UP2030

Urban Planning and design ready for 2030

3

D4.6 - Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 3

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About UP2030:

UP2030 is dedicated to aiding cities in achieving climate neutrality through enhanced urban planning and design. The project introduces the innovative 5UP approach to support city stakeholders and local authorities in integrating climate-neutral strategies into their everyday actions and long-term planning. Focused on promoting spatial justice and inclusive participation, UP2030 empowers communities and local governments to become agents of change, driving socio-technical transitions that enhance urban liveability and sustainability. The project's strategy aims to produce actionable insights and scalable solutions for urban environments, prioritizing resilience, equity, and sustainable urban development.

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Abstract	This report presents a framework for evaluating project prototypes developed by partner cities using Key Performance Indicators (KPIs). The methodology employs a two-track approach, combining a collaborative process of city-led KPI validation with a parallel, objective analysis of KPIs derived from publicly available open data. This synthesis of direct participant feedback and external data provides a holistic and reliable evaluation of the project's performance and impact, establishing a powerful model for future assessments.		

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Executive summary

This report presents the complete Key Performance Indicator (KPI) monitoring framework developed and carried out for the project. It builds on the previous Deliverables D4.4 and D4.5—Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots. The primary objective was to create a robust methodology for evaluating the impact and success of the prototypes developed and implemented by participating cities and their partners.

A novel approach with two tracks was adopted for this evaluation. The first track involved a **collaborative process with the partner cities**. Through a series of discussions, a tailored list of KPIs was co-created to accurately reflect the specific actions and objectives of each city's prototype. By the end of the project (M30), these KPIs were formally validated by the cities, providing direct, ground-level feedback on the project's effectiveness and outcomes.

The second track provided an objective, external perspective by monitoring a distinct set of measurable KPIs derived from **publicly available open data**. This data-mining effort ran in parallel to the city-led validation, allowing for a broader, quantitative assessment of the project's impact beyond the direct feedback from participants.

The results from both methodologies are presented and analysed. The city-validated KPIs confirm the successful implementation of the prototypes and highlight their specific achievements. The external KPI analysis complements these findings by providing data-driven evidence of the project's wider influence. By combining direct participant validation with objective open-data analysis, this monitoring framework offers a holistic and reliable evaluation of the project's performance, establishing a powerful model for future impact assessments.

Content alignment with other UP2030 deliverables

The UP2030 project fosters exchange and cooperation among partners and deliverables beyond the work packages (WPs) structure. Therefore, the content of this document has been developed in alignment with WP4 and WP2; Universitat Internacional de Catalunya (UIC), Resilient Cities Network (RCities), and the Benchmarking, Monitoring, KPIs Taskforce, as well as the previous deliverables D4.4 and D4.5 about UP2030 implementation plan for the pilot cities". 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
D2.2 — UP2030 benchmarking report against state-of-the-art and identification of pilot opportunities 1 D2.3 — UP2030 benchmarking report against state-of-the-art and identification of pilot opportunities 2 D3.2 — Transformative pathways roadmaps: strategic integration of solutions and interoperability 2 D4.1 — UP2030 pilot implementation plan for the pilot cities 1 D4.2 — UP2030 implementation plan for the pilot cities 2	

D4.4 — Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 1 D4.5 — Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 2 D5.2 — Analysis and recommendations for transformative governance and policy 2	
Mil.4 Cities have set-up LAAs Mil.5 Cities run first workshop on needs Mil.6 Cities run second workshop on vision Mil.10 Cities run third workshop on Action Mil.13 All cities have at least one successful prototype Mil.14 Cities run fourth workshop on upscale	

The target groups of this report are the Pilot Cities and City Liaisons as well as the technical partners (RCities, TSPA, BH, DRAXIS). The main beneficiaries of this deliverable will be taskforce leaders related to implementation of prototypes and their assessment, as well as project coordinators. Part of this report is based on the work done with the Pilot Cities and City Liaisons from UP2030, analyze the impact of implemented methods on the pilot cities.

