2.7 City mapping

At the current project stage, Buro Happold is in exchange with the city of Münster regarding possible implementation of the tool. Further cities such as Granollers and Thessaloniki have expressed interest in possible application of the methodology in an exchange in the General Assembly (GenA) carried out between the 13th and 15th of November 2023, but further coordination and evaluation is required.

3 City Scan - Data driven geospatial analysis solution.

3.1 Introduction

City Scan is a data-driven decision-making methodology, based on digital tools that analyses spatial data to visualise and decode complex spatial and temporal systems. The solution is provided by TSPA.

3.1.1 Solution Short Description

City Scan is a data-driven service to improve urban planning processes and is designed to be precise and efficient in its analytical process. In addition to analysing spatial data and visualizing intricate systems, City Scan can also generate scenarios for a variety of quick and accurate decision-making tasks.

3.1.2 Objectives

The method aims at interpreting complex spatial systems through advanced spatial analysis and remote sensing methods, which supports decision making by simplifying and overlaying spatial systems to support decision making. City scan allows the decoding and visualization of various heterogeneous systems (built environment/ natural environment / socio-economic / demographic / urban) and works to layout the results in an easy-to-understand fashion. City scan illustrates the impact of current trends across temporal (short-term, intermediate, long-term) and spatial dimensions across scales to evaluate the suggested planning and design options with the goal of achieving high level targets and goals efficiently and effectively.

3.1.3 Existing Installation

Currently, this digital solution is a service-based methodology and should be operated by the users with an expertise in Geographic Information Systems (GIS) software as well as knowledge in Python and R[1].

However, the methodology was already applied multiple times in the past:

- Structural Plan of five rural cities in Mozambique: GIS based and participatory planning for the elaboration of long-term urban development plans in emerging countries.
- Public Toilets for Berlin: Evaluation of existing locations and identification of a new locations (including equipment characteristics) using data driven analysis.
- Makkah 2070. Citywide vision and development concept.

3.1.4 TRL status

The technology level in City Scan is proven and demonstrated in space and relevant environments, the method is also proven through different successful implementations that are mentioned in the previous section (3.1.3 existing installations). The implementation of City Scan may vary significantly from one use case to another depending on the study criteria of the space. Additionally, successful implementation of City Scan is dependent on the availability of relevant spatial data and will face certain limitations in data sparse environments.

[1] https://www.r-project.org/

3.2 Technical specifications

The tool is a service-based methodology that utilizes GIS software as a base for data aggregation and processing. However, it may depend on auxiliary data processing environments such as Python[2] for deep learning and semantic feature extraction, and R for in depth data analytics and visualization. The digital tools are used under scientific methodologies and measures to evaluate various urban development scenarios to identify dependencies and impacts of climate-positive actions and design solutions across sectors and scales.

The technical process can be simplified into the following overarching:

- Data collection and identification
- Data aggregation and filtering
- Task-space specific methodical framework development
- Data processing using GIS and auxiliary data analysis tools.
- Data visualization and results interpretation

The methodology may rely on external GIS software's that requires licensing (such as ArcGIS Pro[3]). However, currently there is no licensing or other applicable legal restrictions to the use of this methodology other than required knowledge to collect, analyse and assess the data or the outputs. Currently, this digital tool is a service-based methodology and must be operated by users with expertise in GIS software as well as in Python and R. Nevertheless, since the methodology relies on ArcGIS software, the system should be compatible with the minimum requirements[4] for ArcGIS.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 4: Technical aspects of the City Scan - Data driven geospatial analysis solution

Technical Aspect	Description
Versioning information	Not applicable
License	No licensing
Online-documentation	Not applicable
Programming Language	• Python • R

3.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the City Scan solution.

[2] https://www.python.org/
[3] https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview
[4] https://pro.arcgis.com/en/pro-app/latest/get-started/arcgis-pro-system-requirements.htm

Table 5: Data inputs and outputs for the City Scan – Data driven geospatial analysis solution.

Data Input	Data output/results

• Geospatial data
  ○ Vector spatial data (e.g. shapefile)
  ○ Raster and satellite imagery (e.g. GeoTIF)
  ○ Spatialized CSV data
  ○ Social media data scraping
  ○ CAD or architectural data (e.g. dwg)
	• Geospatial database
	• Analysis output in the form of science-based measures related to the specified criteria
	• Cartographic output in the form of high-resolution static maps or Dynamic maps and data visualization through online platforms such as ArcGIS online
	• Monitor the impact of proposed (and implemented) solutions across sectors (for example in development scenarios)

3.3.1 Data requirements

The methodology relies on spatial data that is compatible with GIS software such as ArcGIS and are accepted by EU standards. Thus, it requires expertise in urban planning and design systems and principles, expertise in sustainable urban development principles and a clear project concept and vision.

The examples of the data format include but are not limited to: Geography Markup Language (GML[5]), GeoJSON[6], Keyhole Mark-up Language (KML[7]), GeoTIF[8], and Network Common Data Form (NetCDF[9]), Shapefile[10].

3.4 Integration and interoperability plan

Figure 3 shows the integration Gantt diagram of the proposed solution.

[5] https://www.ogc.org/standard/gml/
[6] https://geojson.org/
[7] https://www.ogc.org/standard/kml/
[8] https://www.ogc.org/standard/geotiff/
[9] https://www.unidata.ucar.edu/software/netcdf/
[10] https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/shapefile.pdf

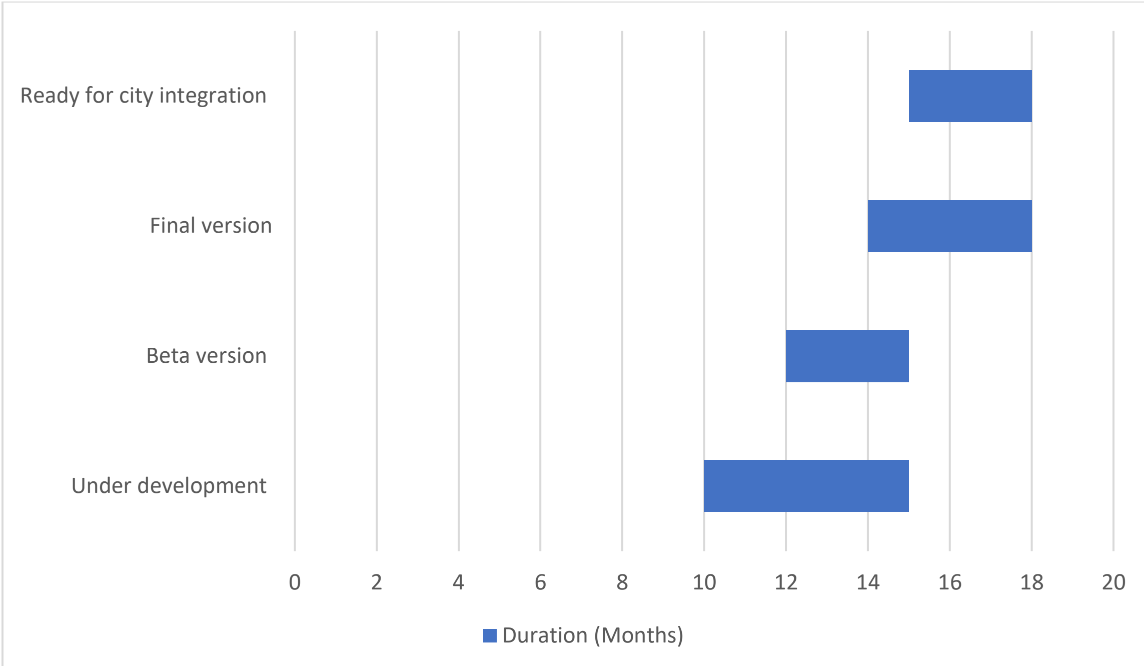

Figure 3.Integration Gantt diagram for the City Scan – Data driven geospatial analysis solution.

The output of City Scan can be divided into qualitative information and insights, and quantitative measures and results. The quantitative output of city scan is the analysis results typically in the form of industry standard Geodata formats, such as shapefile, GeoTIF, or CSV. This format can easily feed into and be operated by other data-driven process and tools. The qualitative output of City Scan is the interpreted results of the quantitative segment, this may be in the form of tailored data visualization such as maps or charts, or insights that can directly influence action plans and goal settings. City Scan is designed to be interoperable with different processes as it uses results from other process in the form of spatial data as an input and produces data and information that can be integrated in parallel process.

3.5 Solution limitations

The method demands knowledge as an urban planner and advanced GIS abilities. Within the UP2030 project there will be no training for GIS/planning certificates, but the overall methods can be taught and transferred in their holistic and cross-cutting approach. In addition, the shortage in digital skills among city representatives and the lack of up to date and comprehensive datasets may limit the solution. Finally, the method can be used on a technical level, while they also enable a mind-set of informed decision making for city makers without the technical knowledge of using all involved tools themselves.

3.6 Solution Evaluation

The accuracy of the results of City Scan are mainly dependant on the accuracy of the input data, well evaluated and reliable data sources will produce reliable results. The final output of City Scan will be evaluated through a hybrid approach of feedback loops with stakeholders, client, and experts in GIS software, and a comparative evaluation with similar studies and information.

3.7 City mapping

At the time of writing this report, the Beta version of City Scan is being developed for implementation in the city of Granollers, Spain. Where the special analytics component of City Scan plays an essential role in gathering and preparing data for the Parametric Design and Assessment tool. It is likely that City Scan will be developed and implemented in other cities of the UP2030 project.

4 Parametric Modelling Assessment Tool solution

4.1 Introduction

Parametric Modelling Assessment Tool is a digital design methodology, in which the digital twin space is procedurally manipulated through various parameters, in a process that aims to explore different spatial configurations and optimize spaces according to a pre-set design criterion. The solution is provided by TSPA.

4.1.1 Solution Short Description

Too often, urban planning decisions are being made based on intuition due to either lacking or overly complex information. On the other hand, much of spatial analysis is undertaken without having design actions in mind. Parametric design models aim to evaluate various urban development scenarios to identify dependencies and impacts of climate-positive actions and design solutions across scales.

4.1.2 Objectives

The Parametric Design and Assessment tool proposed by TSPA aims to procedurally investigate possible spatial configurations and urban design scenarios through a step-by-step parametric generation of urban environments, while simultaneously analysing the cross-impact of the proposed scenarios on each relevant design criteria (e.g. Walkability, Density, Solar energy).

The Parametric design approach help cities better understand the impact of the design decisions through active involvement in the design process, and allowing for a real time analysis of the impact design choices may have on the neighbouring environment. The tool also allows designing spaces through parameter setting which optimizes designs to meet pre-set target goals.

4.1.3 Existing Installation

The methodology was already applied in the Blankenburger Süden area:

- (TSPA, n.d.)(and 22nd) Century - evaluate dependencies and climate positive actions and design solutions across scales to support decision making[11].

4.1.4 TRL status

The technology level of the Parametric Design and Assessment tool is demonstrated and was successfully implemented in the Blankenburger Süden project. The tool was also partially thoroughly tested and proofed by the chair for computational architecture (Weimar, n.d.).

4.2 Technical specifications

The 3D model compatible with Rhinoceros 3D[12] software is connected to the prepared script in Grasshopper [13] which allows the evaluation of proposed density design solutions against climate positive impacts. The outcome is reflected in a spreadsheet or can be visualised to support the calculations in video or image formats.

[11] https://www.dropbox.com/scl/fo/ws1kysx0x7mc7zxx9320j/h?dl=0&rlkey=1iqi5wg30hg9snm3glamj9utr
[12] https://www.rhino3d.com/
[13] https://www.grasshopper3d.com/

Currently, this digital tool is a service-based methodology and must be operated by users with some level in expertise in 3D software. The methodology relies on Rhinoceros 3D software. Therefore, the system should be compatible with the minimum requirements[14] for Rhinoceros 3D.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 6: Technical aspects of the Parametric Modelling Assessment Tool solution

Technical Aspect	Description
Versioning information	Not applicable
License	The methodology relies on the external 3D modelling software Rhinoceros 3d that requires licensing (Rhino 7 or higher).
Online-documentation	Not applicable
Programming Language	The tool is a service-based methodology using Rhino 3d + Grasshopper, which, in some parts includes the use of Python or C# programming language.

4.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Parametric Modelling Assessment Tool solution.

Table 7: Data inputs and outputs for the Parametric Modelling Assessment Tool solution.

Data Input	Data output/results
• City Scan's post processed Geodata export • (if available) 3D CAD model in proprietary formats such as, but not limited to: 3DM, DWG/DXF, SKP, FBX, IGES	• Density and design solution evaluation in a form of spreadsheet. • The output can be supported by video or images. • Various design scenarios as a volumetric urban design model in 3DM format

4.3.1 Data requirements

Rhinoceros 3D software is compatible with the following open data format, but not limited to: STL, OBJ, PLY, Collada.

As well as spatial data, either in 3D proprietary formats such as, but not limited to: 3DM, DWG/DXF, SKP, FBX, IGES, or Processed and correctly exported geodata, optimally through the City Scan's Geodata export.

[14] https://www.rhino3d.com/7/system-requirements/

The later formats are more common in the daily business; however, they require licensing and certain computer skills. Licensing and Data Ownership: Proprietary licences or restrictions on data usage can limit interoperability. In the case of licensed data sources, the terms and conditions of those licences may impact the ability to share or integrate the data with other systems or tools.

4.4 Integration and interoperability plan

Figure 4 shows the integration Gantt diagram of the proposed solution.

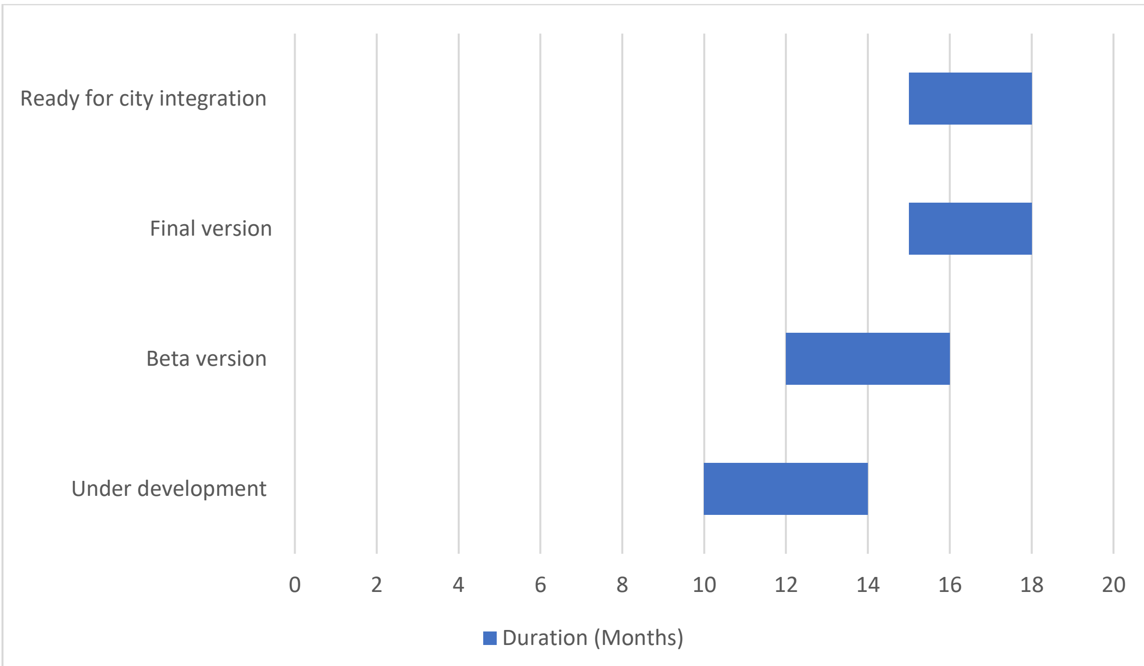

Figure 4. Integration Gantt diagram for the Parametric Modelling Assessment Tool solution.

The Volumetric results of the Parametric Design and Assessment tool are compatible with any 3D modelling software through simple data format conversions. Additionally, the tool has the capacity to integrate target parameters set by other tools and processes in the UP2030 project.

4.5 Solution limitations

The methodology relies on the external 3D modelling software Rhinoceros 3D that requires licensing. In addition, the shortage in expertise in urban planning and design or the lack of project vision and target may limit the effective implementation of the solution. Moreover, the dynamic nature of the Rhino + Grasshopper development space often leads to incompatibilities between different plug-ins and deprecated tools, that need to be hard coded again, extending development times.

4.6 Solution Evaluation

The iterative nature of parametric modelling gives space for constant evaluation of the tool through the constant readjustments and optimization of the design parameters, and continuous exploration of limitations. The final Scenarios will be evaluated directly by the client, or stakeholders.

4.7 City mapping

At the time of writing this report, the Parametric Design and Assessment tool for the city of Granollers is being developed, where the basic code is being readjusted for late iterative optimization. It is possible that the Parametric Design and Assessment tool will be developed and implemented in other cities of the UP2030 project.

5 Citizen Voice solution

5.1 Introduction

Citizen voice is a survey tool for spatial data collection. It works like conventional questionnaires but connected to maps. The solution is provided by TUD.

5.1.1 Solution Short Description

Citizen Voice is powered by the open-source Python framework Django[15], which provides the developers with an excellent toolset for rapid development and scalable code (back-end development). Together with the Postgres [16] database, it provides the ability to store multiple datatypes and serve this data through public-facing and authorized application programming interfaces (APIs) for communication with third parties and the platform front end. Citizen Voice also uses open-source technology to serve an optimal user and development experience with fast-loading static pages. These include Vuejs [17] for serving dynamic data and component base development, and Nuxtjs [18] for static page rendering and great rapid development.

5.1.2 Objectives

Citizen Voice is a survey tool to collect spatial information from citizens (or other stakeholders), to support cities in understanding the spatial needs and aspirations of their citizenry.

5.1.3 Existing Installation

The first prototype will be tested within UP2030.

5.1.4 TRL status

Current TRL status is 2. The first prototype will be tested within UP2030.

5.2 Technical specifications

Surveys made by the TUD team within UP2030 must comply with TU Delft guidelines for data management while data will follow the Findability, Accessibility, Interoperability, and Reusability (FAIR) principle. The code will be provided as open source.

The solutions comes with an GUI where survey designers need to provide their credentials to be able create surveys. However, for testing, respectively links will be provided for respondents.

Due to privacy concerns, responses are anonymous while there is no authentication for respondents.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

[15] https://www.djangoproject.com/
[16] https://www.postgresql.org/
[17] https://vuejs.org/
[18] https://nuxt.com/

Table 8: Technical aspects of the Citizen Voice solution

Technical Aspect	Description
Versioning information	The first prototype is being finalized, to be tested within UP2030.
License	GNU General Public License v3.0
Online-documentation	Not available yet.
Programming Language	Python

5.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Citizen Voice solution.

Table 9: Data inputs and outputs for the Citizen Voice solution.

Data Input	Data output/results
• The survey designer (user 1) creates questions using the designer interface. • The survey respondent (user 2) responds to the questions via a respondent interface.	• Answers to the questions in geospatial files in the format .shp, or data frames in .csv and. json formats.

5.3.1 Data requirements

There are no specific data requirements for the above-mentioned solution.

5.4 Integration and interoperability plan

Figure 5 shows the integration Gantt diagram of the proposed solution.

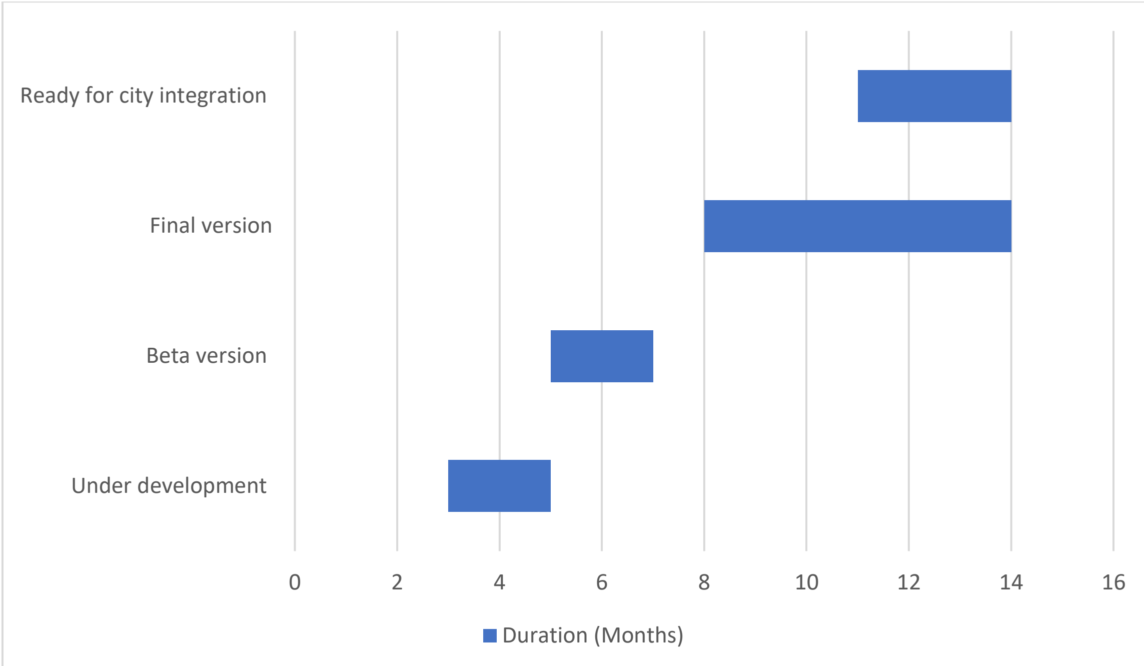

Figure 5. Integration Gantt diagram for the Citizen Voice solution.

The tool will not be integrated into the city's system. It will be used as a stand-alone tool. In the final version of the tool, APIs will be available to retrieve the survey data.

5.5 Solution limitations

There are no specific limitations for the above mentioned solution.

5.6 Solution Evaluation

To evaluate the tool, interviews with city officials and liaisons will be scheduled.

5.7 City mapping

Budapest and Rotterdam have shown interest in Citizen Voice

6 CLIMACT Prio tool solution

6.1 Introduction

CLIMACT Prio is a tool that aims to support decision making and climate action planning in cities.

The solution is provided by GGGI.

6.1.1 Solution Short Description

CLIMACT Prio is a climate awareness, decision support and capacity building MS Excel tool with a few Visual Basic features for screening and prioritizing of local climate change actions.

CLIMACT Prio tool utilizes a multi-criteria approach to assist decision makers and urban planners to (1) identify a wide range of decision criteria and set priorities among objectives while (2) performing an analysis and assessment of climate change (mitigation or adaptation) actions, and based on these criteria to (3) identify and rank the most suitable climate actions for the city climate change action plan.

An important functionality of the MCDA (Multiple Criteria Decision Analysis) process is the identification and weighting of multiple criteria (environmental, economic, social, institutional, etc.) that would be used to assess the different climate mitigation and adaptation actions. The tool provides a systematic process where individuals or groups can follow a step-by-step guided weighting criteria approach to understand and determine the most important criteria and objectives that need to be taken into account during the assessment of the climate actions. This process facilitates stakeholders' discussion and exchange of information and knowledge.