Acronyms

Acronym	Full Name
ABCD	Asset Based Community Development
AWC	Available Water Capacity
BIM	Building Information Modeling
BoTu	Bospolder - Tussendijken
bsk	Cold Semi-Arid Climate
CAMS	Copernicus Atmosphere Monitoring Service
CBA	Cost-benefit Analysis
CCC	Climate City Contract
Cetaqua	Centro tecnológico del agua
cfa	Humid Subtropical Climate
cfb	Oceanic Climate
csa	Mediterranean Hot Summer Climate
CRF	City Resilience Framework
D	Deliverable
DC	Design Clips
DCAP	District Climate Action Plan
dfb	Warm Summer Continental Climate
DSS	Decision Support System
ES	Ecosystem Services
ESA	Ecosystem Services Assessment
GDP	Gross Domestic Product
GEM	Green Economy Model
GenA	General Assembly
GF	Green Finance
GHG	Greenhouse Gas
HSKC	Healthy Streets Knowledge Center
KPI	Key Performance Indicator
LAA	Learning and Action Alliance
LCA	Life Cycle Assessment
LNEC	National Laboratory for Civil Engineering
MfC	Mapping for Change
Mil	Milestone
NBS	Nature-Based Solutions
NDVI	Normalised Difference Vegetation Index
NSM	Neutrality Story Maps
NZNF	Net Zero Neighbourhood Framework
OECD	Organization for Economic Cooperation and Development
PAC	Air Climate Plan
PV	Photovoltaic
Q	Question
RAF ICARIA	Resilience Assessment Framework

SCL	Scene Classification Layer
SUDS	Sustainable Urban Drainage Systems
SWIR	Short-Wave Infrared
U4SSC	United for Smart Sustainable Cities
UBTEM	Urban Building/Transport Energy Model
UCCRN	Urban Climate Change Research Network
UDCW	Urban Design Climate Workshop
UIC	Universitat Internacional de Catalunya
UPV	Universitat Politecnica de Valencia
URCAM	Urban Regeneration Carbon Accounting and Management
VUB	Vrije Universiteit Brussel
WP	Work Package

1 Introduction

The progress of the UP2030 project is measured through defined Key Performance Indicators (KPIs), which are used to guide decision-making and policy. This third deliverable (D) on KPI monitoring, evaluation, and validation (D4.6) explains the framework developed for this task. Its purpose is to provide a clear method for assessing the impact and success of the prototypes created and tested by participating cities and their partners. The KPIs offer measurable evidence of how well objectives are being met and support the wider goal of showing impact across social, economic, and environmental areas in all pilot cities.

To ensure a reliable evaluation, the framework introduces a two-track method. The first track is city-led, with partner cities selecting KPIs through discussions and co-design. These indicators reflect the specific objectives and actions of each city's prototype. The second track runs alongside it, using an external set of KPIs based on publicly available open data. Together, these two tracks combine local knowledge with independent analysis and link the indicators to the goals of urban planning and climate neutrality research.

The report presents and examines the results from both tracks. City-validated KPIs confirm progress within each prototype, while the external data provides additional evidence of broader effects. By bringing these two perspectives together, the framework delivers a complete and trustworthy picture of project performance. It also connects progress to the project's three main pillars: climate neutrality, resilience, and spatial justice. This system creates a solid basis for future impact assessments and for continuing to track the pilots after the project ends.

1.1 Purpose and scope

The reports on monitoring, evaluation, and KPI validation in the 5UP-approach pilots have developed over time. They began with early definitions and strategic direction and have grown into the current two-track evaluation system.

The first report, D4.4 — Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 1 , was submitted on December 2023. It set the groundwork by using KPIs to measure progress in pilot cities toward a shared vision. It explained how KPIs were identified, described the pilot city profiles. The work also noted that KPIs would need updates and changes as feedback came in. This first phase, carried out in 2023, focused on defining the strategy and initial design of the KPIs.

The second report, D4.5 — Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 2, was submitted on June 2024. It built on the first report by linking the KPI process more closely with the UP2030 project activities, especially the definition of objectives and visions. New KPIs were created to reflect these goals. Each city received a defined profile based on earlier activities such as the needs workshop (Milestone 5 (Mil.5)) and the vision workshop (Mil.6). These profiles helped filter the KPI list into ten city-specific sets. Río de Janeiro's KPIs were not monitored during this period. This was due to Río following a different methodology from the other 10 cities included in the analysis. At this stage, the KPIs were not final, since they still had to be matched with the strategies and actions that would later define how objectives would be achieved. The report's goal was to make sure KPIs were both relevant and measurable in relation to the actions that would follow.

The most recent version, D4.6, presents the current evaluation framework. Its purpose is to assess the prototypes developed by partner cities through KPIs. The main innovation is a two-track system. The first track is city-led, with each partner city working to create a specific list of KPIs that matches its own objectives and actions. The second track runs in parallel, using an external set of KPIs based on publicly available open data. This combination of direct input from the cities and independent data analysis is designed to give a full and reliable picture of the project's results.

Table 1 KPI Monitoring Deliverables Goals and Scope.

Document	Goal	Scope
D4.4	To **establish the essential framework** for monitoring, evaluation, and KPI validation within the UP2030 project. To define a list of measurable KPIs related to the UP2030 project ambitions and cities' visions.	Defined the iterative **KPI Monitoring Process** with three phases: Strategic Alignment, Refinement, and Execution. Built a preliminary list of 128 KPIs. Included initial feedback on data measurability from the **General Assembly (GenA) Lisbon workshop**
D4.5	To **align the KPI identification process** with the actual UP2030 project activities and prototypes, focusing on defined objectives and vision formulation. To define a smaller, **focused list of KPIs for each pilot** by applying strategic filters	Used the objectives and vision formulated during workshops (Mil.5 and Mil.6) to define **Pilot Profiles** for each city. Used these profiles to filter the preliminary KPI list, resulting in **ten tailored KPI lists** (one for each pilot). Recognised that the defined KPIs are preliminary and must be **matched with the considered actions (strategies)**. Confirmed that cities can primarily collect data at the **city-wide level, not the pilot area level, for most variables**.
D4.6	To present **the final framework for evaluating project prototypes using KPIs**. To perform a holistic and reliable evaluation of the project's performance and impact. To track the impact of adopted actions and drive positive urban transformation.	Follows a novel two-track evaluation approach: Track 1 involves a **collaborative process of city-led KPI** validation tailored to specific prototype actions. Track 2 involves a parallel, objective analysis of measurable KPIs derived from **publicly available open data**.

1.2 Document structure

The document is structured as follows:

- **Section 1 - Introduction**: Introduces the report's plan to check city prototype success using a two-track KPI method.
- **Section 2 - Methodology**: Details the method for creating the KPI plan, from initial design to final approval, including the two-track approach.
- **Section 3 - KPI Validation and City Actions Results**: Presents the specific results from cities' self-reporting, comparing starting data to progress data for each prototype.
- **Section 4 - External KPI Analysis Results**: Shows the findings from the independent analysis of public data on climate, pollution, transport, and green surfaces.
- **Section 5 - Discussion**: Compares and explains the findings from both city reports and external data, noting data gaps and the difference between local progress and national trends.

- **Section 6 - Proposed Monitoring Schedule**: Outlines the future plan for yearly data collection, combining city self-reports with external open data to track progress.
- **Section 7 - Conclusions**: Summarizes the mixed results, highlighting data gaps, positive local growth, different city starting points, and the link between economic issues and project goals.

2 Methodology

This section explains how the KPI monitoring framework for the UP2030 project was built and refined. It describes the path from the first design steps to the validation of indicators, showing how broad ideas were linked to the goals of each pilot city. The section also introduces the two-track approach: one track based on city-led KPI selection and another using external indicators from open sources.

2.1 From Framework Design to KPI Validation

The development of the KPI monitoring framework in the UP2030 project advanced through a series of structured steps. It began with the creation of the core methodology and then moved toward refinement, alignment with city goals, and the start of actual measurement.

Table 2 KPI Monitoring Framework Development Progress – Deliverables.

Document	Primary Focus	Key Concepts	KPI Status / Next Step
D4.4	Establishing the **Monitoring Framework** and **Preliminary KPI Identification.**	Defined the **3-Phase Iterative Methodology**. Classified KPIs into **Core (Common)** and **Pilot-Specific**. Gathered initial feedback on data measurability during **GenA Lisbon**.	**Preliminary list of KPIs** defined (128 total). Validation pending confirmation of measurability and project alignment.
D4.5	Aligning KPIs with **Pilot Objectives and Visions.**	Defined detailed **Pilot Profiles** based on city objectives and visions. Filtered KPI lists to create **ten preliminary lists** (one per pilot). Noted major focus areas are "urban planning," "community involvement," and "organisation".	**Second pilot specific KPI lists** and pending matching/confirmation with the **defined actions (strategies)**. Validation delayed to ensure alignment.
D4.6	**Final KPI Validation** and initiation of continuous **Monitoring/Measurement.**	**Matching of KPIs with actions/strategies**. **Measurability confirmation** from the cities. Final formal validation and classification. **Launch of data collection** for the "As-Is" state.	**Beginning of the KPI data collection.** KPIs validated, ready for measurement.