6.1.2 Objectives

CLIMACT Prio can be used for several purposes:

- Screening and rapid feasibility assessment: The tool can be used for screening and a rapid feasibility assessment process of climate actions considering different feasibility criteria.
- Decision support and assessment of climate actions: The final objective of the tools is to provide support on decision making and assessment of different climate action by considering multiple criteria and objectives. As such the tool can support the development of a city climate change action plan.
- Prioritization process: The tool through its specific features can facilitate the identification and setting of city's multiple objectives (environmental, economic, social, institutional, etc.) and priorities to be used for the assessment (and prioritization) of climate change actions.
- Stakeholders' co-creation and engagement process: The tool supports the prioritization process of climate actions by facilitation the active engagement of stakeholders in the process in different stages such as objectives setting, selection of climate actions, screening of long list of climate actions and assessment, criteria weights, and scoring/ assessment of climate actions. The tool aims to facilitate a stakeholder's co-creation and engagement process to lead to the prioritization of climate actions for the development of a city climate change action plan.
- Knowledge generation and sharing: Through the stakeholders' co-creation and engagement process in the different stages of the prioritization of climate actions, stakeholders can exchange and generate knowledge and information regarding the climate change challenges, mitigation and adaptation objectives and sectoral and cross- sectoral climate actions and solutions suitable for the city.

- Capacity building: Because of all the above features, the CLIMACT Prio tool has been widely used for capacity building and training of city officials and urban planners on climate actions decision support and prioritization as part of city's climate action planning process.

6.1.3 Existing Installation

The tool has been used extensively for training and capacity building of urban professionals both in Europe and globally. In addition, it has been used by cities for prioritization of climate actions. E.g., San Diego (USA), The Hague (Netherlands), Kampala (Uganda), Colombo (Sri Lanka). It has also been used by different organizations as a tool to support climate action planning and has been included in their reports e.g., UN-Habitat, ICLEI, Cities Alliance. Lastly it has been used also by another European funded project, called Resin, on climate adaptation actions prioritization.

6.1.4 TRL status

CLIMACT Prio is almost readily available, it can be customised further to city's needs, which may take some time (few weeks).

6.2 Technical specifications

The MS Excel based CLIMACT Prio tool is structured in six main steps:

- Identification of preliminary wish-list of actions based on cities vulnerability profiles, broader development goals and visions (this step forms the basis to use the tool) (Main actors: policy makers and city officers)
- Feasibility Assessment: Consists in the screening of each action identified in the wish-list against pre-defined feasibility criteria and formulation of a shortlist of actions to take further into the assessment (Main actors: policy makers and city officers)
- Evaluation Criteria Identification: Based on city vulnerability profiles, broader development goals and the preliminary list of adaptation actions, evaluation criteria are identified. (Main actors: city officers and civil society)
- Impact assessment: Consists of experts' judgments and impact assessment matrix along with normalized scores and graphs (Main actors: relevant experts/consultants depending on the type of actions)
- Weighting of criteria: Consists in the weighting of criteria by the stakeholders and the generation of relevant graphs (Main actors: policy makers, city officers, civil society, private sector)
- Results: Consists of the presentation of weighted scores, final ranking, and the generation of relevant graphs (Main actors: All those part of previous steps)

In addition, the CLIMACT Prio tool, has two versions: one that focuses on the prioritization of climate mitigation actions and another one that focuses on the prioritization of climate adaptation actions. The version with the mitigation actions, also incorporates a marginal abatement cost analysis module so that in the end the decision maker could see two prioritizations based on the two different methodologies for a well-informed decision. In principle, the outcomes of the marginal abatement cost analysis could be incorporated in the multi-criteria analysis.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 10: Technical aspects of the CLIMACT PRIO solution

Technical Aspect	Description
Versioning information	Last version of the tool can be provided by GGGI
License	No license required
Online-documentation	• https://city-development.org/tool-19-climact-prio/# • https://city-development.org/wp-content/uploads/2016/09/CLIMACT-Prio-Adapt-Manual.pdf • http://wiki.resin.itti.com.pl/supporting-tools/4918-2/ • https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bc825a1a&appId=PPGMS • https://www.youtube.com/watch?v=rBvt75KsaG8&t=207s
Programming Language	CLIMACT Prio is an Excel based tool with a few Visual Basic features

6.3 Data Management Overview

The following table represents the respectively data inputs and outputs for the CLIMACT PRIO solution.

Table 11: Data inputs and outputs for the CLIMACT PRIO solution.

Data Input	Data output/results
The tool requires two main types of inputs: • Performance/ score data/ information of the different climate actions which can be based either on existing studies (e.g., GHG emission abatement analysis) or on experts' judgments. • Criteria weights, provided by different stakeholders. The criteria weights could be provided by different stakeholders: ○ at an individual stakeholder level, and then the tool can calculate the average criteria weights based on the individual stakeholders' preferences, along with the convergence or divergence of stakeholders' preferences, or	• Weighted scores and ranking (prioritization) of climate (mitigation or adaptation) actions against evaluation criteria. • Visual presentation of weighted scores, • Final ranking and the generation of illustrative graphs

○ as group weights based on a consensus based discussion.	

6.3.1 Data requirements

No specific data requirements for the above-mentioned solution except the ones placed as data inputs on Table 11.

6.4 Integration and interoperability plan

Figure 6 shows the integration Gantt diagram of the proposed solution.

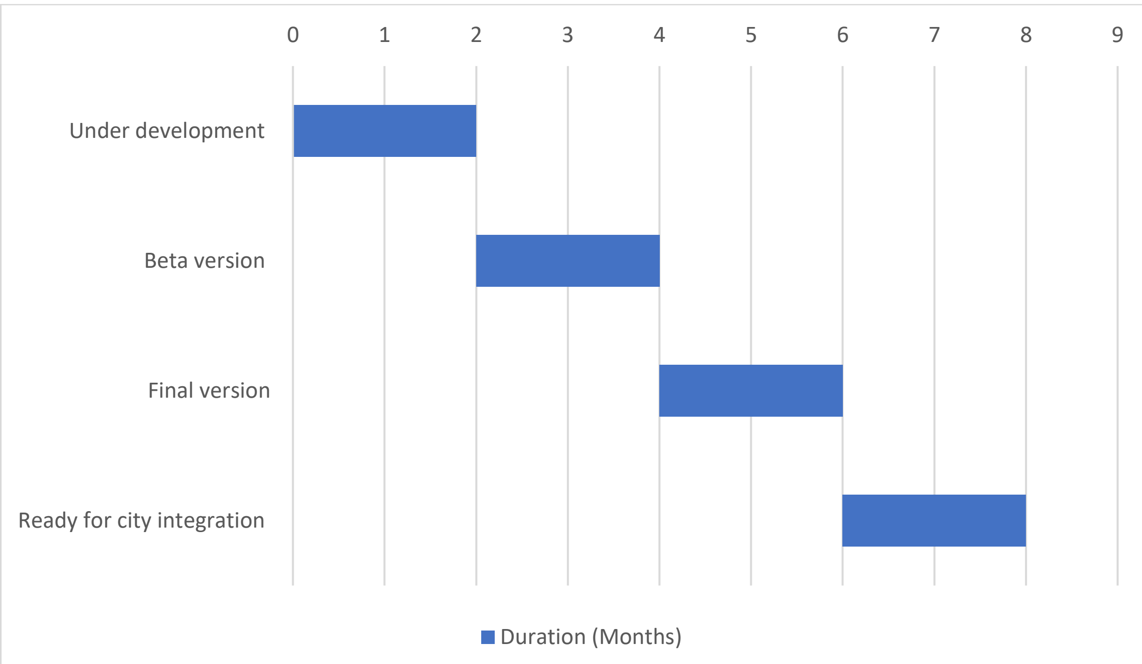

Figure 6. Integration Gantt diagram for the CLIMACT PRIO tool.

6.5 Solution limitations

It is recommended to take at least one day to run the first two steps of the tool (Formulating an initial wish list of Actions and Feasibility Assessment) and one to two full days for the remaining steps (Criteria selection; Impact matrix; Weighting of criteria; results). The process can take longer depending on the availability of stakeholders. Also, the tool has not been optimized for mobile platforms.

6.6 Solution Evaluation

The evaluation of this solution will be defined in the following up months of the project.

6.7 City mapping

Until the writing of this report none of the cities have selected CLIMACT Prio for implementation and use.

7 Green Economy Model solution

7.1 Introduction

Green Economy Model (GEM) solution is a simulation tool of climate interventions and low carbon development scenarios against environmental and macroeconomic indicators. It is an integrated model - which considers the interlinkages existing between populations, economic activity, and environmental outcomes - that assesses various economy-wide emission reduction pathways. Therefore, it supports the estimation of the economic outcomes of decarbonisation, including the economic valuation of several social and environmental externalities, in addition to job gains and losses. The solution is provided by GGGI.

7.1.1 Solution Short Description

The GEM model was designed explicitly to analyse green economy and low carbon development scenarios. GEM is built using the System Dynamics (SD) methodology, serving primarily as a knowledge integrator. SD is a form of computer simulation modelling designed to facilitate policy planning in the medium to long term across key economic sectors and subsectors (energy, industry, waste management, agriculture and Land Use, Land-Use Change, and Forestry (LULUCF). The purpose of SD is not to make precise predictions of the future, or to optimize performance; rather, these models are used to inform policy formulation, forecasting policy outcomes, and leading to the creation of a resilient and well-balanced strategy.

7.1.2 Objectives

Green Economy Model (GEM) has several objectives, including:

- Informing policy formulation and evaluation: GEM is designed to inform policy formulation and evaluation, with a focus on shaping consumption and production towards a greener economic development paradigm.
- Simulating impacts of green economy policies: GEM simulates the impacts of green economy policies across sectors prioritized in national sustainable development plans, such as agriculture, forestry, fishery, energy, and mining.
- Generating systemic, cross-sectorial scenarios: GEM generates systemic, broad, and cross-sectorial scenarios over time that address environmental, economic, and social issues in a single coherent framework, simulating the main short-, medium-, and longer-term impacts of investing in a greener economy.
- Incorporating relationships between society, economy, and environment: GEM provides policymakers with a tool that explicitly includes the relationships existing between society, the economy, and the environment, allowing for a better understanding of the dynamics of the system analysed and the design of better policies.

GEM includes four key capitals (physical, human, social and natural) as interconnected via the explicit representation of feedback loops (reinforcing or balancing). Policies can be implemented to strengthen growth (i.e., reinforcing loops) or curb change (e.g., by strengthening balancing loops). In this specific study GEM is used to (1) test the effectiveness of individual policies and investments (by assessing their impact within and across sectors, and for social, economic, and environmental indicators); and (2) inform development planning (by assessing the outcomes of the simultaneous implementation of various intervention options).

7.1.3 Existing Installation

GEM (with Vensim[19] software) was used for the preparation for several countries (just to name some, Hungary, Serbia, Moldova, Indonesia, Ethiopia, Mozambique, Mauritius, and Zambia) for several applications, to analyse and test interventions, supporting climate policy formulation. In Hungary GEM was used for developing the country's long-term low-emission development strategy[20] (decarbonization roadmap).

7.1.4 TRL status

The GEM is fully developed and has been applied in many countries for various uses, at national level. However, for the GEM to be applied at the sub-national/ urban level the model needs to be adjusted accordingly. That would require certain modules of the model such as those related to the national emitting sectors and national macroeconomic indicators to be adjusted to reflect urban emitting sectors and urban economic indicators.

7.2 Technical specifications

Systems Thinking is used as underlying method for the quantitative analysis carried out with the GEM, by combining knowledge and experience in System Dynamics and project finance assessments as well as sectoral assessments (e.g., energy, LULUCF and waste management).

A systems approach is required to identify and estimate relevant criteria for selecting among possible projects and interventions. These include (i) cost-effectiveness analysis; (ii) costing of interventions to improve or reduce risks to investments; and (iii) inequitable risks borne by vulnerable population groups and economic sector (e.g., carbon intensive and trade exposed). These costs can be economic, as well economic valuations of social and environmental outcomes. The framework meets the increasing need to address shared, borderless challenges such as land use change, health, and well-being.

Causal Loop Diagrams (CLDs): system maps are a powerful tool to identify causality using a systems approach, anticipate impacts (both desired and undesired) and test the possible transformational outcomes. A CLD is a map to explore and represent the interconnections between the key indicators in the analysed sector or system. A causal diagram consists of variables connected by arrows denoting the causal influences among the variables. Variables are related by causal links, shown by arrows. It provides information about what would happen if the variable were to change. Practically, the creation of a CLD supports (a) the selection of relevant indicators, (b) the determination of causality among these variables, and (c) the identification of critical drivers of change (e.g., feedback loops, or circular relations) that are the primary responsible for the past, present and future behaviour (or trends) of the system.

Integrated Cost Benefit Analysis (CBA): CBA assess the outcomes of projects on three main components: investments, avoided costs and added benefits. An integrated or extended CBA considers both social and environmental avoided costs and added benefits in addition to the more traditional economic ones.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

[19] https://vensim.com/

[20] https://kormany.hu/dokumentumtar/nemzeti-tiszta-fejlodesi-strategia

Table 12: Technical aspects of the GEM solution

Technical Aspect	Description
Versioning information	Vensim Software, v. 9.3.5
License	The licensed version of the Vensim is available upon purchase. Free downloads are available with limited functionalities (Vensim PLE (Evaluation or Educational), Vensim Model Reader, Molecules).
Online-documentation	https://www.vensim.com/documentation/index.html
Programming Language	Not applicable

7.3 Data Management Overview

The following table represents the respectively data inputs and outputs for the GEM solution.

Table 13: Data inputs and outputs for the GEM solution.

Data Input	Data output/results
• Quantitative MS Excel data. Data sources are required for key indicators in macro economy and relevant sectors e.g., energy, LULUCF, waste, IPPU. • For sectors in which emissions are explicitly modelled, data sources for the estimation of emission factors per unit of activity is required.	• Extended Cost Benefit Analysis • Macroeconomic indicators (e.g., employment, GDP) • Carbon emissions • Energy savings • Others depending on the sectors included.

7.3.1 Data requirements

The model works with specific macroeconomic, environmental, social and sector related data, e.g., population, GDP, employment, energy demand and supply, GHG emissions and carbon stock, agricultural outputs, mining, spatial data (land, road length etc.) and so on, which are used to understand historical and current trends and can be embedded in simulation models. Sector specific data needs depends on the focus of the assessment. Data requirements are crucial for creating and calibrating models, as well as for generating future projections and scenarios to support policy formulation and assessment in the context of green economy interventions. In terms of data requirements all macroeconomic data and indicators should reflect the urban (macro)economic data indicators such as urban GDP, urban employment, etc. Other data needs relate to costs of urban climate mitigation interventions and benefits identified.

Data is populated into MS Excel files that are fed into the Vensim software preparing CLDs and CBA assessments. Data is collected using verified sources such as official statistical information and/or information provided by ministries and other public organizations. The GEM models different scenarios to support decision making and planning in the context of climate policy and planning

7.4 Integration and interoperability plan

Figure 7 shows the integration Gantt diagram of the proposed solution.

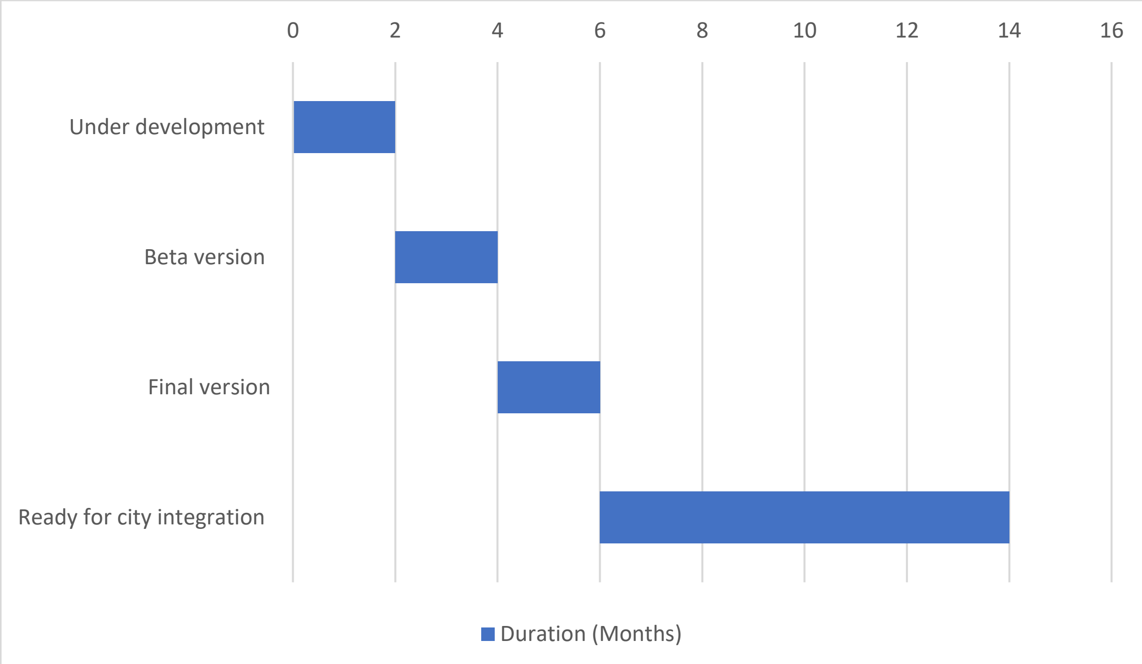

Figure 7. Integration Gantt diagram for the Green Economy Model solution.

- GEM to be applied at sub-national and urban level has to be adjusted, which will require two months. That would require certain modules of the model such as those related to the National emitting sectors to be adjusted to reflect urban emitting sectors. In addition, all macroeconomic data and indicators should be adjusted to reflect the urban (macro)economic data indicators such as urban GDP, urban employment, etc.
- Data collection will take around 2 months.
- Testing and calibrating will take around 2 months.
- Model application and engagement with stakeholders: 6 - 8 months.
-

7.5 Solution limitations

GEM is relatively data intense and requires regular revision to improve its accuracy and granularity. The GEM has been developed to conduct low emission development scenario analysis at the national (wide economy) level. Therefore, it would require additional resources to be customized at the urban level.

7.6 Solution Evaluation

The evaluation of this solution will be defined in the following up months of the project.

7.7 City mapping

As at the end of 2023, three cities have indicated that they are interested in the application of GEM: Thessaloniki, Granollers and Belfast.

Discussions have started about the development of GEM for urban use together with CERTH for development and application in Thessaloniki. Based on first discussion between GGGI and Granollers it was identified that the city would need to apply GEM at a neighbourhood level, which cannot be supported by GEM, even after ‘downscaling’ to urban use. Discussions are still to be held between GGGI and Belfast to address their needs and identify whether GEM could be an appropriate tool for the city to use.

8 Resilience Maturity Model & Risk Systemicity Questionnaire solution

8.1 Introduction

Resilience Maturity Model & Risk Systemicity Questionnaire (RSQ) is primarily a tool for facilitating group discussions about risk scenarios. The solution is provided by ICLEI.

8.1.1 Solution Short Description

The RSQ is intended to support a group's discussions regarding risks that are of importance to their city.

8.1.2 Objectives

The aim of the solution is to provide a tool for reflection and guidance in the resilience building process, that enables cities to develop an analysis of its status and providing a guideline about what the following steps should be from a strategic approach.

8.1.3 Existing Installation

8.1.4 TRL status

The TRL level of this solution will be defined in the following up months of the project.

8.2 Technical specifications

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 14: Technical aspects of the Resilience Maturity Model & Risk Systemicity Questionnaire solution

Technical Aspect	Description
Versioning information	Not applicable
License	It is open access as a deliverable of Horizon 2020
Online-documentation	• https://smr-project.eu/tools/maturity-model-guide/ • https://smr-project.eu/fileadmin/user_upload/Documents/Resources/WP_3/SMR-RSQ-manual-WWW.compressed.pdf
Programming Language	Not applicable

8.3 Data Management Overview

The additional data inputs and outputs /result of this solution among its data requirements will be defined in the following up months of the project.

8.4 Integration and interoperability plan

The integration and interoperability plan of this solution will be defined in the following up months of the project.

8.5 Solution limitations

The solution limitations of this solution will be defined in the following up months of the project.

8.6 Solution Evaluation

The solution evaluation will be defined in the following up months of the project.

8.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

9 UDCW facilitation toolkit/P-GIS (Participatory GIS) solution

9.1 Introduction

The Urban Design Climate Workshops (UDCW) Facilitation toolkit is a family of participatory tools that allow to engage different typologies of city actors (experts: decision makers, city officials, planning/design practitioners; and non-experts: third sector and citizens) in a co-created climate resilient design process. The solution is provided by UCCRN.

9.1.1 Solution Short Description

The toolkit includes:

1. Collaborative mapping through analogue (boards/stickers) or digital (online mapping) tools (with experts and non-experts);
2. Urban Climate Factors/City visions/local needs matching (Priority mapping/co-design exercise with non-experts);
3. A day in the life (Visioning exercise with experts and non-experts);
4. 3D neighbourhood configurator tool (co-design exercise with experts), linked to the 3D Modelling tool – see UDCW simulation tools section – to simplify the development of design proposals to test.

The UDCW Facilitation toolkit supports the implementation of the "Collaborative mapping and co-design" phase of the "UDCW Methodology". It can be used as a standalone toolkit (and its tools as standalone components for partial analyses) but provides significant additional outcomes if used in synergy with the "UDCW Simulation toolkit". The main co-produced data include perception of climate risks, local issues and opportunities, quality of urban spaces, environmental pressures, social capital, socio-spatial issues, infrastructures and service availability, everyday risks, community and stakeholders' priorities.

The technical solution here described is the Participatory Geographic Information System (P-GIS), which is used to incorporate all the information gathered with the engagement of communities and stakeholders. Final mapping can be integrated in a GIS format and used as complementary input in the UDCW Simulation toolkit.

9.1.2 Objectives

The UDCW P-GIS helps creating participatory maps to spatialize and visualise the local knowledge and priorities gathered within the UDCW "Collaborative mapping and co-design" phase, which is usually acquired through a combination of digital and analogue tools, in a single web-based mapping platform (such as open street map). The on-line open-source maps are intended as a platform in which both top-down (expert-driven) and bottom-up (participants) information is seamlessly and available for communities and decision-makers. The tool enables the integration of community knowledge about a neighbourhood/district and guides the contextualizing of design strategies and specific solutions in a specific territory.

UDCW experts develop maps with baseline information that can include qualitative and quantitative data (e.g., data on climate-related risks and other environmental risks, vulnerability of population, building typologies etc.). Through a focus group or a neighbourhood walk the engagement of participants is triggered. They are invited to develop a mapping exercise on physical maps (with stickers) to collect fine-grained bottom-up data highlighting local knowledge components, followed by a priorities' mapping session in relation to possible transformation of the area. These data are depending on the specific aim of the activity and on the specific local focus and issues to be interlinked with climate topics. UDCW experts collect the data and implement digital maps to deliver a public platform of knowledge sharing available for communities and decision makers.

9.1.3 Existing Installation

The P-GIS tool has been implemented in Urban (UCCRN, n.d.)and Naples (Italy). The solution has been used by students and experts for mapping neighbourhoods of Montreuil (Paris) and East Naples to map the quality of the urban spaces, local initiatives, risk perceptions, social hubs, every-day risks.

9.1.4 TRL status

The Participatory Geographic Information System (P-GIS) described above is at a TRL of 5, with technology validated in relevant environments. The system has undergone testing and validation in community-based projects focusing on climate risk assessment and urban fabric analysis. It successfully integrates with existing GIS tools and platforms, demonstrating interoperability through standardized data formats and open-source software compatibility. The P-GIS has been deployed in real-world scenarios, engaging community members effectively and validating its scalability and performance. The system's technology is validated and positioned for further refinement and broader adoption in diverse community settings. Feedback mechanisms are being established to collect insights from users, contributing to ongoing improvements.

9.2 Technical specifications

For visualisation or implementation of P-GIS data with expert-driven GIS data technical aspects refer to GIS tools used by the UDCW simulation toolkit (see technical specifications section of GIS UDCW simulation tools).