The first document, D4.4, set out a detailed **methodology** for identifying, measuring, and monitoring KPIs. This stage defined the process of KPI development in three phases: Strategic Alignment and Preliminary Design, Refinement and Ratification, and Execution and Analytical Review. A key task was to compile an initial **integrated list of 128 KPIs** drawn from different standards and frameworks. These were classified into **Core (Common) KPIs**, representing the overall project ambitions (about 15 indicators), and **Pilot-Specific KPIs**. The report highlighted the need to connect KPIs with pilot visions and objectives. It also broke down the data requirements to test whether indicators could be measured, using feedback from the GenA Lisbon workshop to assess the capacity of cities to collect data and an additional check after filtering KPIs for D4.6. All this can be seen in Table 2.

The next deliverable, D4.5, marked a shift from general methodology toward connecting the framework with the practical work of the city pilots. While D4.4 focused on what should be measured, D4.5 focused on **how the selected KPIs link to the strategic goals** of the cities. To achieve this, **pilot profiles were created** for each of the ten cities, based on their objectives and vision statements from milestones. These profiles allowed the filtering of the broad KPI list from D4.4 into ten smaller lists of **specific KPIs that reflect the goals of each pilot**. The analysis of these profiles showed that most pilots placed strong emphasis on "urban planning", "community involvement", and "governance". D4.5 also noted that validation of KPIs had been postponed to ensure they matched the finalised objectives and visions. Feedback showed that data would be gathered both as numerical values and Likert scales.

This work leads into the next stage, D4.6. At the end of D4.5, the KPI lists were still preliminary, pending their **link to the actual actions and strategies** planned by the cities. D4.6 is expected to describe the process of aligning KPIs with these actions, which is needed for their **final validation, as it is shown in** Table 2. This will confirm that the KPIs are relevant, measurable, and reflect the expected changes within the pilots. D4.6 also classifies KPIs according to how they will be measured. The outcome of this stage is a clear **schedule for measurement**, along with the **start of data analysis** and reporting. This will allow assessment of the initiatives' impact and support positive urban transformation.

The decision to use two separate ways to track progress comes from the need to see the full picture of how the project is working. The first track focuses on the internal view, while the second looks at the external view. The **internal view relies on the cities collaboration**. This is necessary because only the people working inside the project can explain the specific details of their prototypes. For example, they know exactly how many residents took part in a workshop or if the different departments in the local government are working together better than before. This kind of feedback describes the quality of the work and the immediate reaction of the community. In this phase, the project required the cities to help build lists of indicators that were suitable and measurable before collecting the data.

However, **relying only on the partners for information causes practical problems**. On the one hand, city staff are often very busy with the daily work of urban planning and may not have **time** to fill out long reports. On the other hand, asking each city to calculate their own numbers often leads to results that are hard to match up. One city might **measure a green area differently** than another. To solve this, the project uses external data sources. This allows to compare the results across all ten cities fairly and It helps to apply the **Strategic Learning/City Twinning strategies**. By using satellite images and public maps, the team can see the changes in green space or bike paths using the same ruler for everyone.

The **value of this independent checking became clear when facing the challenges of the validation process**. During the reporting period, there were gaps in the information sent by the partners. For instance, some cities provided no data at all for the second phase, and definitions of indicators were sometimes misunderstood even though they were written down clearly in several documents during the feedback rounds. If the project relied on the city reports alone, it would be impossible to describe the progress in those places. The external open data is usually updated more often and it is always available. This creates a safety net. It makes sure that even if the local teams are responsible of other urgent tasks, there is still a record of how the city is changing over time.

2.2 KPI Validation Process

This report includes monitoring based on questionnaires as the main monitoring track which is expected to be continued. The questionnaires measure the success of each prototype at the prototype scale. This method and the calculations for each KPI were carefully reported in previous deliverables and has been improved and used on this deliverable.

The UP2030 project develops and checks KPIs to make sure they show what cities want to achieve. The project selects indicators that match its three main ideas: climate neutrality, resilience, and spatial justice. These indicators must meet strict rules. They need to be relevant, clear, and consistent. Most important, they must be possible to measure in an objective way, and the data must be easy to get. City partners give feedback during the whole process. At the GenA workshop in Lisbon, cities looked at whether they could collect data for the first KPI lists. They checked if they could gather information at the pilot area level or across the whole city. This approach often leads to changes. For example, cities said it was hard to measure "social polarisation". Because of this feedback, this indicator was left out of final list.