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 15: Technical aspects of the Participatory GIS solution

Technical Aspect	Description
Versioning information	Version 1.0
License	Open-source license
Online-documentation	Public documentation will be uploaded to the repository.
Programming Language	Not applicable

9.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the UDCW facilitation toolkit/P-GIS (Participatory GIS) solution.

Table 16: Data inputs and outputs for the Participatory GIS solution.

Data Input	Data output/results
• Format: KML/KMZ; txt.; ESRI Shapefile; DBF or CSV; raster images (.tiff; .jpeg.;.png). • Types: public services; transports; urban functions; historical and cultural landmarks; population; land use; building typologies; other typologies depending on data produced by research	• Format: KML/KMZ; txt.; ESRI Shapefile; CSV; raster images (.tiff; .jpeg.;.png). • Types: social assets; quality of built environment and urban spaces in terms of climate, environment, and services; perception of the built environment or climate change impacts, community priorities.

9.3.1 Data requirements

The additional data requirements will be defined in the following up months of the project.

9.4 Integration and interoperability plan

Figure 8 shows the integration Gantt diagram of the proposed solution.

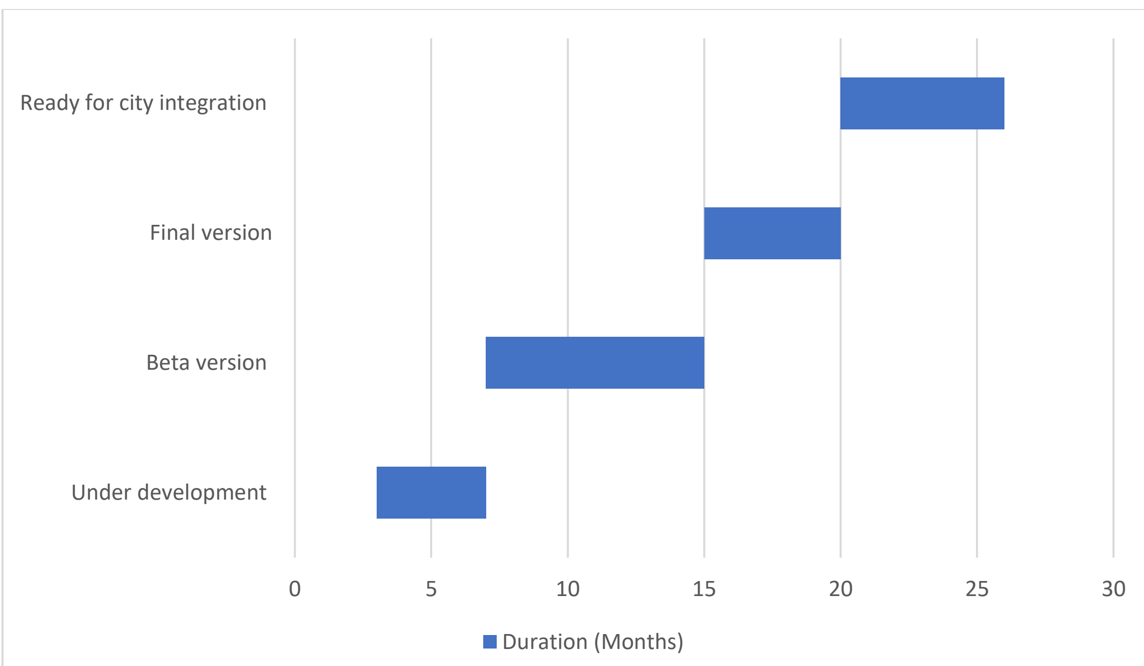

Figure 8. Integration Gantt diagram for the UDCW facilitation toolkit/P-GIS (Participatory GIS) solution.

Interoperability is ensured through the exchange of files readable by all the software platforms involved (.shp, KML, .tiff, .dwg) and the possibility of easily embedding online maps on websites through webGIS APIs.

9.5 Solution limitations

A UCCRN expert (facilitator) to lead the activities is needed or specific training for local experts should be developed for capacity building of city design and planning offices. The collaborative mapping exercises need a strong effort for community engagement. A GIS background is required to integrate data from different sources (bottom-up information from communities or scientific data).

9.6 Solution Evaluation

The solution will be evaluated to the use of surveys to collect, aggregate, and analysing the responses from questions. The survey will be oriented to evaluate community experience in the participation of the mapping, the feasibility of the data collection for facilitators or local experts engaged in the use of the tool.

9.7 City mapping

The solution has not been selected yet for implementation in any of the pilot cities.

10 UDCW simulation toolkit solution

10.1 Introduction

The UDCW simulation toolkit consists in set of IT tools (GIS and 3D Modelling tools) supporting the multi-scale (city to building) planning and design of integrated mitigation and adaptation strategies, with a focus on heat waves and flood hazards and considering urban microclimate effect (due to morphology, land use and cover, building features, etc.). The solution is provided by UCCRN.

10.1.1 Solution Short Description

The tools can measure the climate benefits in terms of adaptation and mitigation measures through fully quantitative indicators, also including a quantitative/qualitative assessment of social, economic, and environmental co-benefits associated to climate resilient development strategies.

The UDCW simulation toolkit supports the implementation of the “Climate Analysis Mapping” and “Planning and Design” phases of the “Urban Design Climate Workshops Methodology”. It can be used as a standalone toolkit (and its tools as standalone components for partial analyses) but provides significant additional outcomes if used in synergy with the “UDCW facilitator toolkit”.

10.1.2 Objectives

Its main objectives are:

- To consider urban climate design principles in city planning, urban and building/open space design.
- To perform robust climate hazard/impact and mitigation/adaptation assessments based on IPCC AR6 and EU Taxonomy/DNSH approaches.
- To streamline the use of quantitative indicators for support multi-scale evaluation of planning and design solutions (urban, neighbourhood and building scale).
- To link climate benefits (mitigation and adaptation) of proposed plans/projects with social, economic, and environmental co-benefits of climate-resilient developments

10.1.3 Existing Installation

A first version of the toolkit has been developed, tested, and improved within several projects (UCCRN ARC3.2; UCCRN ARC3.3; H2020 CLARITY; H2020 ESPREssO; Erasmus+ UCCRN_edu, Horizon Europe KNOWING)

10.1.4 TRL status

The current Technology Readiness Level (TRL) of the solution is 5: technology validated in relevant environment.

In the framework of the projects mentioned in Section 10.1.3, the UCCRN team had the opportunity to develop and test the UDCW simulation tools in several application cases for both educational (workshops, master’s degree Courses, etc.) and research purposes. The tests were carried out in several cities at a multiscale level. To cite some examples: Paris, Barcelona, Naples, Aalborg, Dublin, Durban, and others

10.2 Technical specifications

The set of IT tools (GIS and 3d Modelling Algorithm Aided Design (AAD) tools) that composes the solution operates at different scales. Depending on the specific type of output or indicator to be assessed, each tool can be classified into different categories: weather data projection and visualisation, performance simulation, climate analysis mapping and meta-design modelling tools.

Through GIS, one can run a series of models that provide a quantitative and spatialized analysis of the climate benefits of urban-scale planning/design scenarios, as well as characterize the impacts of certain climate change-related risks (heat wave, pluvial and coastal flooding, energy consumption, CO_2 absorption potential)

From a technical point of view, GIS tools consist of a set of algorithms programmed through PostgreSQL and python, which use from a 2.5D model, i.e., two-dimensional but with some three-dimensional character information (shading, sky view factor, etc.), of an urban space and a set of information characterizing it, to be used as input. Each algorithm is programmed to produce one or more outputs in relation to various impact indicators.

AAD tools provides a fully quantitative and spatialized analysis of climate benefits of planning/design scenarios at the neighbourhood scale. Quality of outcomes is measured against observed historical data and available statistics.

From a technical perspective, the AAD tools consist of a set of algorithms programmed through Grasshopper, the Visual Programming Language (VPL) for Rhino (McNeel), implemented with various plug-ins: EleFront [21](metadata generation and management), Ladybug Tools[22] (environmental design and energy simulation), URBANO[23] (GIS interoperability) and various custom python components. Starting from a 3-dimensional model of an urban space and a set of information characterising it, to be used as input.

The toolkit is offered as a service, so it doesn't require a License.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 17: Technical aspects of the UDCW simulation toolkit solution

Technical Aspect	Description
Versioning information	Version 1.0
License	The toolkit is offered as a service, so it doesn't require a License
Online-documentation	Public documentation will be provided with the solution.
Programming Language	• GIS tools ○ Qgis 3 ○ PostgreSQL

[21] https://www.food4rhino.com/en/app/elefront
[22] https://www.food4rhino.com/en/app/ladybug-tools
[23] https://www.food4rhino.com/en/app/urbano

	○ PostGIS • 3D modelling/AAD tools ○ Rhinoceros (McNeel) SR 7 ○ Python Grasshopper plug-ins: ○ Ladybug Tools (at least v1.5) ○ EleFront v5.1.1 ○ Urbano

10.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the UDCW simulation toolkit solution.

Table 18: Data inputs and outputs for the UDCW simulation toolkit solution.

Data Input	Data output/results
• GIS tool ○ Types: climate data (air temperature, solarradiation and position, rain amount); landuse (building, open spaces, vegetation features); population distribution (number of people, age of people) ○ Format: TXT, CSV, EPW (climate data), ESRI Shapefile, Geopackage .gpkg, Raster .tiff, .asc, ecc. (landuse); ESRI Shapefile (population distribution) • 3D modelling/AAD tools ○ Types: district scale 3D models, landcover, building features (construction, Window to Wall Ratio, Hvac, etc), open space features (trees, surfaces thermal properties, etc) ○ Format: .3dm (geometries), .csv (landuse and building features)	• GIS tools ○ Types: Universal Thermal Climate Index (UTCI) [°C], Mean Radiant Temperature (TMRT) [°C], Hospitalisation costs [€], Mortality rate [%], Probability of propensity to flood (qualitative), Restoration costs for Buildings [€], Restoration costs for Roads [€], Energy consumption (urban scale) [kWh/m2] ○ Format: ESRI Shapefile, Geopackage (.gpkg), raster (geoTIFF), geoJSON, image(jpeg, png). • 3D modelling/AAD tools ○ Types: projected climate data, 2d maps and graphs reporting: Universal Thermal Climate Index (UTCI, [°C] Mean Radiant Temperature (TMRT), Predicted Mean Vote [PMV]; Weather Data (air temperature, relative humidity, wind speed, etc.), Energy consumption (single building or neighbourhood scale) [kWh/m2]

	○ Format: .3dm (geometries), .tiff (graphs and maps), .png (graphs and maps),. epw (projected weather data)

10.3.1 Data requirements

All the software included in the solution are compatible with a lot of open data format and some specific GIS and 3D proprietary formats.

Although UDCW offers the simulation tools as a service, proper use of the technical solution requires some basic knowledge of GIS and 3d modelling in Rhinoceros.

In addition, a proper familiarity with the operation of climate data in Energy plus format (epw) facilitates interoperability and guarantees better results when using the solution.

10.4 Integration and interoperability plan

Figure 9 shows the integration Gantt diagram of the proposed solution.

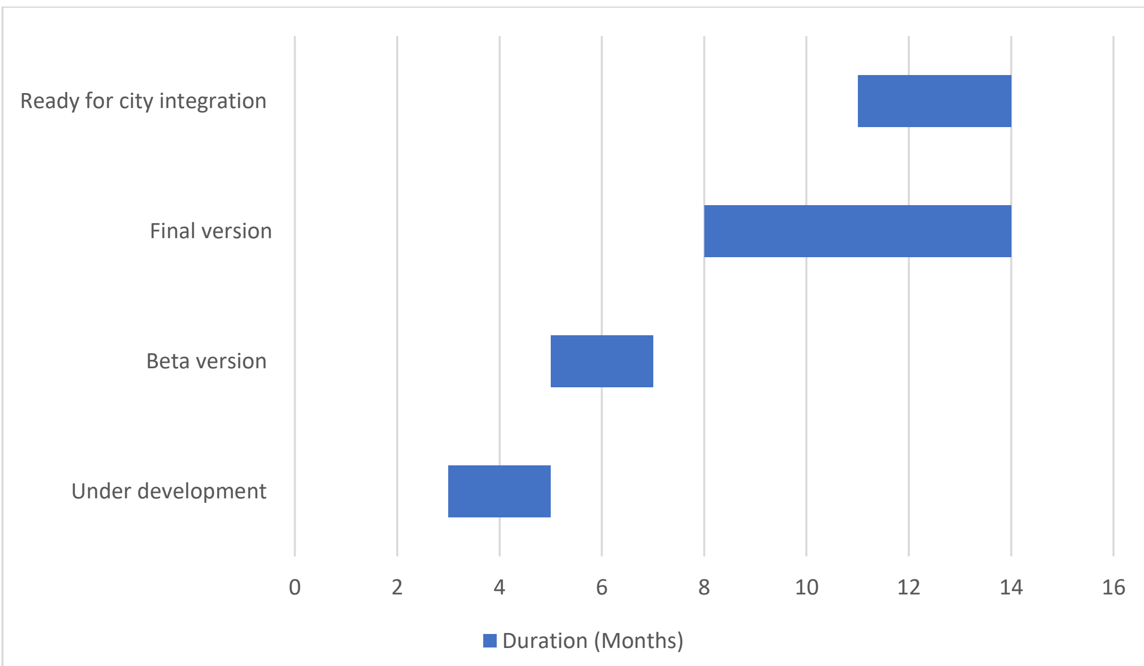

Figure 9. Integration Gantt diagram for the UDCW simulation toolkit solution.

The interoperability is ensured through the exchange of files readable by all the software platforms involved. The support of custom algorithms streamlines the process of files/data exchange.

To ensure a proper data exchange among all the systems, the interoperability steps proposed are: objectives and requirements definition; selection of the standards; definition of data and software; implementation of Web services; data quality assurance; Integration with Existing Systems; User authentication and authorization; Interoperability Testing; results evaluation; documentation; feedback mechanism; legal and Ethical Considerations.

10.5 Solution limitations

UDCW simulation tools are particularly specialised computational tools. For this reason, they need an adequate technical and IT background to be used correctly.

Local authorities must be supported by technically qualified experts in the preparation of the files within GIS and Rhinoceros software environments, based on a guide provided by UCCRN.

UDCW simulations are generally provided as a service by UCCRN EU team, based on specific end-user requirements and user-tailored workflows.

In addition to technical knowledge in the field of environmental planning/design and climate-resilient development, operators should have an adequate knowledge of GIS and 3D modelling software. The 3D neighbourhood configurator (see UDCW Facilitation toolkit section) has been developed to simplify the modelling input from a designer's perspective, while specific taxonomies have been made available through a user guide to help the preparation of city/district plans in GIS consequent targeted simulations.

10.6 Solution Evaluation

The effectiveness of the technical solution will be tested through comparison with other similar validated systems and through a user satisfaction questionnaire.

10.7 City mapping

The solution will be tested in the city of Rio de Janeiro. Other pilot cities for tests have yet to be defined.

11 Resilience strategies database and tool solution

11.1 Introduction

The Resilience Strategies Database and Tool is a solution resulting from the H2020 RESCCUE project (https://toolkit.resccue.eu/) that helps decision makers choose the most cost-effective solutions to maximize cities' resilience to climate. The solution is provided by AUATEC/LNEC.

11.1.1 Solution Short Description

Resilience strategies database and tool is a solution that assists decision makers to select the most efficient measures, in terms of both their costs and the degree of risk reduction that they can guarantee, to optimally increase cities' resilience to climate change.

11.1.2 Objectives

As data is scarce in some situations, the methodology behind this platform is flexible and two assessments can be conducted: preliminary and detailed. The first will provide a rank of climate adaptation measures for a specific strategy. In case enough information is available a detailed assessment may follow a process to analyse the effectiveness of adaptation scenarios (i.e., a set of measures acting jointly) according to user-defined prioritization criteria. Graphs are provided at the end of the process to summarize the results.

11.1.3 Existing Installation

The Resilience Strategies Database and Tool has been used, in the framework of RESCCUE project, by the cities of Barcelona, Bristol and Lisbon during the process of developing a Resilience Action Plan for the cities.

11.1.4 TRL status

Current TRL value of the solution is 8.

11.2 Technical specifications

The platform includes an extensive database of climate change adaptation measures gathered by the different project partners of RESCCUE project (www.resccue.eu) based on their experience in building resilience at Barcelona, Bristol, and Lisbon.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 19: Technical aspects of the Resilience strategies database and tool solution

Technical Aspect	Description
Versioning information	First version available at: https://adaptationstrategies.resccue.eu/
License	No license (free)
Online-documentation	https://adaptationstrategies.resccue.eu/faqs

Programming Language	Not applicable

11.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Resilience strategies database and tool solution.

Table 20: Data inputs and outputs for the Resilience strategies database and tool solution.

Data Input	Data output/results
• The user must initially select the main objectives for the strategy: • The target climate hazard to be addressed by the strategy: flooding, combined sewer overflows, sea level rise, drought, heatwaves, or compound events. • The key benefits targeted: citizen's engagement, climate hazard reduction, exposure reduction, capacity building, etc. • Type of measure: Structural or non-structural measures • Spatial scale of the strategy: building, neighborhood, city, etc. • Urban sector/service to address • Adaptation or mitigation target • Secondly, the user selects those measures that interest him/her most. • Finally, the user is requested to introduce a weight to each one of the economic, social, or environmental co-benefits associated with each one of the measures, an implementation cost and an effectiveness indicator.	• Based on the user's inputs, the platform finally ranks the measures based on 4 parameters: • Cost-effectiveness assessment (ratio Investment over effectiveness indicator and co-benefits) • Economic co-benefits • Social co-benefits, and • Environmental co-benefits • The weight of each parameter is adjustable according to your specific interests. • Based on the available information when tailoring the adaptation measures, the user would be also able to analyze and compare between adaptation scenarios (i.e., sets of measures) according to his/her own prioritization criteria.

11.3.1 Data requirements

The following data must be introduced by the user in order to obtain results.

For the use of the database:

1. Selection criteria to filter available adaptation measures.
2. Complete description if new measures are added (including co-benefits).

For the use of the Decision Support tool:

1. The user must initially select the main objectives for the resilience strategy including:

a. The target climate hazard to be addressed by the strategy: flooding, combined sewer overflows, sea level rise, drought, heatwaves or compound events.

b. The key benefits targeted: citizen's engagement, climate hazard reduction, exposure reduction, capacity building, etc.

c. Type of measure: structural, non-structural, etc.

d. Spatial scale of the strategy: building, neighbourhood, city, etc.

e. Urban sector/service to address

f. Adaptation or mitigation target

2. The user selects those measures that interest him/her most.

3. Finally, the user is requested to introduce a weight to each one of the economic, social or environmental co-benefits associated with each one of the measures, an implementation cost and an effectiveness indicator.

11.4 Integration and interoperability plan

Figure 10 shows the integration Gantt diagram of the proposed solution.

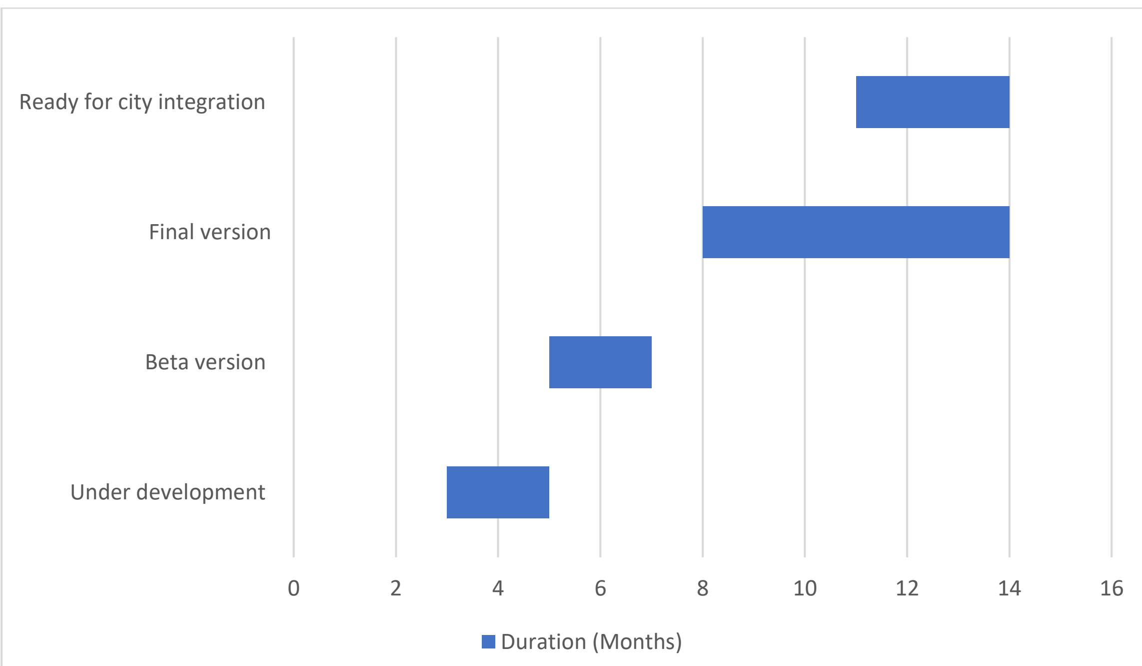

Figure 10. Integration Gantt diagram for the Resilience strategies database and tool solution.

The Resilience Strategies Database and Tool can be directly used by cities looking for technical support when selecting a resilience strategy for the whole city or a specific neighbourhood. In a single session, the functionality and operation of the solution can be shown to the end user, who could use it directly or with the help of the developer (Aquatec). Results can be obtained in a matter of a few hours, as long as the data required by the platform is available: implementation costs for each measure, criterion and variable(s) for prioritisation, etc.

As previously commented, the database is formed by around 200 measures, most of the climate change adaptation measures. It can be though fed with mitigation measures, as long as a detailed description of such measures was provided.

11.5 Solution limitations

A minimum set of data must be provided to allow the database and tool to perform the prioritization. This includes:

- Selection criteria to filter available adaptation measures.
- Complete description if new measures are added (including co-benefits).
- Implementation cost and effectiveness indicator (type and value) for each selected measure.
- Weights to prioritization criteria. Default prioritization criteria are set (cost-effectiveness and co-benefits for measures and cost for strategies) but new criteria can be added to prioritize strategies.

If just looking for mitigation measures or strategies this can be also a limitation given that the database currently includes very few examples of mitigation measures, although, as explained, mitigation measures can be included as long as the user enters all the required information.

11.6 Solution Evaluation

The solution will be evaluated by checking if obtained results are useful or not for meeting the pilot objectives. In the case of Granollers, UP2030 pilot objectives are:

1. Designing La Bòbila to be a net-zero emissions neighbourhood
2. Implementing cross-cutting climate mitigation and spatial justice tools to assess future urban planning
3. Identifying the balance between grey and blue/green infrastructure
4. Maintaining inclusion and equity and preventing gentrification

After testing the solution, a small document will be prepared justifying:

- How the results obtained by the Resilience Strategies Database and Tool contribute to each of the identified objectives.
- How the results obtained will be integrated or used in the following planning phases of the pilot.

11.7 City mapping

The Resilience Strategies Database and Tool will be tested in Granollers (la Bobila sector pilot) during January'24-March'24. Part of the obtained results will be included, as an input, to the second tool that will be tested in Granollers: The Data driven geospatial analysis and parametric design from TSPA.

12 Liveable Cities Index methodology solution

12.1 Introduction

The Liveable Cities Index methodology is designed to determine the overall or sectoral health situation of cities (environmental, economic, social) through the integration of a variety of variables and measurement parameters gathered from public data. The result is an aggregated index of liveability which provides cities with a decision-making tool to identify their weaknesses and options for improvement related to society, environmental quality, health, land use, and resources. The solution is provided by CETAQUA.

12.1.1 Solution Short Description

The Liveable Cities Index methodology is a multi-method tool using 75 indicators distributed in 5 categories - Society, Environmental Quality, Health, Land Use, and Resources. The result is an aggregated index of liveability and a liveability ranking, with the possibility to disaggregate the index according to each category. Through the collection of public municipal data, the Liveable Cities Index methodology provides either an overall or sectoral picture of the cities' health situation, giving direct results that allow the identification of improvement points. The comparability element of the tool provides a global picture where each city can learn by comparing the assessment with other cities. On the other hand, the Liveable Cities Index methodology can also be applied to a more local scale by selecting neighbourhoods or regions as the object of the assessment, thus offering a more disaggregated final picture.

12.1.2 Objectives

The overall objective of the Liveable Cities Index tool is the identification of specific services and solutions for the improvement of individual indicators. The methodology aims to provide a liveability index and a subsequent ranking to determine the health situation of cities through indicators related to society, environmental quality, health, land use, and resources. Through disaggregated index calculations, cities obtain relevant information as a result of disaggregated index calculations, cities obtain relevant information to support different areas of sustainable development and to facilitate more efficient budget allocation decisions.

12.1.3 Existing Installation

The methodology has been used to assess 25 Spanish cities following a Cetaqua project with Dinapsis: 1.Alicante, 2.Avilés, 3.Barcelona, 4.Benidorm, 5.Calviá, 6.Cartagena, 7.Ciudad Real, 8.Gavà, 9.Granada, 10.La Laguna, 11.León, 12.Madrid, 13.Marbella, 14.Murcia, 15.Orense, 16.Pontevedra, 17.Rincón de la Victoria, 18.Roquetas de Mar, 19.San Fernando, 20.Santiago de Compostela, 21.Tarragona, 22.Telde, 23.Torremolinos, 24.Torrent, 25.Torrevieja

12.1.4 TRL status

The approximate TRL of the solution is estimated to be around 8, as it is an interpretation through the aggregation of indicators.

12.2 Technical specifications

Liveable Cities Index is used as an Excel/ Google Sheet tool, however an API used to be existed in past developments. The solution uses public data, so no identified risks in terms of security were recognized. In addition, as the solution comes as an Excel/Google Sheets for data collection, there is no interface. However, there is a possibility for later developments of a graphical interface.

Based on the Excel/ Google Sheet that the solution provides, the target is to obtain all this information from municipal public sources, calculate the liveability index and offer this result as a decision-making tool for cities to detect their weaknesses and options for improvement.

In order to understand the activity, organisation and other information about the city, preliminary contact sessions will need to be set up. Once these meetings are held, data collection will be carried out by us through public sources. The city will only need to assist in answering specific questions or providing access to data. Thereafter, to calculate the liveability index, the data will be converted to rates to be able to compare and rank each city dataset. The Z-score method will be used for data normalisation and the aggregation of indicators will be done through linear aggregation by symmetric weights.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 21: Technical aspects of the Liveable Cities Index methodology solution

Technical Aspect	Description
Versioning information	No versioning
License	No license (free)
Online-documentation	Not applicable
Programming Language	Not applicable as it is an Excel/google sheet

12.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Liveable Cities Index methodology solution.

Table 22: Data inputs and outputs for the Liveable Cities Index methodology solution.

Data Input	Data output/results
○ • Data from municipal public sources: ○ Resources, e.g. volume of water reused, proportion of waste going to controlled landfill, reported energy consumption. ○ Environmental Quality, e.g. annual NO2 limit value, number of vehicles in the municipality, average monthly maximum temperature.	• Liveable aggregated index • Final ranking and generation of illustrative graphs per category

○ Land Use, e.g. green urban area, population density, artificial surface area. ○ Health, e.g. hospitals, the gender gap in life expectancy at birth, road traffic fatalities, obesity. ○ Society, e.g. budgetary burden of rental housing, unemployment rate, average disposable income, electric vehicle charging points. ○	

12.3.1 Data requirements

The solution is a based and uses public data.

12.4 Integration and interoperability plan

Figure 11 shows the integration Gantt diagram of the proposed solution.

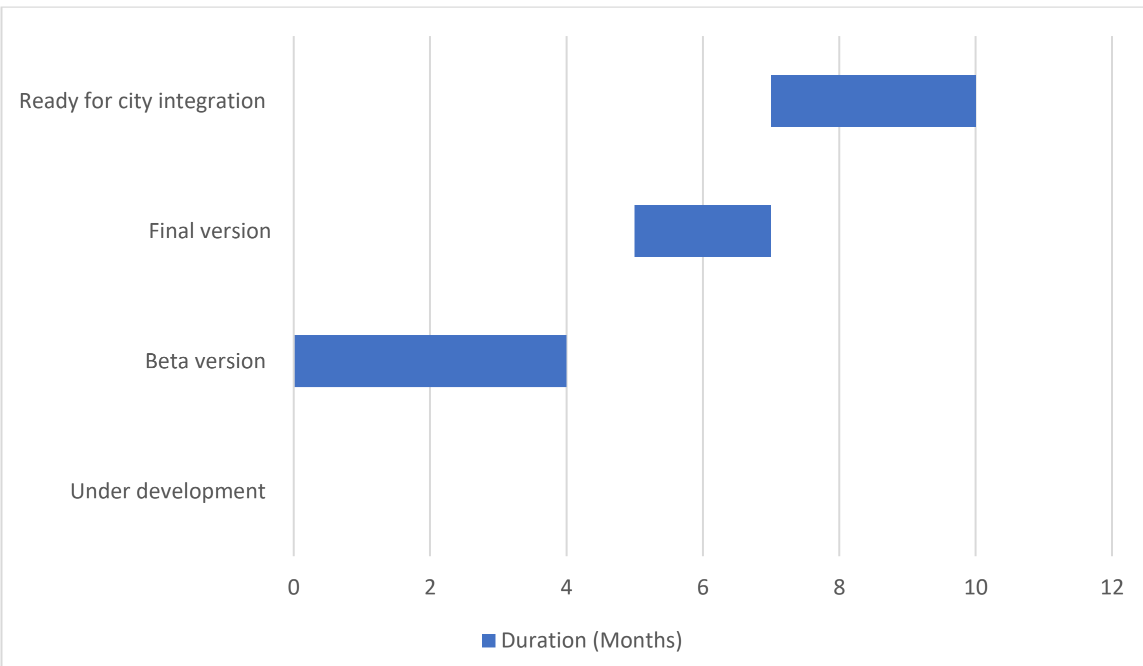

Figure 11. Integration Gantt diagram for the Liveable Cities Index methodology solution.

The idea would be to further refine the tool to make it as intuitive, self-explanatory, and functional as possible. The final product would be an Excel/Google Sheet that allows for data collection of inventories and at the same time can be used to interpret this data.

The MS Excel/Google Sheet based Liveable Cities Index will be built up through 5 main steps:

- Selection of categories representative of our objective (balance between what exists and what is needed),
- Selection of feasible and relevant indicators
- Search for open data from public sources
- Data aggregation and index calculation - Transformation to rates → comparability of cities - Normalisation → aggregation of indicators
- Result: liveable Cities Index and Ranking
-

12.5 Solution limitations

There are no apparent limitations except for possible limitations in data collection regarding municipal data accessibility.

12.6 Solution Evaluation

Excel/ Google Sheet forms will be used for data collection.

12.7 City mapping

Now there are no plans to use it in any pilot city.

13 Water-smartness Assessment Framework Tool for circularity in the urban water cycle solution

13.1 Introduction

The Water-smartness Assessment Framework Tool is an objective-driven comprehensive framework and tool (web-based dashboard) that was developed to support multi-stakeholder and strategic decision-making towards the transition to a water-smart society developed under H2020 B-Water Smart project[24]. The solution is provided by LNEC.

13.1.1 Solution Short Description

The tool is an assessment tool itself with a consistent portfolio of Key Performance Indicators (KPIs) for supporting the development and the monitoring of a strategic plan for a water-smart organisation or territory and related issues of environmental concern.

13.1.2 Objectives

The tool allows measuring the performance towards five strategic objectives "Ensuring water for all relevant uses", "Safeguarding ecosystems and their services to society", "Boosting value creation around water", "Promoting adaptive change towards resilient infrastructure", and "Engaging citizens and actors across sectors in continuous co-learning and innovation", aligned with 15 assessment criteria and materialised in 60 indicators/indices' [25]

13.1.3 Existing Installation

The tool has been developed and used in the scope of H2020 B-Water Smart project.

13.1.4 TRL status

The solution is on level of TRL 4

13.2 Technical specifications

The tool can be used at different scales (local, city, metropolitan, regional). It uses indicators to assess water-smartness addressing technical, economic (circular economy), societal (governance, policy, acceptability), environmental, and risk dimensions. It is grounded on existing established frameworks and tailored to support UN SDGs. Using an integrated approach, the framework aspires to constitute an assessment tool to be applied at the strategic level of decision-making. The framework is fully developed, and the web-tool is in development until august 2024.

The tool has been used and co-developed with the 6-living lab [26] owners (hosts) of the B-WaterSmart project Alicante (Spain), Bodo (Norway), Esat Frisia (Germany), Flanders (Belgium), Lisbon (Portugal), Venice (Italy).

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

[24] https://b-watersmart.eu/
[25] https://bwatersmart.eu/results-downloads/water-smartness-assessmentframework/
[26] https://bwatersmart.eu/living-labs/

Table 23: Technical aspects of the Water-smartness Assessment Framework Tool solution

Technical Aspect	Description
Versioning information	The information will be available only after August 2024
License	Free
Online-documentation	https://b-watersmart.eu/results-downloads/water-smartness-assessmentframework/
Programming Language	○ For the methodology N/A. ○ For the software the information will be available only after August 2024

13.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Water-smartness Assessment Framework Tool solution.

Table 24: Data inputs and outputs for the Water-smartness Assessment Framework Tool solution.

Data Input	Data output/results
○ The inputs are variables such as water volumes (treated wastewater, reclaimed water, operational variables (number of samples, number of days, energy used,), demographic data, (number of households, residents), among others.	○ Values of indicators and respective classification.

13.3.1 Data requirements

Even if you need to provide the required data input for the assessment, no specific data requirements are needed to use the tool.

13.4 Integration and interoperability plan

Figure 12 shows the integration Gantt diagram of the proposed solution.

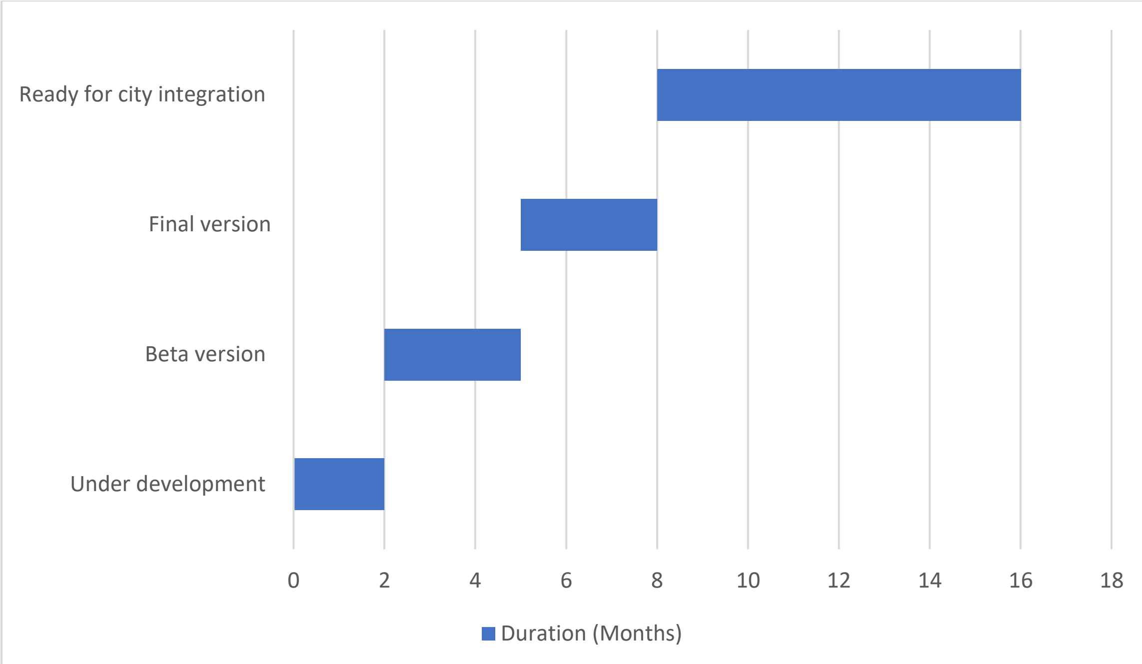

Figure 12. Integration Gantt diagram for the Water-smartness Assessment Framework Tool for circularity in the urban water cycle solution.

This tool will offer the possibility to input values or metrics' values using formats from an interface file as excel or Jason file. This would facilitate to input data from other tools or platforms existing in the organization; and will provide PDF reports.

13.5 Solution limitations

The only limitation of the solution is that addresses water-related issues.

13.6 Solution Evaluation

The evaluation may be obtained based on a questionnaire.

13.7 City mapping

Although bilateral meetings are taking place with the cities of Lisbon and Milan, it is not yet possible to confirm the cities that the tool will be used.

14 Resilience Assessment Framework Tool for resilience strategies solution

14.1 Introduction

In the framework of H2020 RESCCUE project [27] the Resilience Assessment Framework (RAF) was developed to support resilience assessment and inform about the opportunities to improve resilience and selection of resilience measures for its enhancement, as well as the effect of resilience measures on each dimension of urban resilience. It can be integrated in the Resilience strategies database and tool by Aquatec and LNEC. This solution is provided by LNEC.

14.1.1 Solution Short Description

The methodology and web-tool constitute an assessment tool itself with a consistent portfolio of indicators for supporting the development and the monitoring of a resilience plan for a territory or a service. The tool is objective driven. The assessment allows to identify development levels, ranging from the whole city to a more detailed assessment regarding a specific service framework that guides you to undertake a structured urban resilience assessment to climate change. It considers four dimensions in the city, namely organisational integrating top-down governance relations and urban population involvement; spatial referring to urban space and environment; functional regarding resilience of strategic services and physical that looks at resilience of infrastructures.

14.1.2 Objectives

The framework is objective-driven being the objectives identified for each dimension. It enables you to assess the development level of city resilience, considering the contribution of strategic services and their inter-dependencies to the city resilience. Services included are water supply, wastewater, stormwater and waste management, electrical energy distribution and mobility. The RAF allows a stepwise process going into a gradual depth assessment, depending on the resilience maturity of a city. It may also be applied at other spatial scales, as district level.

14.1.3 Existing Installation

RAF has been used in Barcelona [28](Spain), Bristol [29](UK) and Lisbon [30](Portugal) within the RESCCUE H2020 project.

14.1.4 TRL status

The solution is on level of TRL 6

14.2 Technical specifications

The RAF app, the web application main interface materializes several menus that present to the user the RAF structure in a dynamic way. After authentication, the user can manage his previously created studies, insert new information or check results.

[27] www.resccue.eu
[28] https://toolkit.resccue.eu/wp-content/uploads/2020/11/Barcelona-Resilience-Action-Plan_Toolkit.pdf
[29] https://toolkit.resccue.eu/wp-content/uploads/2020/11/Bristol-Resilience-Action-Plan_Toolkit.pdf
[30] https://toolkit.resccue.eu/wp-content/uploads/2020/11/Lisbon-Resilience-Action-Plan_Toolkit.pdf

Each study takes the user through several categories of information required, including among others the historic records of climate-related events and a description of city services and infrastructures. This information is processed on-the-fly, and several indicators of the RAF are calculated, organized along resilience dimensions, objectives, criteria, and metrics. After the results generation, these can be explored by the user and graphically visualised.

RAF App has a typical Django web app architecture, containing the Frontend where the user interaction components are and the Backend containing the web framework itself and the application database.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 25: Technical aspects of the Resilience Assessment Framework Tool for diagnosis and resilience strategies solution

Technical Aspect	Description
Versioning information	Latest
License	Free
Online-documentation	○ https://toolkit.resccue.eu/wp-content/uploads/2020/10/RESCCUE-e-book_Final-version_EC_web.pdf ○ https://toolkit.resccue.eu/all-tools/ ○ https://toolkit.resccue.eu/wp-content/uploads/2020/12/D6.5.pdf
Programming Language	RESCCUE RAF App has a typical Django web app architecture, containing the Frontend where the user interaction components are and the Backend containing the web framework itself and the application database.

14.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Resilience Assessment Framework Tool for resilience strategies solution.

Table 26: Data inputs and outputs for the Resilience Assessment Framework Tool for resilience strategies solution.

Data Input	Data output/results
• The user answers predefined questions. To get the assessment information through several categories, it is required as, among others, the historical records of climate-related events, consequences, and a description of city services and infrastructures.	• The application provides instant results after data input from the user. The app uses resources from Infraestrutura Nacional de Computação Distribuída (INCD) as computation and storage. • Output are tables and graphics with information on the level of resilience

	development for a city, a resilience dimension, an urban service, a resilience objective, or metrics

14.3.1 Data requirements

Even if you need to provide the required data input for the assessment, no specific data requirements are needed to use the tool.

14.4 Integration and interoperability plan

Figure 13 shows the integration Gantt diagram of the proposed solution.

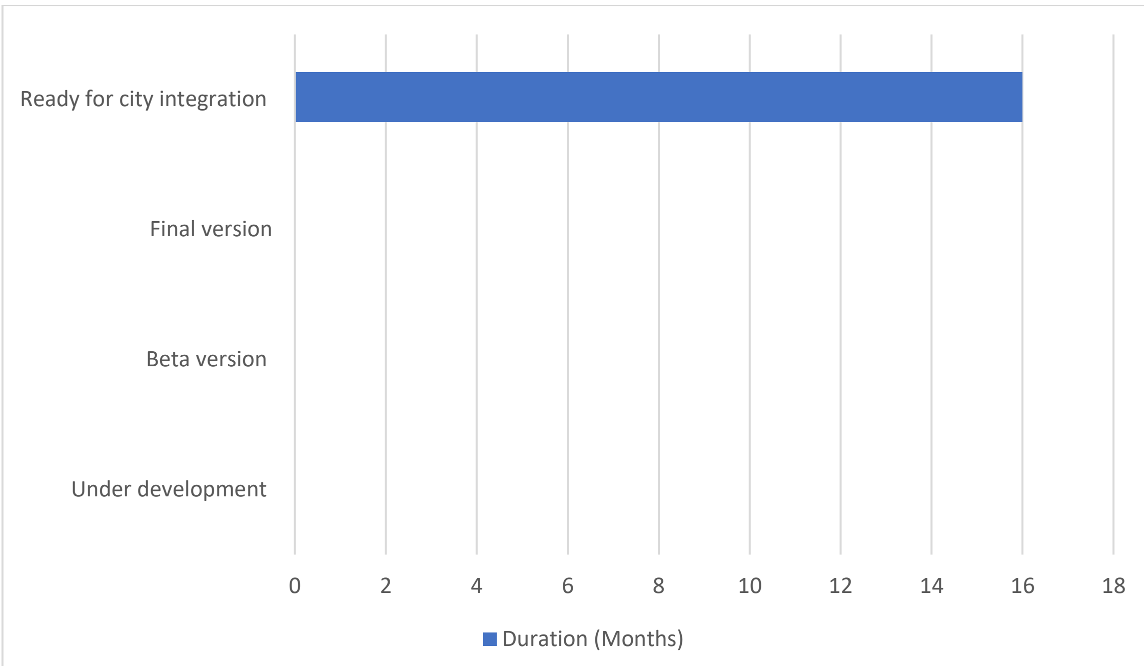

Figure 13. Integration Gantt diagram for the Resilience Assessment Framework Tool for resilience strategies solution.

This tool is not integrated into other systems and platforms but allows exportation of results to excel/csv and PDF reports.

14.5 Solution limitations

The solution addresses urban resilience to climate change with focus on water for the dimensions presented.

14.6 Solution Evaluation

The evaluation may be obtained based on a questionnaire.

14.7 City mapping

Although bilateral meetings are taking place with the cities of Lisbon and Milan, it is not yet possible to confirm the cities that the tool will be used.

15 AI-powered toolset for the decarbonisation of buildings & transport solution

15.1 Introduction

The solution is a machine learning based approach for estimating and matching energy demand with energy generation. This solution is provided by METU/ODTU GUNAM.

15.1.1 Solution Short Description

The solution provides an Urban-scale modelling, simulation and machine learning based calculation of (a) building energy consumption and energy retrofit options for years 2020 and 2050 (b) BIPV energy generation (c) determination of e-scooter charging stations and associated energy demand, and (d) conducting feasibility analysis and designing of controller.

15.1.2 Objectives

The objective of the tool is to support decision-making for carbon neutrality of cities with building, PV and e-mobility integrated approach. In this regard, the tool utilizes deep learning and other machine learning approaches to estimate: (I) Energy to be consumed by different energy consumers in the same time window (Model 1), (II) Energy to be generated by solar panels in a certain time window (Model 2), (III) optimized locations of PV-integrated e-vehicle charging stations (Model 3).

The data required for developing and training these machine learning models will be obtained as follows:

- Data for Model 1: 3D models of buildings in a selected neighbourhood will be obtained. The geometric data of these buildings (building footprints, building heights, etc.) as well as the semantic data (thermal insulation properties, window to wall ratio, number of occupants, etc.) will be collected. With these data, simulation software will be used to calculate the amount of energy consumed by the buildings.
- Data for Model 2: 3D models of buildings in a selected neighbourhood will be obtained. Virtual solar panels will be added on rooftops in a simulation environment and based on weather & solar orientation, the amount of energy to be generated will be calculated.
- Data for Model 3: Travel data (start location, start time, end location, end time) of e-vehicles.

The solution also considers obtaining data for mobile energy consumers (e.g., e-cars, e-bikes, e-scooters) while it will provide feasibility analysis for integration of e-mobility (e-bike and/or e-scooter) and PV electricity generation and a real-time control of micro e-mobility (e-bike and/or e-scooter) and PV electricity generation co-deployment.

15.1.3 Existing Installation

There is no existing installation yet. However, in the pilot area selected with IMM, a PV integrated urban furniture will be designed and installed fabricated which can support various functions such as PV supported charging, sitting and socializing area.

15.1.4 TRL status

The current TRL of the solution is 3.

15.2 Technical specifications

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 27: Technical aspects of the AI-powered toolset for the decarbonisation of buildings & transport solution

Technical Aspect	Description
Versioning information	This technology is going to be developed within the project. Parts of it (energy modelling and simulation-based analysis of building energy performance calculation, and machine learning based prediction) have been developed previously and implemented for two other neighbourhoods in Turkey.
License	TBD
Online-documentation	TBD
Programming Language	Python for machine learning, EnergyPlus for building energy modeling, PVWatts for PV modelling

15.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the AI-powered toolset for the decarbonisation of buildings & transport solution.

Table 28: Data inputs and outputs for the AI-powered toolset for the decarbonisation of buildings & transport solution.

Data Input	Data output/results
• Building information, Geometric data (related with 3D model), material, loads etc.), semantic data (loads, insulation materials, etc.), weather information, • PV panel characteristics, weather information. • Electric power demand (hourly consumption), e-scooter/e-bike battery information, e-scooter/e-bike utilization information (use times, energy demand, start location, end location etc.)	• Energy demand estimation for the current year and 2050, as well as energy retrofit scenarios. • Energy generation estimation from PV. • charging schedule for e-vehicles, Location of PV-integrated charging batteries of e-vehicles

15.3.1 Data requirements

The following tables shows data requirements for Model 1, Model 2, and Model 3, respectively.

Table 29: Data requirements for Model 1

	Abbreviation	Definition	Unit
Geometric Data			
	bldlayout	Footprints of building	
	bldgheight	The height of the building	
	zonedivision	Information about how each building is divided to zones	
Semantic Data			
	U_{wall}	Thermal transmittance of wall	W/m^2K
	U_{roof}	Thermal transmittance of roof	W/m^2K
	U_{ground}	Thermal transmittance of ground	W/m^2K
	U_{window}	Thermal transmittance of window	W/m^2K
	wwr_N	Window to wall ratio in north direction	%
	wwr_W	Window to wall ratio in west direction	%
	wwr_S	Window to wall ratio in south direction	%
	wwr_E	Window to wall ratio in east direction	%
	PPL	Number of people per square meter	$people/m^2$
	η_{boiler}	The efficiency of boiler	%
	Infiltration	The ratio of air leakage	
	SHGC	Solar heat gain coefficient of window	
	LPD	Lighting power density	W/m^2
	EPD	Equipment power density	W/m^2
	$T_{heating}$	The heating set point for thermostat	°C
	SE_N	The visible sky ratio from north direction (calculated from energy models)	%
	SE_W	The visible sky ratio from west direction (calculated from energy models)	%

	SE_S	The visible sky ratio from south direction (calculated from energy models)	%
	SE_E	The visible sky ratio from east direction (calculated from energy models)	%
Climate Data			
	$T_{outside}$	Dry bulb temperature	°C
	HDD	Heating degree days	°C
	CDD	Cooling degree days	°C
	GHR	Global horizontal radiation	W/m^2

Table 30: Data requirements for Model 2

	Abbreviation	Definition	Unit
Panel related			
	Panel_efficiency	The percentage of incident solar energy that is converted to electricity	%
	Panel_area	The area of the PV surfaces	m^2
	Age	The age of the PV panels	-
	Panel_tilt	The slope angle at which solar panels are mounted to face the sun	°
	Panel_azimuth	The angle between the projection of sun rays and a line due south or north	°

Shading related			
	Annual shading	Thermal transmittance of wall	W/m^2K
Climate Data			
	Dry_bulb_aver	Average of dry bulb temperature	°C
	HDD	Heating degree days	°C
	CDD	Cooling degree days	°C
	GHR_aver	Average of global horizontal radiation	W/m^2

Table 31: Data requirements for Model 3

	Abbreviation	Definition	Unit
Building related			
	Building coordinates	The coordinate points of each building	
	Qelectricity	Electricity energy consumption of buildings	kWh/m^2
PV related			
	Qelecproduction	Electricity energy production from PV	kWh/m^2
Mobility related			
	start_loc	The starting point of each drive	
	end_loc	The end point of each drive	

15.4 Integration and interoperability plan

We want to show our process based on the proposed models. The following figures shows the integration Gantt diagrams for Model 1, Model 2 and Model 3, respectively.

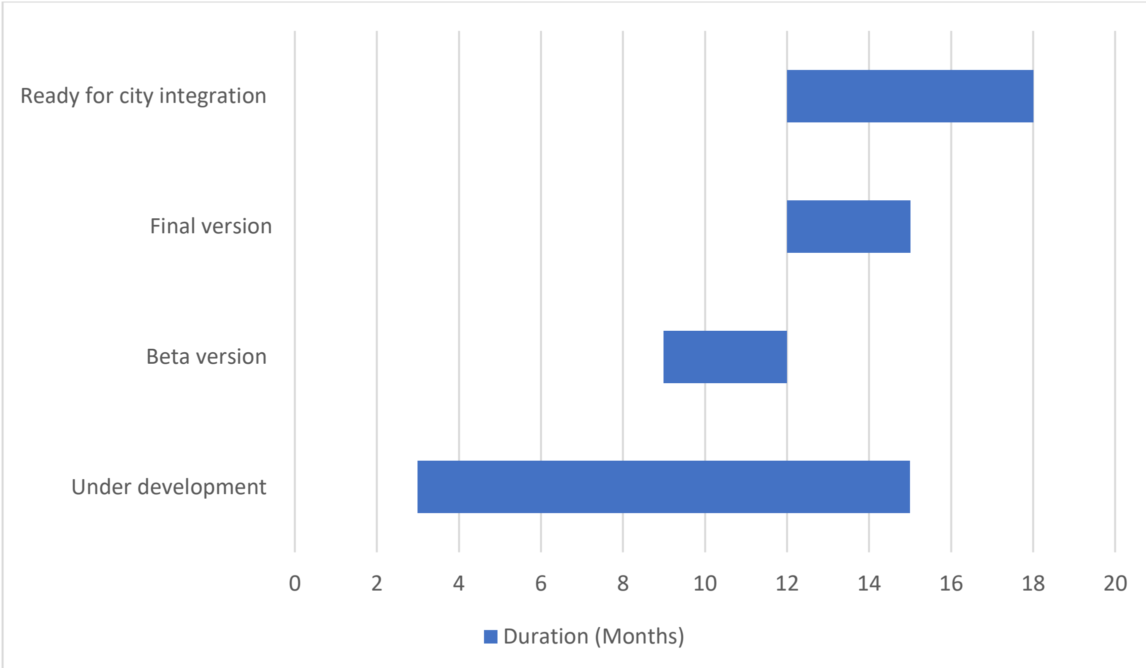

Figure 14. Integration Gantt diagram for the AI-powered toolset for the decarbonisation of buildings & transport solution. (Model 1)

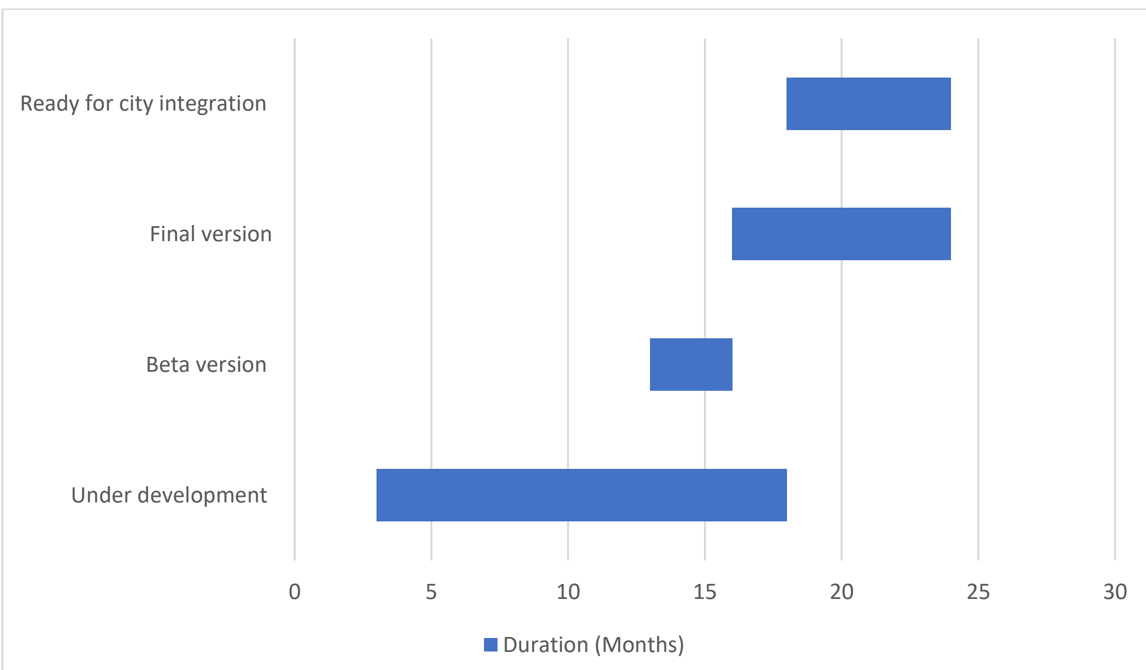

Figure 15. Integration Gantt diagram for the AI-powered toolset for the decarbonisation of buildings & transport solution. (Model 2)

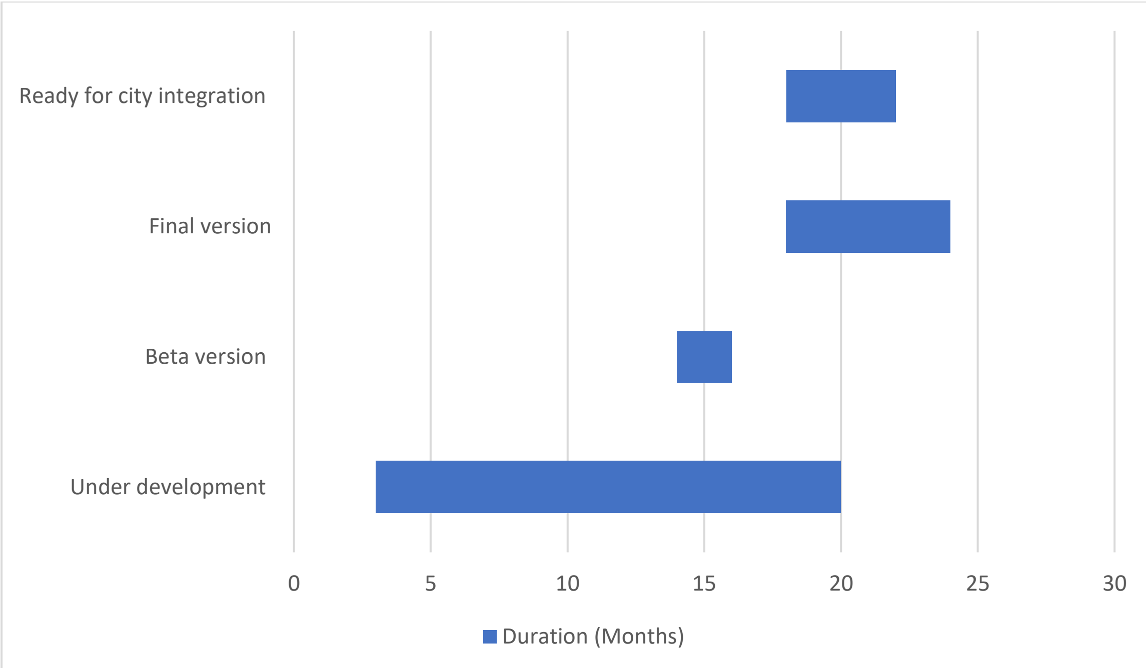

Figure 16. Integration Gantt diagram for the AI-powered toolset for the decarbonisation of buildings & transport solution. (Model 3)

15.5 Solution limitations

The main data limitations are:

- The lack of data: Data may not be available for every building on a city scale; data available in one city may not be available in another city.
- Data format: The lack of a standard accepted format of the data makes it impossible to directly integrate the data into the model. All data must be converted to a standard format to be given to the models (for example, for energy models, all data must be mapped side by side in Excel tables for each building or zone).

The other limitation is that the process of energy modelling has a high computational cost.

15.6 Solution Evaluation

The evaluation of the current solution will be discussed during the progress of the project.

15.7 City mapping

We have been working closely in Istanbul for the last year. Istanbul aims to use the tool we developed for the carbon neutrality target. Additionally, a PV integrated urban furniture will be designed and installed fabricated in place which can support various functions such as PV supported charging, sitting, and socializing area. This urban furniture also has potential to be used as post-disaster facilitate for PV powered electricity.

16 BIM module & Building LCA assessment module solution

16.1 Introduction

Discussion with the cities revealed a lack of availability of Building Information Modelling (BIM). Consequently, a strategic shift is underway to adapt the original approach to a more viable solution, involving the collection of necessary data through an inventory for the specific elements involved in the different rehabilitation scenarios. This change will facilitate user data entry, as otherwise, it would be unfeasible to provide all the necessary data for the BIM model.

Based on these data, a Life Cycle Assessment (LCA) will be conducted following the established methodologies. The information gathered will be complemented by an analysis of emissions resulting from post-rehabilitation energy consumption and other city-wide measures considered in this solution. This approach facilitates the assessment of the final greenhouse gas balance and guide the decision-making towards the most suitable scenarios. This solution is provided by CIRCE.

16.1.1 Solution Short Description

Various rehabilitation scenarios and the implementation of city-wide solutions will be assessed to guide decision-making towards those most suitable for reducing greenhouse gas emissions.

16.1.2 Objectives

The aim of this solution is to assess the impact of various rehabilitation scenarios and other city-level measures to recommend those most suitable for minimizing greenhouse gas (GHG) emissions.

16.1.3 Existing Installation

The methodologies were partially developed in different European projects (RINNO, INCUBE). However, the proposed new approach requires to update the design and specification of the procedures, followed by the development of the required algorithms and functionalities.

16.1.4 TRL status

At the time of writing this deliverable, the approach of the solution is being adapted, and its architecture is being detailed. The goal is to achieve the TRL expected in the proposal.

16.2 Technical specifications

Given the new approach for this solution, the GHG balance assessment will be performed based on these aspects:

- Building information inventories to provide the required information regarding rehabilitation scenarios.
- Data collection through surveys about typology and quantity of constructive materials, Energy constructive standards depending on the year of construction, etc.

Once defined, the tool behaves like an API, receiving inputs and returning outputs, or runs automatically reading inputs from DB and writing the results to another table.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 32: Technical aspects of the BIM module & Building LCA assessment module solution

Technical Aspect	Description
Versioning information	The functionalities of the new approach of the solution are being developed.
License	TBD
Online-documentation	Not available
Programming Language	Python

16.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the BIM module & Building LCA assessment module solution.

Table 33: Data inputs and outputs for the BIM module & Building LCA assessment module solution.

Data Input	Data output/results
• Building information inventory to provide the required information regarding rehabilitation scenarios. • Data about Building construction materials collected through surveys. (JSON format).	• Expected reduction in greenhouse gas (GHG) for different rehabilitation scenarios and city-wide measures. • Recommended scenarios and measures.

16.3.1 Data requirements

Data requirements are currently being defined, particularly the building information inventory, which is required to characterize rehabilitation scenarios.

16.4 Integration and interoperability plan

Figure 17 shows the integration Gantt diagram of the proposed solution.

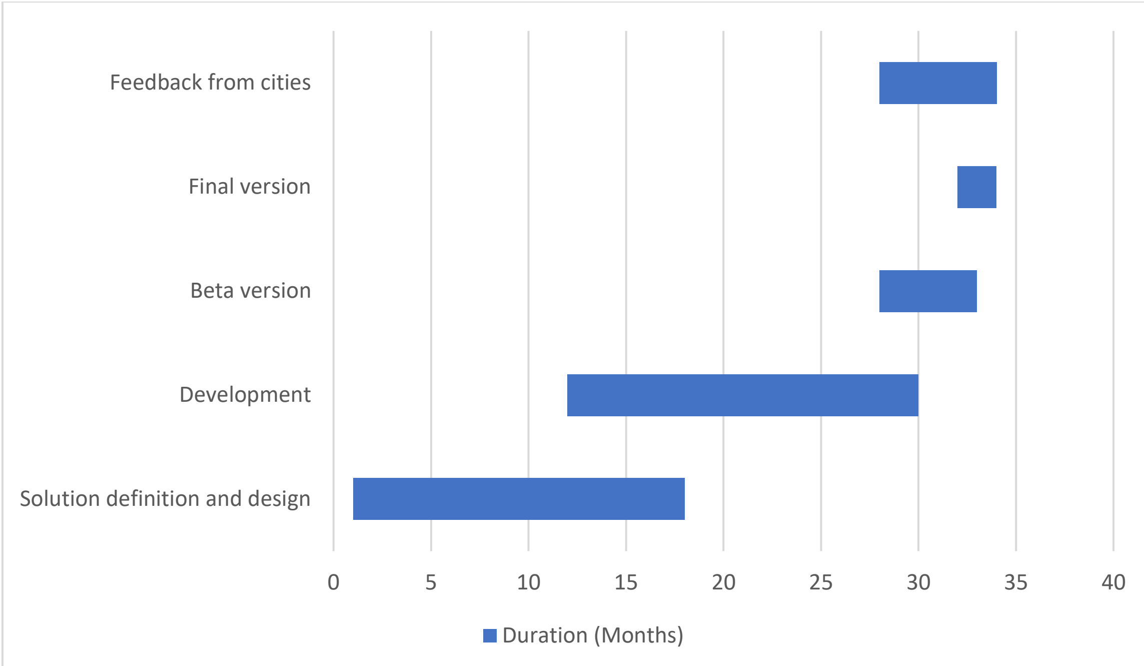

Figure 17. Integration Gantt diagram for the BIM module & Building LCA assessment module solution.

Communication with the other tools involved in the solution is currently being defined by the partners involved. At the moment, an approach based on REST API requests is under consideration to communicate the different modules.

16.5 Solution limitations

A potential limitation that may arise is the lack of knowledge of the users to provide the required information, especially for building rehabilitation scenarios. To mitigate this issue, the essential inputs are being carefully characterized so that they are easier to obtain and input in the tool.

16.6 Solution Evaluation

The evaluation will be performed based on feedback that will be collected from the cities.

16.7 City mapping

The described solution will be employed by the cities of Istanbul y Thessaloniki.

17 Climate Resilient City Tool solution

17.1 Introduction

Climate Resilient City Tool (CRCTool) is a web tool that aims to support collaborative climate adaptation planning and to promote multi-disciplinary dialogue on adaptation options to increase urban climate resilience. This web tool is provided by DELTARES.

17.1.1 Solution Short Description

The tool contains a database of over 50 adaptation measures including descriptions, pictures of best practices and references for further reading. The CRCTool is easy to use by both experts and non-experts in the field of urban planning and adaptation and can be used in a workshop setting with multiple stakeholders as well as behind a desk.

17.1.2 Objectives

The CRCTool is developed around a central interactive map window that displays base layers like a map and/or aerial photograph that is used as spatial reference. On top of these base layers' semi-transparent thematic maps can be displayed like an elevation map, flood or heat stress maps that help to understand the climate challenges in an area and to choose effective locations for interventions.

The first step is to define the extent of the project area and set properties of the project area (e.g., soil type, land use scale of interest and relevant climate hazards). Based on these properties the list of adaptation measures is ranked by their effectiveness. The ranking method is based on key figures and a set of rules to combine technical feasibility, site suitability, system capacities and location suitability (Voskamp et al, 2015).

Adaptation measures can be drawn on the map as polygon, line or point element and the measure appears in list of applied measures. Next, the main properties of the measure, like water storage depth and contributing area can be given, after which climate resilience and cost Key Performance Indicators are calculated and shown in the user interface. The main KPI's are storage volume, return time factor, additional groundwater recharge, additional evapotranspiration, heat reduction, cool areas, construction costs and maintenance costs. The hydrological KPI's are based on a multi reservoir model: The Urban Water Balance model[31], the effect on heat stress is based on statistical relations and the cost figures are based on unit costs.

17.1.3 Existing Installation

The relevant information will be provided in the following up months of the project.

17.1.4 TRL status

The TRL level status of the solution will be provided in the following up months of the project.

17.2 Technical specifications

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

[31] https://publicwiki.deltares.nl/display/AST/Urban+Water+balance+model

Table 34: Technical aspects of the Climate Resilient City Tool solution

Technical Aspect	Description
Versioning information	2.0
License	Solution provider grants to the user a non-exclusive, worldwide, royalty-free, non-transferable, and non-sub licensable license to use the Website strictly for the purpose and in accordance with the limitations specified in this User Agreement. This license is provided solely under the condition that User complies with the provisions of this User Agreement.
Online-documentation	https://publicwiki.deltares.nl/display/AST/Climate+Resilient+City+Tool+Documentaton
Programming Language	JavaScript, Python

17.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Climate Resilient City Tool solution.

Table 35: Data inputs and outputs for the Climate Resilient City Tool solution.

Data Input	Data output/results
User input: Mouse and keyboard Input for customization to local conditions for a city performed by specialist: - Local rainfall (time series) - Local evapo(transpi)ration (timeseries) - Land use type (map) - Vegetation of unpaved areas - Type of Sewer System - Storage capacities - Pumping capacities - Infiltration capacities - Surface water levels - Pumping capacity - Groundwater level	The results can be saved and exported as: - A project file that can be opened again in the CRCTool (JSON) - A pdf file that contains: o the map of the selected adaptation measures, o a summary table with all KPI's on the level of the project o A summary table with all KPI's per type of measure o List of applied adaptation measures including a description and images - A geospatial file with the project area and all applied measures and main KPI's (geojson) - A table listing all individual adaptation measures, their properties and KPI's (csv)

- Construction cost (unit prices) - Maintenance cost (unit prices)	

17.3.1 Data requirements

The data requirements will be defined in the following up months of the project.

17.4 Integration and interoperability plan

The integration and interoperability plan of this solution will be defined in the following up months of the project.

17.5 Solution limitations

The solution limitations of this solution will be defined in the following up months of the project.

17.6 Solution Evaluation

The solution evaluation will be defined in the following up months of the project.

17.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

18 Draxis UP2030 Decision Support System solution

18.1 Introduction

The current solution is a Decision support system for (DSS) smart cities. It is a state-of-the-art geospatial intelligence platform with clear vision of providing innovative tools and services to citizen and organizations. The solution is provided by K3Y.

18.1.1 Solution Short Description

K3Y will support Draxis in the creation of Draxis UP2030 managing the Big Data life-cycle allowing the chaining of value adding activities across multiple platforms, incl. geospatial data processing.

18.1.2 Objectives

The DSS offers a complete solution for the collection, processing and analysis of data via geospatial intelligence and machine learning algorithms in order to produce new information and services that will elevate the municipality, the people and their potential.

18.1.3 Existing Installation

The solution has been already used in a series of relevant EU projects.

18.1.4 TRL status

The solution is on level of TRL 6 (tested in several demonstrated environments)

18.2 Technical specifications

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 36: Technical aspects of the Draxis UP2030 Decision Support System solution

Technical Aspect	Description
Versioning information	Version 1.0
License	TBD
Online-documentation	TBD
Programming Language	JavaScript, PHP

18.3 Data Management Overview

The DRAXIS solution can combine data from multiple sources (Internet of Things, geospatial, satellite, open source and citizen data) of any format or data following common measurement standards.

The platform's implementation approach utilizes state of the art technology in data entry, storage and processing. Data flow and processing technologies such as Apache Kafka[32], Apache Spark Cluster[33], feed the data into the visualization and business logic layer, provided with full interconnection through Open Geospatial Consortium (OGC) communication protocols, geospatial data and REST APIs.

18.3.1 Data requirements

There are not any specific data requirements for the above-mentioned solution.

18.4 Integration and interoperability plan

Figure 18 shows the integration Gantt diagram of the proposed solution.

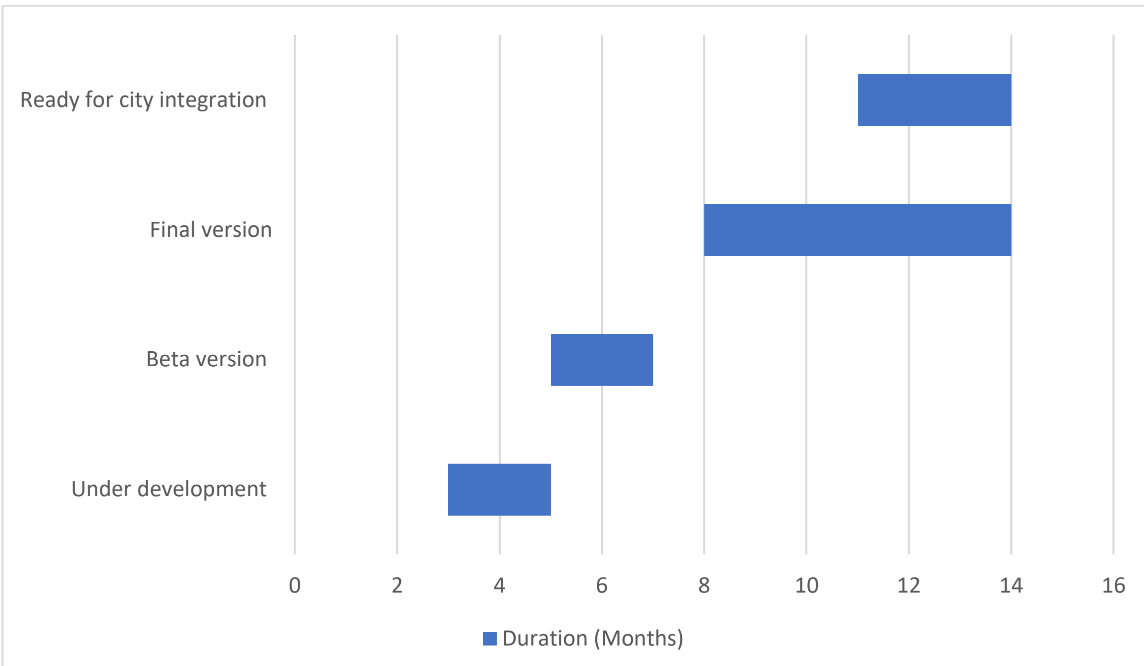

Figure 18. Integration Gantt diagram for the Draxis UP2030 Decision Support System solution.

18.5 Solution limitations

There are not any specific solution limitations for the above-mentioned solution.

18.6 Solution Evaluation

The evaluation will be performed based on feedback that will be collected from the cities.

[32] https://kafka.apache.org/
[33] https://spark.apache.org/docs/latest/cluster-overview.html

18.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

19 Air quality monitoring and forecasting service solution

19.1 Introduction

19.1.1 Solution Short Description

Air quality monitoring and forecasting service is a software component that will be able to forecast the level of pollutants and therefore compute an air quality index given an area of interest within the supported geographical regions. The solution is provided by LINKS.

19.1.2 Objectives

The tool will process satellite, traffic and weather data using machine learning algorithms to provide the forecast. Historical data (satellite, meteo, and traffic) shall be available to train the model within an area (city). A different model will be prepared for each supported city.

19.1.3 Existing Installation

The relevant information will be provided in the following up months of the project.

19.1.4 TRL status

The TRL level status of the solution will be provided in the following up months of the project.

19.2 Technical specifications

The service will support two modes: operational and on-demand. In the former, it will periodically and autonomously trigger, providing its outputs to a given storage (database) and enabling the retrieval of the generated outputs via web-based APIs. In the latter, it will allow end-users to trigger a computation providing specific boundary conditions to run what-if scenarios.

The service will be deployed using a dockerised solution, and, to run operationally, it should be interfaced with the existing systems to retrieve the input data required to perform the forecast, namely:

- Recent satellite data pollutant levels (Copernicus Sentinel 5-P)
- Recent meteo conditions and operational weather forecast
- Recent traffic data

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 37: Technical aspects of the Air quality monitoring and forecasting service solution.

Technical Aspect	Description
Versioning information	The service will output the forecasted pollutant levels in a geospatial format (e.g., geoJSON, shapefile, netCDF, GeoTIFF). The final format will be provided at a later stage.

License	1.0 that will be created within the project. The service has yet to be made available.
Online-documentation	TBD
Programming Language	Python

19.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Air quality monitoring and forecasting service solution.

Table 38: Data inputs and outputs for the Air quality monitoring and forecasting service solution.

Data Input	Data output/results
In the operational mode, no input from the end user will be required. In the on-demand mode, the end-user must provide specific parameters (e.g., on meteo forecasts and/or on traffic conditions) to simulate what-if scenarios.	The format of the input will be decided at a later stage.

19.3.1 Data requirements

Data will be available to service subscribers. During the project, access will be granted to selected stakeholders belonging to the cities that will be supported. Existing standards, protocols, and data formats will be used to ensure the interoperability of the service and of the provided output while FAIR and GEOSS data-sharing guidelines will be fully taken into account in the service design and implementation

19.4 Integration and interoperability plan

The integration and interoperability plan of this solution will be defined in the following up months of the project.

19.5 Solution limitations

The solution limitations of this solution will be defined in the following up months of the project.

19.6 Solution Evaluation

The solution evaluation will be defined in the following up months of the project.

19.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

20 Ecosystem Services Assessment solution

20.1 Introduction

20.1.1 Solution Short Description

The ecosystem services assessment is a tool to identify, quantify and evaluate a wide range of benefits provided by the natural environment. The solution is provided by LINKS.

20.1.2 Objectives

The ecosystem services assessment works on ecosystem services, defined as the goods and services provided by habitats to humans. These are divided into 1) Regulating services (e.g., air purification); 2) Provisioning (e.g., raw material production); 3) Cultural (e.g. ecotourism, health); 4) Supporting (e.g. habitat provision).

20.1.3 Existing Installation

The relevant information will be provided in the following up months of the project.

20.1.4 TRL status

The TRL level status of the solution will be provided in the following up months of the project.

20.2 Technical specifications

Ecosystem services assessment typically involves a systematic and interdisciplinary approach through:

- Study Design: Define the objectives, scope, and spatial boundaries of the ecosystem services assessment. Determine the specific ecosystem services to be assessed based on the context and stakeholder priorities.
- Data Collection
- Data Processing and Analysis (this may involve geospatial analysis, statistical analysis, modelling, and other methods depending on the data and assessment objectives)
- Ecosystem Service Mapping: Utilize geospatial analysis techniques to map the spatial distribution of ecosystem services.
- Ecosystem Service Valuation: Assign economic values to ecosystem services to understand their contribution to human well-being.
- Integration and Synthesis: Integrate the findings from different analyses and synthesize the results to provide a comprehensive understanding of the ecosystem services provided by the assessed ecosystem.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 39: Technical aspects of the Ecosystem Services Assessment solution.

Technical Aspect	Description

Versioning information	TBD
License	TBD
Online-documentation	TBD
Programming Language	TBD

20.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Ecosystem Services Assessment solution.

Table 40: Data inputs and outputs for the Ecosystem Services Assessment solution.

Data Input	Data output/results
• Ecosystem Boundaries: the spatial extent of the ecosystem (and related area) being assessed. • Ecosystem Inventory: Information about the characteristics of the area, including its ecosystem (e.g. land cover, soil types, hydrology, socio-demographic information). • Stakeholder Engagement: Engage with relevant stakeholders to gather their perspectives, knowledge, and priorities regarding ecosystem services. • Biophysical Data: Collect data on environmental variables (e.g. air and water quality, topography, biodiversity). This information helps assess the capacity of the ecosystem to provide various services. • Land Use/Land Cover Data: Obtain data on the current and historical land use and land cover within the ecosystem, including information on urbanization. • Economic Data: Gather data on economic activities within the ecosystem, including market values, resource extraction, tourism, recreational activities, and other relevant economic indicators. • Ecological Models: Utilize ecological models to simulate ecosystem dynamics, assess the potential impacts of different scenarios, and	• Ecosystem Services Assessment: Quantify and describe the various ecosystem services provided by the assessed ecosystem based on various scenarios and variables. • Valuation Results: Assign economic values to ecosystem services to demonstrate their contribution to human well-being and inform decision-making. • Maps and Spatial Analysis: Generate maps and spatial data visualizations to depict the spatial distribution and patterns of ecosystem services, enabling to identify priority areas for restoration efforts. • Policy Recommendations: Provide recommendations for policy interventions to maintain and enhance the provision of ecosystem services. • Decision Support Tools (DST): Develop decision support tools or frameworks that integrate the assessment results into planning processes, environmental impact assessments, land-use planning. • Reports and Communication Materials.

estimate the provision and distribution of ecosystem services.	

20.3.1 Data requirements

The data requirements will be defined in the following up months of the project.

20.4 Integration and interoperability plan

The integration and interoperability plan of this solution will be defined in the following up months of the project.

20.5 Solution limitations

The solution limitations of this solution will be defined in the following up months of the project.

20.6 Solution Evaluation

The solution evaluation will be defined in the following up months of the project.

20.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

21 Urban Heat Island Risk Analysis solution

21.1 Introduction

21.1.1 Solution Short Description

Urban Heat Island Risk Analysis is a methodology based on satellite data analysis for extreme temperature events. The solution is provided by LINKS.

21.1.2 Objectives

Extreme temperature events, such as heat waves or the occurrence of Urban Heat Island phenomena, are among the main challenges for urban planning and design. Heat waves and urbanization intensify the Urban Heat Island effect (UHI), defined as the temperature difference between urban and rural areas caused by the excess heat emitted and the solar gains trapped by the urbanized environment.

21.1.3 Existing Installation

The relevant information will be provided in the following up months of the project.

21.1.4 TRL status

The TRL level status of the solution will be provided in the following up months of the project.

21.2 Technical specifications

The solution essentially offers the possibility of increasing the detail of satellite data to estimate the spatialisation of the heat island effect through the following approaches:

- Create a downscaling model of climatic data cross-referenced with soil characteristics and functions.
- Increase the resolution of satellite climate models through analytical post-processing.
- Increase the resolution of satellite climate models through analytical post-processing. This will be done by cross-referencing the data from satellite observation with those collected from climatic stations.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 41: Technical aspects of the Urban Heat Island Risk Analysis solution.

Technical Aspect	Description
Versioning information	Version 1.0
License	TBD
Online-documentation	https://www.tandfonline.com/doi/full/10.1080/17538947.2019.1593527

Programming Language	Python

21.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Urban Heat Island Risk Analysis solution.

Table 42: Data inputs and outputs for the Urban Heat Island Risk Analysis solution.

Data Input	Data output/results
Cross-analysis of data from the following sources: • temperature data derived from ground-based meteorological survey stations. • data deduced from the thermal radiation detected by the Sentinel 3 satellite constellation (Galileo). • Land cover and land use derived from • satellite data and technical surveys included in the local planning tool. • Identified location data of the main sources of heat emission due to specific anthropogenic functions	• Create a downscaling model of climatic data cross-referenced with soil characteristics and functions. • Increase the resolution of satellite climate models through analytical post-processing. • Increase the resolution of satellite climate models through analytical post-processing. This will be done by cross-referencing the data from satellite observation with those collected from climatic stations.

21.3.1 Data requirements

The relevant information will be provided in the following up months of the project.

21.4 Integration and interoperability plan

The integration and interoperability plan of this solution will be defined in the following up months of the project.

21.5 Solution limitations

The solution limitations of this solution will be defined in the following up months of the project.

21.6 Solution Evaluation

The solution evaluation will be defined in the following up months of the project.

21.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

22 MIRA solution for Cities as Digital Twins solution

22.1 Introduction

The solution is a result of continuous innovation and is being enriched with new functionalities for smart cities and industrial context. The solution is provided my MAG.

22.1.1 Solution Short Description

MIRA solution for Cities as Digital Twins is a configurable solution to model a city as a network of interconnected Digital Twins (DTs) (neighbours, buildings, mobility systems, etc.) and monitor/simulate performance based on data for each individual asset (DT).

22.1.2 Objectives

The solution allows users to define their digital twins of 2 types:

- An individual asset (e.g., building, space, parking, etc)
- A network of assets (e.g., neighbour of different buildings, spaces, parking slots, etc)

In each DT we can integrate information sources to monitor performance and integrate simulation, optimization, and other related services (e.g., building demand response, mobility simulation) on top of each DT (either at asset or network level)

Furthermore, the solution will be able (expected release: Mar 2023) to facilitate collaboration among actors in different contexts, i.e. to share information about assets (DTs) based on the IDS and data spaces specifications.

We are also incorporate an IDS connector to facilitate information sharing among stakeholders in city environments.

22.1.3 Existing Installation

MIRA has been piloted in different projects mainly industrial (energy efficiency, circular economy).

The solution operates in MAG internal production facility (editorial production) where we monitor the energy spent by the production machines.

In Jan 2024 we will start an internal project to integrate MIRA in a city customer in Italy by using information from our existing solution.

22.1.4 TRL status

The solution is on level of TRL 6 (tested in several demonstrated environments and in one real environment)

22.2 Technical specifications

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 43: Technical aspects of the MIRA solution for Cities as Digital Twins solution.

Technical Aspect	Description

Versioning information	The current version is 1.1 and is still evolving with new functionalities.
License	Commercial license. A free license will be used for the needs of the project
Online-documentation	Under construction
Programming Language	Angular, Neo4J, java spring boot

22.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the MIRA solution for Cities as Digital Twins solution.

Table 44: Data inputs and outputs for the MIRA solution for Cities as Digital Twins solution.

Data Input	Data output/results
MIRA integrates two main parts: • data sources - telemetries (which can be any type of information source like sensors, databases) which provide data series for monitoring and understanding behaviour. • External Services (e.g., simulation, optimization, BIM, ….) on top of each Asset or network DT Furthermore, MIRA provides a functionality for configurable Dashboards, where the user can define which DTs, KPIs or other information to visualize in the dashboard	Outputs of MIRA can be: • KPIs, Charts of specific telemetries or their combination and function (e.g., CO_2 footprint of a city or an area) • Outputs of external services (simulation, optimization, BIM, mobility, etc.)

22.3.1 Data requirements

In principle MIRA integrates two types of data:

- Sensor data (any type of sensor, camera or devices that send information about a particular issue)
- Services (more complicated set of data, alerts, notifications and anything that has to be aggregated and reused in a dashboard for monitoring purposes, or for processed in the context of another service).

Depending on the context, we can integrate different information. For instance, in a mobility case we can integrate data from:

- Cameras (to identify mobility congestion rates or patterns of congestion)

- Street lighting
- Mobility service operator solutions
- Other.

For energy purposes (buildings) MIRA can integrate also various data:

- From sensors (temperature, occupancy, HVAC operation, etc.)
- BIM Models
- Energy management solution data

If a city wants to keep tract of a sustainability index in different areas, then MIRA can aggregate information from:

- Sensors (Noise, CO_2, etc.)
- Possible data about occupancy and other operations of the area

MIRA can be used to monitor the performance of those sensors, and create a module for sustainability where we can associate sustainability metrics with urban operations, thus identifying needs for improvements and interventions.

In all the above case, MIRA aggregates them and on top of the modelled digital twin can run different services (or integrate third party services) such as:

- Simulation (forecasting of energy demand, predict mobility)
- Optimization
- Or any other applicable service developed by UP2030 or service used by the pilots.

The main advantage of MIRA is the aggregation of the different information sources to different topologies and execute what-if scenarios for area interventions.

22.4 Integration and interoperability plan

Figure 19 shows the integration Gantt diagram of the proposed solution.

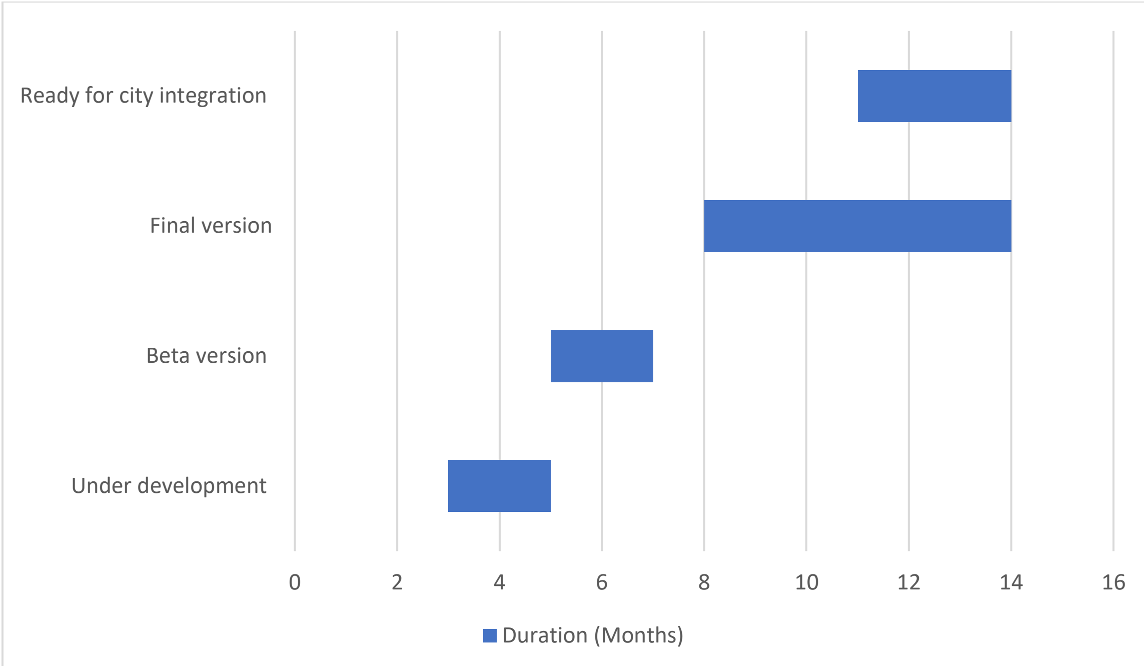

Figure 19. Integration Gantt diagram for the MIRA solution for Cities as Digital Twins solution.

MIRA supports the following types of integration:

- Data feeding / Events (coming from sensors)
- APIs / Web services (custom visualizations based on tools outputs)
- Legacy systems / Applications integration
- Full custom (if needed)

The plan for MIRA adoption and integration will be the following:

- Detailed analysis of the usage needs: identify data flows, visualizations needs and functionalities to be adopted or developed.
- Discussion with UP2030 tool providers or existing tool third parties to define the integration points. For this purpose, we will release an initial set of integration guidelines based on the findings of how the tools will be integrated with MIRA.
- Integration and release of a test demo for the cities. The idea will be that cities will make a functional testing and be able to see the current progress of development and integration.

22.5 Solution limitations

There are no limitations regarding the above-mentioned solution.

22.6 Solution Evaluation

MIRA solution will be evaluated in the city pilots where cities will be able to integrate UP2030 services including their data, thus having a one-stop-shop point for smart cities services consumption.

We will conduct dedicated pilot-specific workshops with all involved stakeholders to assess the solution applicability, extendibility and replication to other city domain scenarios (e.g. mobility, energy, etc.).

In principle we will have two types of evaluation:

- Functional evaluation (where the pilot will test the solution functionality and will report bugs or things to improve).
- Fit-for-purpose and usability evaluation through the dedicated pilot workshops.

22.7 City mapping

Currently MIRA is applicable to the cities of Thessaloniki and Milano. MAG is investigating the detailed scenarios and usage flows to reach a final agreement with the cities.

23 Modular Urban Farm solution

23.1 Introduction

The Modular Urban Farm is a Bio – Socio – Technical modular educational urban farming IoT solution that leverages the "Universal Data Machine," a framework centred around integrating data for machine learning and data analysis. The solution is provided by VM.

23.1.1 Solution Short Description

Bio – Socio – Technical modular educational urban farming system

23.1.2 Objectives

The Modular Urban Farm is a Bio – Socio – Technical modular educational urban farming system that features:

- Vertical farming modules designed for efficient space utilization in urban environments.
- Integrated hydroponic or other systems for soil-less cultivation of crops.
- LED lighting systems to provide optimal light spectrum and intensity for plant growth.
- Automated climate control systems to regulate temperature, humidity, and CO2 levels, plant health, nutrient levels, and environmental conditions.
- Water management systems for efficient usage and recycling of water resources.
- Educational program (Green Polytechnic – 20 modules developed) to teach citizens about sustainable agriculture and urban food systems.
- Demonstration areas showcasing different cultivation techniques and plant varieties and looking classes and recipe demonstrations showcasing delicious and nutritious plant-based meals.
- Interactive displays and information boards explaining the impact of urban food systems on climate change.
- Integration with renewable energy sources to reduce carbon footprint.
- Implementation of circular economy principles, such as composting organic waste and utilizing it as fertilizer.
- Online platforms or mobile applications to connect citizens, share knowledge, and track their farming progress (through external digital platform integration).
- Integration with smart city infrastructure for data sharing and analysis to optimize resource usage and environmental impact.

23.1.3 Existing Installation

Since 2018, Vesela Motika [34] has been a leader in indoor farming, evolving from a $20m^2$ vertical farm and lab to our current $160m^2$ facility. Specializing in vertical farming, we actively pursue technological advancements through ongoing research.

[34] https://veselamotika.com/

Our mission emphasizes producing accessible food, distinguishing us in indoor agriculture. Starting IoT solution development in 2016, inspired by the MIT food computer project, showcases our commitment to integrating cutting-edge technology.

In modular farming, we highlight two implementations: one with the project in Zagreb and a unique container blending farm and bar elements. Our diverse commercial projects include pop-up vertical farms, collaborations with nurseries, and integrating food production into office spaces, showcasing our adaptability.

Vesela Motika stands at the forefront of the indoor farming revolution, pushing boundaries, embracing technology, and making sustainable agriculture a reality.

23.1.4 TRL status

The TRL status of the solution is at 8. This status indicates that, through extensive testing, the technology has demonstrated success under normal operating conditions. However, the operational approach for this solution is rooted in agile management and development, as well as lean principles. Embracing this philosophy, the solution is continuously enhanced and refined on each iteration and implementation.

23.2 Technical specifications

Modular Structure:

- Customizable and scalable modules to accommodate different hydroponic systems.
- Durable and lightweight materials for easy transportation and installation.
- Flexibility to expand or rearrange modules based on specific requirements.

Hydroponic Systems:

- NFT (Nutrient Film Technique) system: Thin film of nutrient-rich water flowing over plant roots.
- DWC (Deep Water Culture) system: Plant roots suspended in nutrient-rich water.
- Aeroponics system: Plant roots suspended in air, with nutrient mist sprayed intermittently.
- Ebb and Flow system: Periodic flooding and draining of plant roots with nutrient solution.
- Drip irrigation system: Nutrient solution drips onto plant roots in a controlled manner.
- Vertical or stacked growing systems to maximize space utilization.

Lighting:

- LED (Light-Emitting Diode) technology for energy-efficient and adjustable lighting.
- Ability to control light spectrum and intensity based on plant growth stage and requirements.
- Integration with smart lighting systems for automated scheduling and optimization.

Climate Control:

- Temperature regulation through heating and cooling systems.

- Humidity control mechanisms such as misting or fogging.
- CO_2 supplementation for enhanced plant growth.
- Ventilation and air circulation systems to maintain optimal conditions.

Water Management:

- Water circulation and recirculation systems to minimize water usage.
- Integration with sensors and controllers for monitoring and maintaining water quality.
- pH and nutrient level monitoring and adjustment.
- Water filtration and purification mechanisms.

Sensors and Automation:

- Environmental sensors for monitoring temperature, humidity, CO_2 levels, and light intensity.
- Nutrient sensors to measure and adjust nutrient levels.
- Automated systems for adjusting environmental conditions based on sensor data.
- Integration with a central control system for data collection and analysis.

Data and Monitoring:

- Real-time monitoring and data logging of environmental parameters.
- Data visualization and analysis tools for optimizing crop growth.
- Remote access and control capabilities for monitoring and managing the farm.

Energy Efficiency:

- Integration with renewable energy sources, such as solar panels or wind turbines.
- Energy-efficient equipment and systems to minimize energy consumption.
- Implementation of energy-saving practices, such as smart scheduling and power management.

Irrigation and Nutrient Delivery:

- Efficient irrigation systems with timers and flow control mechanisms.
- Automated nutrient delivery systems with adjustable dosing capabilities.
- Integration with nutrient mixing and monitoring equipment.

Waste Management:

- Recycling and reuse of water and nutrients to minimize waste.
- Composting systems for organic waste generated during crop production.
- Integration with waste management technologies, such as anaerobic digestion or vermiculture.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 45: Technical aspects of the Modular Urban Farm solution.

Technical Aspect	Description
Versioning information	To be provided/determined later during the project
License	To be provided/determined later during the project
Online-documentation	To be provided/determined later during the project
Programming Language	To be provided/determined later during the project

23.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Modular Urban Farm solution.

Table 46: Data inputs and outputs for the Modular Urban Farm solution.

Data Input	Data output/results
Input is defined by the urban space where modular farm will be places. Important inputs are object legalization, access to electricity and water, profile of citizens who will use the object to learn about growing, diet and climate impact, 24 hours access to object.	The outputs of an urban modular vertical farm extend beyond just the produce, encompassing education, community engagement, environmental sustainability, research, economic benefits, and social impact. By offering a holistic approach to food production and education, such farms can contribute to building resilient and sustainable urban food systems. Outputs could be segmented as follows: • Fresh Produce • Educational Resources • Skill Development • Environmental Impact • Research and Development • Job Creation and Economic Benefits • Social Impact

23.3.1 Data requirements

This Internet of Things (IoT) solution is built upon what the term the "Universal Data Machine," a framework centred around integrating data for machine learning and data analysis. Leveraging R server and Python, this approach emphasizes flexibility for implementation. Recognizing that diverse implementations necessitate varying data structures, sensors, and actuators, we strive to create a versatile system that adapts to unique requirements seamlessly.

23.4 Integration and interoperability plan

Figure 20 shows the integration Gantt diagram of the proposed solution.

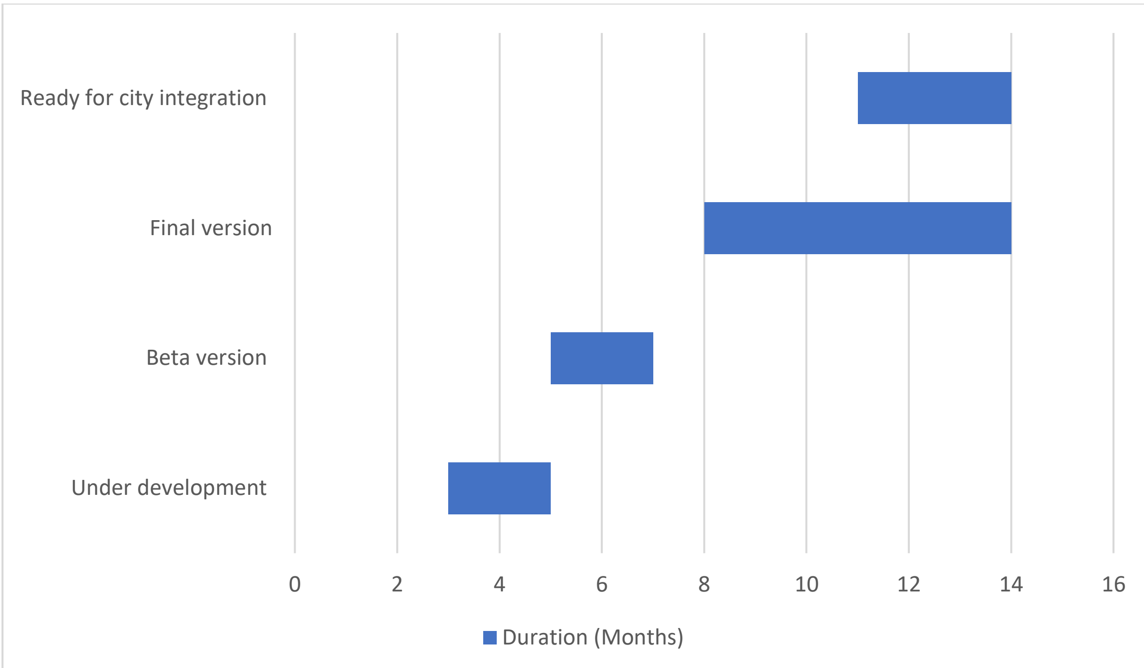

Figure 20. Integration Gantt diagram for the Modular Urban Farm solution.

The Universal Data Machine (UDM) and IoT periphery are predominantly founded on open-source principles, and our growing system adheres to modular design principles, ensuring high interoperability. A key emphasis lies in fostering knowledge spill over, where our system design actively explores avenues for leveraging knowledge in a multipurpose context. This approach not only enhances adaptability but also contributes to a dynamic and versatile ecosystem.

In terms of organizational interoperability, we have established strong collaborations with school teachers, the head of the school, and the City of Zagreb. Our interoperability extends beyond these partnerships to various segments of the project, encompassing air quality, building materials, resilience, and the impact of food production on climate change. Notably, our solution integrates both behavioural and design science principles, aligning seamlessly with the socio-technical paradigm that forms the foundation of the project. This integration enhances the overall fit and effectiveness of our solution within the broader project context.

23.5 Solution limitations

The current limitations of this solution revolve around its alignment with primary school curriculums and the multidisciplinary nature of the project. However, solution address these limitations by strategically matching them with our team members' diverse expertise. VM team boasts members with experience across various disciplines and a proven track record in education, spanning from primary and secondary schools to universities. This wealth of experience positions the solution provider as well to navigate and overcome the challenges associated with educational integration, ensuring the adaptability and effectiveness VM solution across different educational contexts.

23.6 Solution Evaluation

The evaluation framework consistently adheres to the principles of the General System Theory by Bertalanffy[35], encompassing bio, socio, and technical aspects. This holistic approach ensures a comprehensive assessment of our solutions. Being a company, we have established continuous processes that allow us to systematically evaluate and benchmark our solutions against those of other providers. This commitment to ongoing assessment and benchmarking reflects our dedication to maintaining high standards and continually improving the effectiveness of our offerings in the dynamic landscape of bio, socio, and technical considerations.

Generic evaluation framework for vertical indoor farming, considering bio, socio, and technical aspects:

1. **Biological Aspect:**
    - Crop Yield: Evaluate the efficiency of vertical farming in terms of crop production per square meter.
    - Nutritional Quality: Assess the nutritional content and quality of crops grown indoors.
    - Resource Efficiency: Measure resource usage, including water and nutrients, to ensure sustainability.
2. **Social Aspect:**
    - Community Impact: Evaluate the positive influence on local communities, such as job creation and accessibility to fresh produce.
    - Education and Awareness: Assess efforts to educate and raise awareness about indoor farming practices.
    - Inclusivity: Examine the inclusivity of vertical farming initiatives within diverse social contexts.
3. **Technical Aspect:**
    - Automation and IoT Integration: Evaluate the level of automation and integration of IoT solutions for efficient monitoring and control.
    - Energy Efficiency: Assess the energy consumption of indoor farming systems and explore renewable energy options.
    - Technological Innovation: Measure the adoption of cutting-edge technologies to enhance productivity and sustainability.

This framework provides a brief overview of key aspects to consider in evaluating vertical indoor farming initiatives. Adjustments can be made based on specific project goals and context.

[35] https://www.sciencedirect.com/topics/computer-science/general-system-theory

23.7 City mapping

The solution will be used in the district of Sesvete, city of Zagreb.

24 LCA and Matchmaking tool for building material reuse solution

24.1 Introduction

Life cycle assessment (LCA) and matching tool, provided by ETH, is aimed to drive the evaluation of environmental effects of circular construction.

24.1.1 Solution Short Description

The LCA and matchmaking tool aims to be a catalyst for assessing environmental impacts of circular construction, as well as connecting owners, users, designers, suppliers, and fabricators across the construction value chain to tackle the challenge of giving value to construction waste materials.

24.1.2 Objectives

The tool's main objective is to assess the environmental savings of circular strategies and increase the reusing rate and flow of materials from disassembly and demolition sites ultimately extending the end-of-life of buildings to reduce the production on raw materials.

The objective of the tool is to enable a fast exchange of information between owners or "suppliers" of construction waste/building components that can be reused, and "requesters" architects, designers, fabricators, constructors, or other owners, that can make use of these materials, based on environmental saving potential.

The database consists of the main features:

- Circularity indicators for environmental impact assessment
- Adaptation to local database for applicability
- Processing of geographic information systems (GIS) data
- Connection of suppliers "Post" available materials, and requesters "Search" for materials wanted. If they "Find" them, they can "Connect" with the material owners.
- Materials can be filtered/displayed considering different aspects (by location in a map, in a list or grid by filters/tags).
- Materials are described and geo-localized with sufficient detail (e.g., type, geometry, and quantities of materials to be exchanged) to run an LCA analysis to estimate the environmental impacts of the transaction (e.g., estimated kgCO_2e saved).

24.1.3 Existing Installation

The tool is under development and leverages previous work on dynamic LCA and material flow analysis for cities and neighbourhoods. Circularity metrics, allocation principle of environmental saving between the different lives of products, as well as dynamic aspects related to LCA for circularity will be integrated.

24.1.4 TRL status

The tool is on TRL 2 status – Technology concept formulated.

24.2 Technical specifications

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 47: Technical aspects of the Matchmaking tool solution.

Technical Aspect	Description
Versioning information	TBD
License	Open source
Online-documentation	TBD, GitHub, and available interface
Programming Language	Python

24.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Matchmaking tool solution.

Table 48: Data inputs and outputs for the Matchmaking tool solution.

Data Input	Data output/results
TBD. Users input the following information: - Material Type (Steel, Timber, Concrete, etc.) - Component Type (Beam, Column, Slab) - Dimensions - Location (using GPS data or input by user) - Condition (New, As New, Damaged) - Quantity - Age of use - Time availability of the component - Photo(s) or 3D/BIM model - Confidence factor of input data - Residual time	TBD. - Estimate material and environmental flows (e.g., $kgCO_2e$ saved)

24.3.1 Data requirements

The required data includes databases of embodied flows coefficient, new databases of building archetypes for the investigated case studies, databases for each level of scale, GIS databases.

Information to date: ETH Zurich has its own data protection measures and is subject to data protection laws. When using user data, we need to comply with these measures. (https://ethz.ch/en/industry/researchers/contracts/aspects/ip.html)

24.4 Integration and interoperability plan

Figure 21 shows the integration Gantt diagram of the proposed solution.

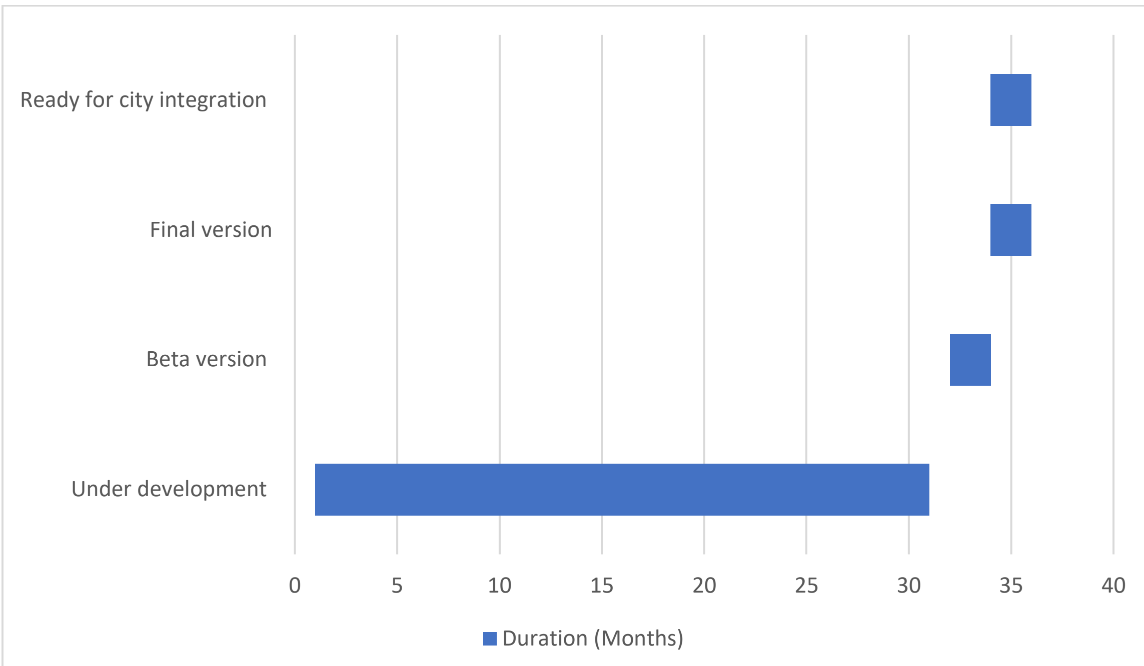

Figure 21. Integration Gantt diagram for the Matchmaking tool for building material reuse solution.

The tool will consider the fact that the coefficients for the embodied flows are suitable for local cases. The solution will be open source and can be adapted to fit local contexts.

24.5 Solution limitations

Limitations include data availability in various geographical contexts, uncertainty related to the assessment of circularity and the corresponding indicators, uncertainty in the application of circular strategies (e.g. cultural heritage of buildings, local legal context etc.), data and model complexity, level of detail of embodied flow coefficients.

24.6 Solution Evaluation

The solution will be demonstrated by applying the developed tool to case studies involving cities.

24.7 City mapping

There is the potential for the above mentioned solution to be integrated to the cities, however it has not been defined yet.

25 GeoKey/Community Maps solution

25.1 Introduction

GeoKey/Community Maps solution is a server-side software component (GeoKey) Client-side application (Community Maps). This software solution is provided by MfC.

25.1.1 Solution Short Description

GeoKey is a web-based platform for participatory mapping that is focussed on providing a server-side infrastructure to receive, store and disseminate geographic data collected by citizens via an open web API. GeoKey is designed towards the ability to host a great variety of use cases. As such, it does not provide client-side applications to collect, manage, visualise, and analyse geographic data through graphic user interfaces (this is provided by Community Maps but can also be provided by other client-side applications). GeoKey provides the backend infrastructure to set-up projects, manage access to data and to store and validate data.

25.1.2 Objectives

Applications tied to specific use-cases can be built on top of the REST API. These apps can vary from smartphone apps for data collection over web maps for data visualisation and editing to GIS for data analysis.

GeoKey's key features include:

- Custom data structures: Create data structures designed for any use case to ensure your community collects exactly the data they need. Using categories, you define what types of data will be mapped and what attributes they will have.

- User groups: Through user groups, you can decide what role members of your community will have in a project and what subsets of data in a project they are able to access.

- Discussions: Discuss aspects of each contribution with your community using comments.

- Attach media: Attach photos, documents, videos, and audio files to a contribution to enrich collected information with additional views.

Participatory mapping activities are organised into projects. Each project has a different objective and geographic extent. Users who are members of a project contribute perceptions or measurements of their environment to a project.

Perceptions and measurements are contributed to a project using contributions. Each contribution has a location. By separating observations and contributions, different users can contribute different perceptions on the same location or continuous measurements can be collected for a certain location. Users can further add comments to contributions, reply to comments or attach media files like photographs, documents, videos, or audio files to a contribution.

Each contribution has a category that describes which information the contributor is expected to provide. Each category has several fields. For each field expected data types, accepted values and if the field is required must be stated. Field itself is an abstract entity and is instantiated by specific field types (see Field Types for available types). Categories are used to validate user inputs and to create forms for user interfaces.

Users are granted permission to add, access, edit and delete data in a project using several user groups. First, each project has a few users assigned that are administrators of the project. Project administrators are allowed to manage all other user groups including their users and permissions, create and manage observation types and fields as well as views.

All other users can be assigned to one of a project's user groups. A user group indicates if its members are allowed to moderate, contribute data in the project. Through user groups, project administrators can further restrict access to a subset of project data by selecting categories or, for each of the selected categories, by defining filters for selected fields.

25.1.3 Existing Installation

GeoKey, being a data platform, does not come with a front-end to interact with data. There are, however, client-side applications that integrate with GeoKey and enable your community to collect data.

An out-of-the-box web mapping solution that integrates with Sapelli [36]and GeoKey is Community Maps. Developed by Mapping for Change, this browser-based application is a sophisticated way to view, collect and edit data with GeoKey. As a web-based application that visualises data added to GeoKey (either from Sapelli, Community Maps itself or from any other app). It offers an intuitive, multilingual interface with data filtering and modern clustering capabilities for large data sets. Users can design their own maps and visualise their data on various devices – from big screen desktops to tablets and mobile phone clients. Further features supported by the software include email notifications about data activity as well as personalisation and branding tailored to their project/company.

The Sapelli platform facilitates data collection across language or literacy barriers through highly configurable icon-driven user interfaces.

EpiCollect+ [37]is a mobile and web application to collect data. The mobile client can be used to collect data for GeoKey.

25.1.4 TRL status

GeoKey and Community Maps have been deployed and proven in operational environments for different contexts and use cases over the past nine years and as such can be considered reaching TRL 9. Updates to extend functionality and their integration with other applications are continually considered.

25.2 Technical specifications

GeoKey and Community Maps have operational installations on Mapping for Change's VPN. Installation of GeoKey on a separate server would require a series of pre-installation/pre-configuration actions to be performed to be usable. These actions include:

- installation of pre-requisites & Python packages,
- setting up the database,

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[36] https://github.com/ExCiteS/Sapelli

[37] https://geokey.org.uk/extensions/epicollect.html

- setting up the virtual environment,
- setting up GeoKey and
- configuring the system files and make necessary modifications to make GeoKey run smoothly.

A detailed online guide is provided towards the latter actions as shown in the table below.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 49: Technical aspects of the GeoKey/Community Maps solution.

Technical Aspect	Description
Versioning information	GeoKey can be run on Python 2.7 or Python 3 (Geokey 1.8 onwards). GeoKey v1.11.2 is the latest version of the tool
License	Copyright 2017 Extreme Citizen Science research group Licensed under the Apache License, Version 2.0
Online-documentation	https://github.com/ExCiteS/geokey
Programming Language	Python Django

25.3 Data Management Overview

The flexibility afforded through the bespoke construction of projects for different contexts allows the creator to determine which data inputs are needed. The following table represents an overview of the data inputs and outputs for the GeoKey/Community Maps solution.

Table 50: Data inputs and outputs for the GeoKey/Community Maps solution.

Data Input	Data output
The following data types are supported: ● text ● number ● single lookup ● multiple lookup ● date ● time The following file types for upload to an individual map contribution are supported: ● PNG	Any data input to a map can be exported as the following file types: ● GeoJSON ● CSV ● KMLP4 ● MKV ● PDF ● MP3 All data captured can be viewed spatially within the Community Maps interface

• JPEG • MP4 • MKV • PDF • MP3 The following file types for data import to create new categories and map contributions or add to existing categories to generate new contributions are supported: • GeoJSON • CSV • KML	

25.3.1 Data requirements

There are not any specific data requirements for the above-mentioned solution.

25.4 Integration and interoperability plan

Figure 22 shows the integration Gantt diagram of the proposed solution.

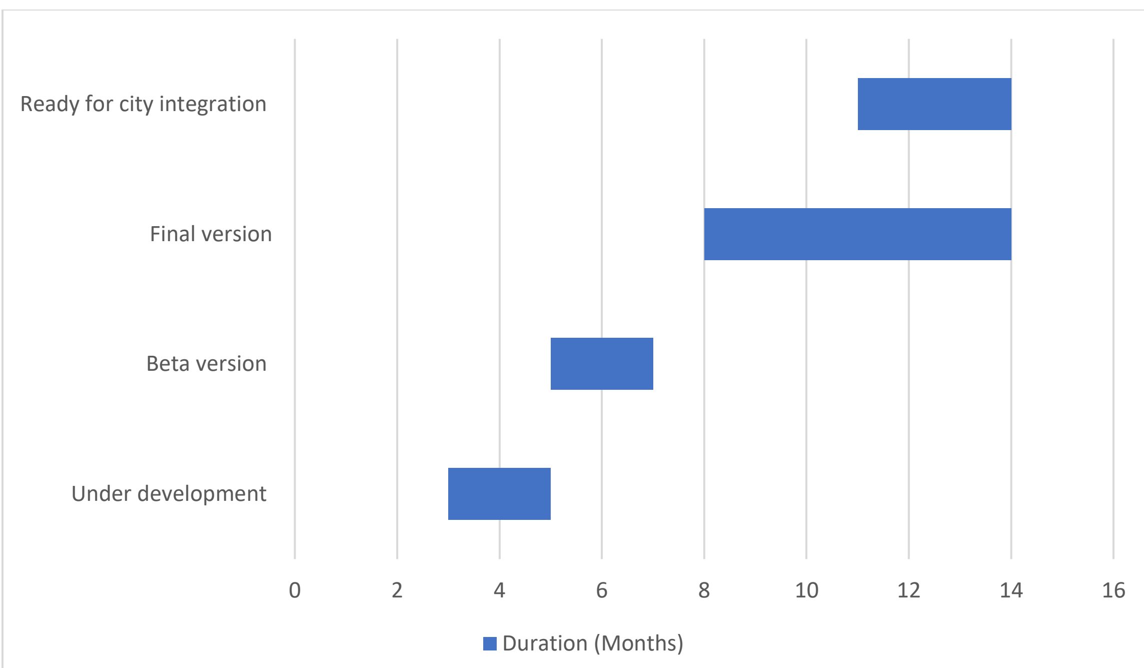

Figure 22. Integration Gantt diagram for the GeoKey/Community Maps solution.

25.5 Solution limitations

The tool aims to support municipalities to engage stakeholders in understanding their needs, co-developing their vision, interventions and eliciting feedback to support the evaluation of any actions. For that, municipalities need to be aware of the potential usefulness of the solution at an early stage if their engagement activities. No GIS skills or specific technical knowhow are required to set-up new mapping projects.

25.6 Solution Evaluation

The evaluation may be obtained based on a questionnaire.

25.7 City mapping

There is the potential for GeoKey/Community Maps to be integrated as a solution for any of the cities.

26 Carbon information framework solution

26.1 Introduction

Carbon information framework (formally presented as carbon "budget" framework) is a solution (with a visual information map output) that provides a system overview of the quantity and quality of carbon data across a city municipality. The solution is provided by UCAM.

26.1.1 Solution Short Description

Carbon information framework is designed to provide an overview of the quality and quantity of carbon data across a city, to help build confidence in this data. Data is often held in spreadsheets and/or generated by tools for specific purposes within a division of an organisation.

26.1.2 Objectives

The anticipated function of this solution is to provide systems map of this information across divisions, showing how carbon data is tracked from the assets through to decision-making. City managers cannot know if they are making good strategic decisions and investments regarding carbon management unless it has visibility of its data (and its usage) across the organisation.

This is relatively simple in concept but requires data collection and curation across a complicated organisational context.

26.1.3 Existing Installation

The relevant information will be provided in the following up months of the project.

26.1.4 TRL status

The TRL level status of the solution will be provided in the following up months of the project.

26.2 Technical specifications

This is a solution based on a manual data collection and mapping effort. Required data is gathered through liaising with key stakeholders across the organisation (a city municipality in this case) being reviewed. UCAM will create a "static" carbon information flow map (an evolution of the concept of an organisational diagram) for the city. Depending on extent of piloting and uptake across the cities, we would hope to use UP2030 as the basis for seeking extra funding for creating an easy-to-use web-platform for creating the maps.

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 51: Technical aspects of the Carbon information framework solution.

Technical Aspect	Description
Versioning information	Not applicable
License	There are no licensing or legal conditions of use associated with the method.

Online-documentation	TBD
Programming Language	Not applicable

26.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Carbon information framework solution.

Table 52: Data inputs and outputs for the Carbon information framework solution.

Data Input	Data output/results
Inputs achieved through stakeholder input, facilitating the identification of: • Sources of carbon data information across the organization. • What format this data is in, extent of coverage, level of trust in accuracy of the data. • Who is responsible for the management of this data. • Who relies on this data for decision-making. • The potential impact of other UP2030 solutions on the availability & trustworthiness of carbon data.	Stylised information map (a diagram in editable form) generated by the UCAM team using diagramming software available online. A bespoke web-based platform will be an ideal future output, but unlikely possible within the scope of UP2030.

26.3.1 Data requirements

The relevant information will be provided in the following up months of the project.

26.4 Integration and interoperability plan

The integration and interoperability plan of this solution will be defined in the following up months of the project.

26.5 Solution limitations

The limitation is that there is not a perceived immediate/pressing need. However, in participating in this project we are anticipating that cities do not have existing solutions to given them enterprise-wide visibility of the quality of their carbon data management. This will be limiting effectiveness of any carbon management decisions.

26.6 Solution Evaluation

The solution evaluation will be defined in the following up months of the project.

26.7 City mapping

The city that this solution will be mapped will be defined in the following up months of the project.

27 Learning and Action Alliances method solution

27.1 Introduction

The Learning and Action Alliances (LAA) method is a collaborative approach/solution used to address complex social, environmental, or organizational challenges (multifaceted issues) for meaningful solutions. The solution is provided by ICA.

27.1.1 Solution Short Description

LLA involves bringing together diverse stakeholders with different perspectives, knowledge, and expertise to collectively learn, problem-solve, and take action to create positive change. LAA aims to foster sustainable solutions to complex challenges by leveraging the collective wisdom and resources of diverse stakeholders.

27.1.2 Objectives

The LAA method can be used for various types of analysis or tasks of multifaceted issues. It can be applied in a wide range of fields, such as community development, environmental conservation, social justice, public policy, and organizational change, among others.

27.1.3 Existing Installation

The Learning and Action Alliances (LAA) approach has been used by local authorities and other organizations in various projects and plans. Examples of projects and reports where it has been implemented are:

- EU INTERREG IVb MARE project [38]
- The PRIMA LENSES project [39]
- The Horizon 2020 REXUS Project [40]

27.1.4 TRL status

All cities in the UP2030 project have kicked off their LAA process in April 2023. Two key stakeholder categories have emerged from the fi first series of workshops on Needs: internal (City Hall) and external stakeholders. Cities are at very different stages of the LAA implementation and are seeking to adapt the approach to their local contexts. In some localities, the LAA is confined to different departments of City Hall while in others, a great number of relevant city or neighbourhood actors are actively involved,

27.2 Technical specifications

Since LLA is a collaborative approach, no technical specifications can be extracted.

[38] https://cordis.europa.eu/project/id/609554
[39] https://www.lenses-prima.eu/
[40] https://www.rexusproject.eu/

27.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Learning and Action Alliances solution.

Table 53: Data inputs and outputs for the Learning and Action Alliances solution.

Data Input	Data output/results
Step 1: Problem Diagnosis and Understanding (Data: Relevant data - research, reports, data, and local knowledge. Skills: Facilitation skills to guide participatory discussions), Step 2: Stakeholder Identification and Engagement (Data: Information about relevant stakeholders, including community members, organizations, policymakers, and other actors who are affected by or have a stake in the challenge. Skills: Communication skills to engage and involve diverse stakeholders and negotiation skills.), Step 3: Collaborative Learning and Knowledge Exchange (Data: Information from stakeholders. Skills: Facilitation skills to promote interactive and inclusive learning), Step 4: Action Planning and Strategy Development (Data: Insights and understanding gained from collaborative learning. Skills: Problem-solving skills to generate actionable ideas, consensus-building skills to facilitate decision-making, and strategic planning skills), Step 5: Implementation and Monitoring (Data: Information on the progress, outcomes, and impacts of the actions taken, which are monitored through regular tracking, evaluation, and feedback. Skills: Project management skills to implement actions, monitoring, and evaluation) and Step 6: Reflection and Learning (Data: Reflections, feedback, and lessons learned from the actions taken, which are shared and discussed among	The specific outcomes and KPIs may vary depending on the nature of the challenge and the goals of the LAA process. Some potential results and KPIs for the LAA method are: -Increased stakeholder engagement (KPIs: number of stakeholders engaged, the diversity of stakeholders represented, and the level of active participation in the process), -Enhanced understanding and knowledge exchange (KPIs: the level of shared understanding among stakeholders, the number of knowledge products generated such as reports and briefs, and the level of knowledge integration into action plans), -Action plans and strategies developed (KPIs: number of action plans developed, the alignment of action plans with the identified challenge, and the feasibility and sustainability of the proposed actions), -Implementation and impact of actions (KPIs: progress and status of action implementation, the level of impact achieved in changes in behaviour or policies, and the effectiveness of actions in addressing the challenge), Reflections and learning (KPIs: level of reflection and learning activities conducted, the quality of insights and lessons learned, and the integration of learning into subsequent actions).

stakeholders. Skills: Reflection and critical thinking skills and adaptive learning skills to inform future actions)	

27.3.1 Data requirements

Since LLA is a collaborative approach, no data requirements existed.

27.4 Integration and interoperability plan

Since LLA is a collaborative approach, no beta or final versions can be extracted. Starting date was April 2023 and there is a continuous engagement until the end of the project.

Figure 23 shows the integration Gantt diagram of the proposed solution.

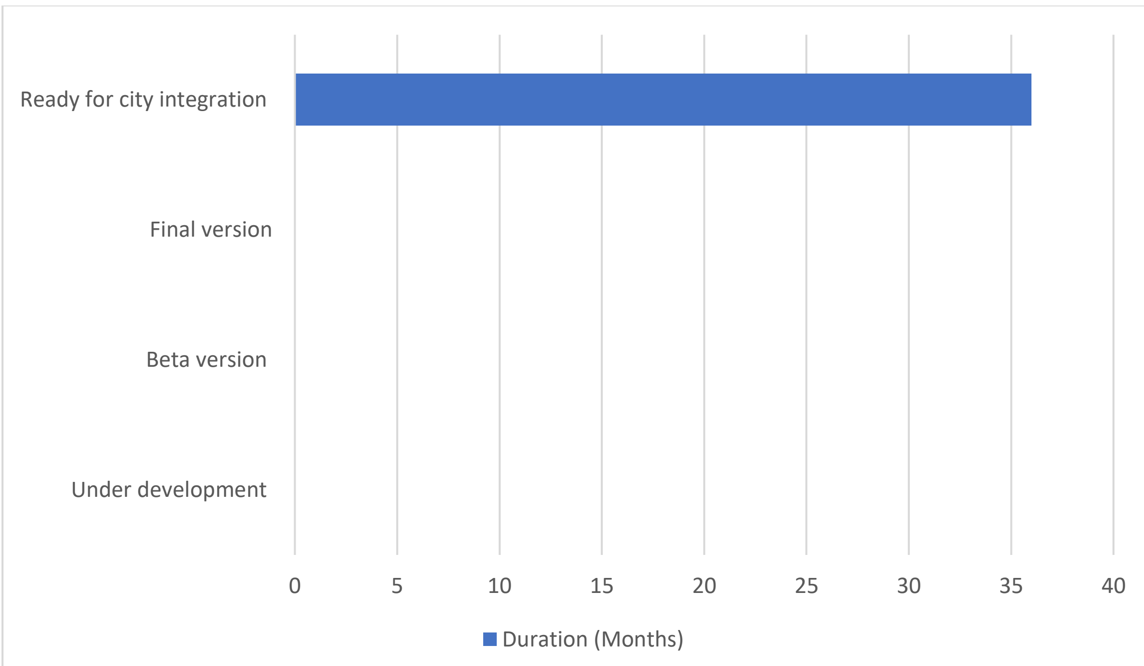

Figure 23. Integration Gantt diagram for the Learning and Action Alliances method solution.

27.5 Solution limitations

All cities in the UP2030 project have kicked off their LAA process in April 2023. Two key stakeholder categories have emerged from the fi first series of workshops on Needs: internal (City Hall) and external stakeholders. Cities are at very different stages of the LAA implementation and are seeking to adapt the approach to their local contexts. In some localities, the LAA is confined to different departments of City Hall while in others, a great number of relevant city or neighbourhood actors are actively involved,

27.6 Solution Evaluation

The evaluation may be obtained based on a questionnaire.

27.7 City mapping

The solution will be used in all UP2030 cities.

28 Tools for measurements in the urban water cycle solution

28.1 Introduction

Tools for measurements in the urban water cycle is a guide on good practice in evaluating measurement and uncertainty resulted from the EMUE project [41]. This guide supports the assessment of uncertainty and reliability of the quantitative measurements of environmental variables (e.g., precipitation). The solution is provided by LNEC.

28.1.1 Solutions Short Description

The methods are of interest to cities to assess and quantitatively measure the quality of data relevant to climate adaptation and sustainable development of urban environments, adding confidence to assessments of implemented solutions, by providing computational procedures allowing estimating measurements uncertainties of models' parameters and measured quantities.

28.1.2 Objectives

The main objective is to improve the confidence of quantitative measurements of variables relevant to climate adaptation and sustainable urban environment by evaluating measurement uncertainties thus supporting improved data analysis and knowledge-based decision-making.

28.1.3 Existing Installation

Not applicable.

28.1.4 TRL status

Current TRL status corresponds to TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies).

28.2 Technical specifications

Measurements are crucial in many tasks required to support analyses and decision-making in cities regarding climate adaptation, carbon neutrality, circularity, stakeholder engagement or public participation. As in other related domains of knowledge, requirements on confidence and uncertainty evaluation are paramount to understanding climate phenomena and supporting decision-making. The evaluation of measurement uncertainty is based on methods described in the ISO-GUM framework (Guide for the Expression of Uncertainty in Measurement), using calculation algorithms and numerical computational tools (in more complex, nonlinear mathematical models), e.g., Monte Carlo and Bayesian methods.

The approach requires a prior definition of the functional relations describing the phenomena intended to be measured, their input and output variables and the contributions to their error and uncertainty. The method relies on scientific instrumentation and its traceability to the SI and applies common knowledge of statistics and probability. The analysis of measurement series obtained for time and space frameworks would support a better insight into the outcomes and discussions based on measurements.

[41] http://empir.npl.co.uk/emue/

The following table represents an overview/summary of the technical aspects of the proposed solution such as versioning, licensing, existence of online documentation and programming language that has been used for the relative solution.

Table 54: Technical aspects of the Tools for measurements in the urban water cycle solution.

Technical Aspect	Description
Versioning information	http://empir.npl.co.uk/emue/wp-content/uploads/sites/49/2021/07/Compendium_M36.pdf
License	The use code of programming described in the examples is free.
Online-documentation	https://www.bipm.org/en/committees/jc/jcgm/publications
Programming Language	The code described in the examples given was made using R-Studio, which is freeware. The code can be easily translated to other programing languages such as Matlab [42]and Python.

28.3 Data Management Overview

The following table represents an overview of the data inputs and outputs for the Tools for measurements in the urban water cycle solution.

Table 55: Data inputs and outputs for the Tools for measurements in the urban water cycle solution.

Data Input	Data output/results
The input required is the mathematical model describing the measurement process, including its input quantities and each contribution to the uncertainty budget. Contributions are evaluated by combining stochastic variability with defined probability distributions.	A major outcome is the ability to provide measurement results with confidence and traceability, allowing comparison with other data for the class of problems to be studied. The outcome of the measurement uncertainty evaluation is the best estimate of output quantities and expanded uncertainty obtained by analysis of their output probability distributions.

28.3.1 Data requirements

The relevant information will be provided in the following up months of the project.

28.4 Integration and interoperability plan

Figure 24 shows the integration Gantt diagram of the proposed solution.

[42] https://www.mathworks.com/products/matlab.html

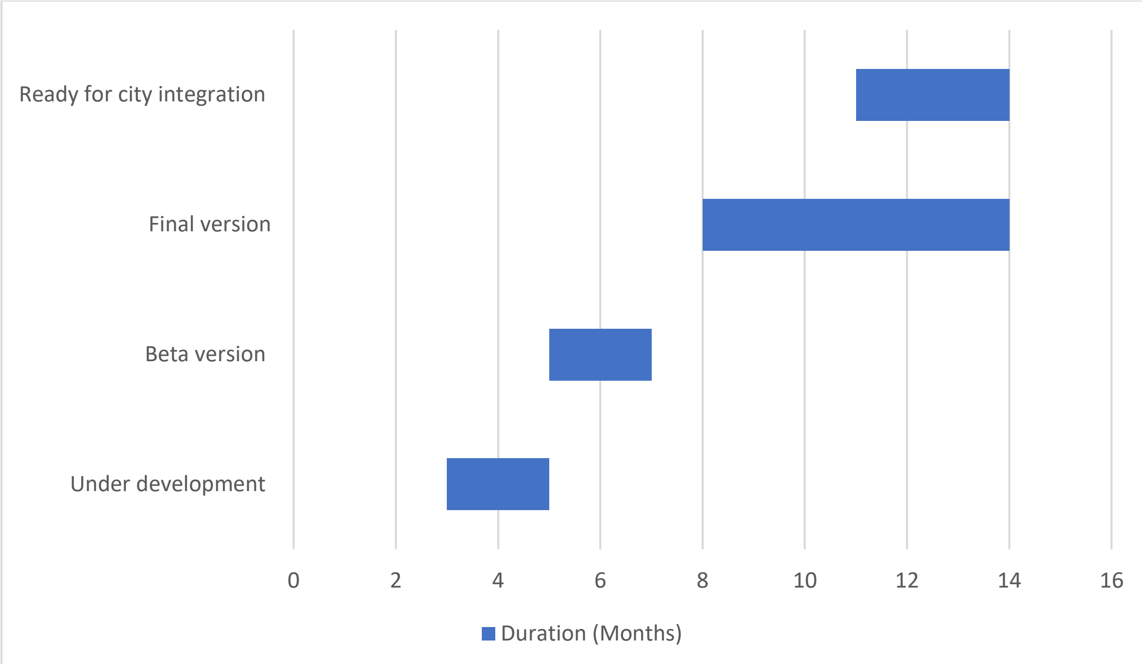

Figure 24. Integration Gantt diagram for the Tools for measurements in the urban water cycle.

These tools can be integrated into other systems and platforms allowing the exchange of data and results.

28.5 Solution limitations

Complex mathematical models might require high computational time and programming skills.

28.6 Solution Evaluation

The procedures were developed under an EU funded project and evaluated by independent referees.

28.7 City mapping

The tool is under implementation using the data and measurement models from an experimental facility in Lisbon, within the pilot borough of Alvalade.

29 Overall integration and interoperability plan

29.1 Introduction

The overall integration plan will be the guideline to the process of combining all the previous mentioned in Section 2 different solutions, components, systems, and technologies in order to create a unified whole that operates harmoniously. It will connect disparate systems, exchanging data, and enable their functionalities to work together effectively. The Integration plan can be achieved through various means such as application programming interfaces (APIs), software connectors, middleware, or custom developments.

A seamless integration is important for the UP2030 project as it will ensure that different components/solutions work together smoothly and efficiently. The seamless integration is crucial as it will help streamline the workflow by eliminating any gaps or bottlenecks in the included solutions. It will ensure that data, information, and tasks of each solution can seamlessly flow between different solutions and towards the project, allowing UP2030 project team to work efficiently. A seamlessly integration will facilitate better collaboration among solution providers and project members. It will allow real-time sharing of information, updates, and progresses, enabling team members to work together effectively and make informed decisions.

Seamless integration ensures that data is accurately and consistently shared across the solutions involved in the project. This will minimize errors, redundancies, and discrepancies, thereby improving the quality and reliability of the project data. In addition, with seamless integration, the project team members can focus on their respective tasks without being hindered by technical or operational barriers. This approach will boost productivity as it will reduce time wasted on manual data entry and troubleshooting integration issues. In addition, enabling efficient workflows and reducing manual effort, seamless integration can save significant costs and time for the project while it will eliminate the need for duplicate data entry, manual data transfers, and manual synchronization, which reduces the chances of errors and saves valuable resources.

29.1.1 Project Goals and Objectives towards integration

Before defining the overall framework of solutions integration, it is essential to recap the UP2030 project's objectives. UP2030 aims to assist cities in achieving their climate neutrality targets by leveraging urban planning and design to drive socio-technical transitions. The project involves city stakeholders and local communities in the process. Authorities will receive support and guidance to promote neutrality in their communities through day-to-day actions and strategic decisions. The project will develop and apply an innovative methodology (5UP-approach) that includes co-development and implementation of science-based, yet practical tools and methods.

Inclusive participation is crucial throughout the project's full cycle of activities to ensure that the real needs of the community are met. The visions of each city reflect the communities within them, and co-designed interventions aim to maximise the delivery of co-benefits. Therefore, UP2030 is expected to have a positive impact on spatial justice in the pilot areas and provide citizens with the opportunity to participate in the transition by becoming agents of change through their sustainable behavioural shifts.

To achieve city-wide impact, cities must go beyond technical designs and piloting. UP2030 aims to empower local authorities to shape their innovation-enabling city environment through a relevant policy framework, inclusive participation, sustainable behaviour shifts, capacity building in city departments, new governance arrangements, and financial facilitation. UP2030 will guide this process. Cities can deliver on the values of equity, resilience, neutrality, and sustainability. This approach aims to upscale solutions and respond to the climate emergency. To accelerate implementation in many cities, UP2030 proposes the 5UP-approach for activating cities and stakeholders through 5 interlinked phases. The five components have an obvious sequential order, and their outcomes are reinforced by feedback between them. The 5UP approach differentiates itself from conventional methodological approaches that focus on testing a particular innovation, such as a digital solution, to bring about incremental change. Instead, the 5UP approach places the city at its centre and offers an integrated strategy for multilevel action on identified leverage points.

29.2 Integration Framework

According to the individual integration plans provided by each solution, it is obviously that most of the proposed solutions do have the maturity level to be already integrated to the involved cities. Some of them are close enough to be integrated to the cities as they need a few more months to be refined or enhanced, but a good starting point is to initiate the integration process with those that they are mature enough.

We are proposing therefore the overall integration framework to be divided in two parallel areas, starting at M13. These discrete periods are in align with above-mentioned milestones of all Gantt diagrams presented on the previous sections, for each solution separately. The first period refers to those solutions that already have the ability to be integrated to the cities or they are close enough to their final versions. Table 56 presents the solutions as presented in the previous sections with a maturity level of to be integrated to the cities of UP2030 among with their respectively responsible partner.

Table 56: Ready for city-integration / final version solutions

a/a	Solution Name	Partner
1	Checks on Climate Impacts / Climate proofing	BH
2	Citizen Voice	TUD
3	CLIMACT Prio tool	GGGI
4	Green Economy Model	GGGI
5	Resilience Maturity Model & Risk Systemicity Questionnaire	ICLEI
6	UDCW simulation toolkit	UCCRN
7	Resilience strategies database and tool solution	AUATEC/LNEC
8	Liveable Cities Index methodology	CETAQUA
9	Water-smartness Assessment Framework Tool for circularity in the urban water cycle solution	LNEC
10	Resilience Assessment Framework Tool for resilience strategies solution	LNEC
11	AI-powered toolset for the decarbonisation of buildings & transport solution	METU/ODTU GUNAM

12	Draxis UP2030 Decision Support System solution	K3Y
13	MIRA solution for Cities as Digital Twins solution	MAG
14	Modular Urban Farm solution	VM
15	GeoKey/Community Maps solution	MfC
16	Learning and Action Alliances method	ICA
17	Tools for measurements in the urban water cycle	LNEC

For the solutions presented on the previous table, we propose to organize a series of monthly meetings starting on M13 with the tool owners to report the progress/status of the integration, the level of the integration to the respectively cities and to record any issues obstacles that may be occurred. The tools of managing and recording the integration status these solutions will be decided on M13 however the best approach is to use a live excel file sheet in UP2030 project repository. At the beginning of each month starting on M14, a report regarding the status of the tools will be also generated and placed into the project repository. This process will prepare the ground for integration for those tools that currently lack the required maturity in terms of integration to the cities.

This first period of integration will be contacted from M13 till the end of the second year of the project. In the meantime, and at the half of this first round, a second period of integration attempt will start in parallel for those tools/solutions that currently are not in a level of maturity for integration in the cities. These tools are presented in Table 57. In addition, we will ensure that if a solution reaches earlier the maturity level of integration to the cities to be included in the first round of integration.

Table 57: Under development/Beta version solutions

a/a	Solution Name	Partner
1	City Scan - Data driven geospatial analysis	TSPA
2	Parametric Modelling Assessment Tool	TSPA
3	UDCW facilitation toolkit/P-GIS (Participatory GIS)	UCCRN
4	BIM module & Building LCA assessment module	CIRCE
5	Climate Resilient City Tool solution	DELTARES
6	Air quality monitoring and forecasting service	LINKS
7	Ecosystem Services Assessment solution	LINKS
8	Urban Heat Island Risk Analysis	LINKS
9	LCA and Matchmaking tool for building material reuse solution	ETH
10	Carbon information framework solution	UCAM

Nevertheless, as the integration is a live – on going process, re-evaluation of the maturity level of the solutions integration to the city will be performed on a monthly basis. The on-going report will be presented to the second report of D3.1 on M24.

29.2.1 Common interfaces, protocols, and standards

Data interoperability refers to the ability of different systems and applications to exchange and understand data seamlessly. In today's digitally driven world, where data is created and consumed at an unprecedented pace, standards play a crucial role in ensuring efficient and effective data interoperability. These standards act as a common language, enabling disparate systems to communicate and share information in a unified and reliable manner. Standardization enables businesses, governments, and organizations to streamline their operations, improve data quality, enhance decision-making processes, and unlock the full potential of data-driven insights. By adhering to established standards in data interoperability, stakeholders can foster collaboration, integration, and innovation, ultimately driving progress and growth across various sectors.

Data interoperability standards are key to ensuring seamless communication and integration of information across different systems. Some commonly recognized standards include XML, which provides a framework for structuring and exchanging data in a platform-independent manner. Another important standard is JSON, which enables the efficient transmission of data between web applications. Additionally, REST (Representational State Transfer) is a widely used architectural style that defines a set of constraints for building web services that can exchange data easily. These standards promote interoperability by establishing common data formats, structures, and protocols, enabling disparate systems to effectively exchange and utilize data resources. The latter is a widely adopted architectural style that facilitates interoperability between various systems and software applications. By adhering to the principles of a RESTful design, REST-API allows these systems to communicate and exchange data seamlessly. It promotes the decoupling of client and server implementations, enabling different platforms and devices to interact with each other effortlessly. This approach ensures interoperability by providing a standardized interface for request-response communication, allowing businesses to enhance their integration capabilities and effectively leverage the power of interconnectedness.

29.2.2 Data Management and Sharing

Additionally, it is important to include information on the types and formats of data to be generated or re-used, their expected size, and their origin/provenance. The purpose of data generation or re-use and its relation to the objectives of UP2030 should also be clearly stated, as well as potential usefulness of the data outside of the project. The purpose of data generation or re-use and its relation to the objectives of UP2030 should also be clearly stated, as well as potential usefulness of the data outside of the project.

Data protection is crucial, and therefore, it is essential to provide provisions for data security. Partners should also specify whether the datasets will be stored safely in trusted repositories for long-term preservation and curation. The ethical or legal impact of the datasets should be carefully handled, and it should be mentioned whether informed consent for data sharing and long-term preservation will be included in questionnaires dealing with personal data.

30 Conclusions

This deliverable, developed in Month M12 of the project, provides a foundation for UP2030 City and Technical partners to gain a shared understanding of the technological roadmap required to integrate UP2030 solutions within UP2030 cities. Its purpose is to provide a clear development and integration plan for each solution. Each UP2030 solution is presented in a dedicated section that includes its description, objectives, relevant existing installations, and TRL status. Furthermore, the technical specifications of the solutions, including an overview of data management and their requirements, are provided along with the development and integration plan. Lastly, a comprehensive section presents an integration and interoperability plan with defined milestones, and timelines. This will ensure a smooth integration process between the proposed solutions in UP2030, while also providing seamless interconnectivity between UP2030 subcomponents.

D3.1 is a living document that will be updated with further details as the implementation of the UP2030 project progresses and when significant changes occur. An updated version in M24 and M36 will build upon this document and become an updated version of it.

31 References

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