Each city gets its own KPI list. Cities confirm these lists to make sure they match their plans and actions for their prototypes. Some KPIs are quantitative. Examples include the number of planted trees at city scale from 2023 to 2025, and the number of stakeholders who take part in pilot activities. Other measures are qualitative. These measure what people think and feel. An example is local community involvement in the planning phase. These measures usually use a five-point Likert scale. The validated indicators show how well prototypes work. They show changes from the starting point.

The method for creating KPIs makes sure they match the project's core ideas and what each city wants. The basic rule says that KPIs must relate to project goals. They must cover environmental, social, economic, and governance areas. They must be possible to measure in objective way. The indicators must also confirm that data can be accessed and how frequently. Their definitions and how they are calculated must be clear and consistent.

This system helped narrow down a first list of 128 general indicators. These came from global standards like the United for Smart Sustainable Cities (U4SSC) and the City Resilience Index. The process created unique lists for each pilot city. The indicators show the results that cities described in their local goals and visions. Cities worked on these during special project workshops.

City partners help define KPIs through a process that involves working together and checking multiple times. An important first step was the workshop at the GenA in Lisbon and also during the GenA in Zagreb. Cities and liaisons looked at whether they could gather the information needed to calculate the first Core KPIs. This check gave direct information about whether cities had the technical ability to measure indicators. It also confirmed that many variables could only be collected at the city-wide level, not at the smaller pilot area level. These practical inputs shaped the next steps in the method and filtering process.

KPIs get final validation only after they match the specific plans and actions defined for the prototype phase in each city. This step makes sure the final indicator list directly checks how cities put their planned actions into practice. These actions help cities reach their defined goals. The validated KPIs include both quantitative reports with numbers and qualitative measures using a Likert scale. For example, Milan reported specific quantitative measures of its physical progress, and counted the number of planted trees at city scale from 2023 to 2025. The city logged 15,164 trees. Milan also counted the number of stakeholders involved in pilot activities. This number was 10 stakeholders. Milan measured the number of City Resilience Framework (CRF) objectives investigated for the resilience assessment. The city reported eight objectives. Qualitative aspects about governance or community are also captured. One question asks how much residents and users have been involved in the project planning process. Another measures how well the project coordinates with other government bodies. This dual reporting system makes sure the evaluation captures both physical results and the socio-organisational progress related to how the project is put into practice.

The cities were divided into two groups to improve the learning capacities by introducing a peer review approach of similar prototype typology. For the review of the collected voluntary reporting results, the project established two primary groups. **Group 1 includes Belfast, Budapest, Munster, Rotterdam, and Thessaloniki**, while **Group 2 includes Granollers, Istanbul, Lisbon, Milan, and Zagreb**.

Group 1 cities build their prototypes around internal administrative change, governance frameworks, and methodology dissemination, which naturally rely on broader, less granular, or process-oriented metrics. While Group 1 cities track important physical metrics (e.g., Thessaloniki tracks buildings and energy), their prototype core output is frequently a process or framework (Guideline, Toolkit, Methodology) that tries a city-wide scale-up. Measuring the success of governance frameworks involves metrics concerning implementation efficiency, local authority cooperation, and compliance (often using Likert scales). The KPIs related to the implementation of strategies and governance are consistently monitored across the pilot, and it was decided to make it in a uniform manner for the five cities belonging to this group.

Group 2 (Lisbon, Milan, Istanbul, Zagreb, and Granollers) tend to center their prototypes around **advanced analytical platforms and digital tools** designed to process complex, quantifiable physical, and environmental data. These prototypes focus on technical implementation and simulation, generating quantifiable outputs related to energy, buildings, or ecological function, thereby requiring specific, objective metrics to validate performance. In this case, the cities were allowed to have more flexible KPI definition according to the needs of their specific prototype so the survey differs from city to city and specially in comparison to Group 1 set of KPIs.

The KPI filtering process started with the original KPIs defined in deliverable 4.5. Each city began with a different number of original KPIs. For example, Munster had 25 original KPIs, while Budapest had 33.

Cities and liaisons were involved to reduce these lists. They checked which KPIs made sense for each city. They asked for feedback and advice from partners. This helped create shorter, more useful lists. Shorter lists are easier to use and help the people in charge of projects make better decisions based on clear information.

Another important step was merging the KPIs from group 1 together. There was a matching of KPIs between different cities from the initial lists. Some meetings were held by Vrije Universiteit Brussel (VUB), Centro Tecnológico del Agua (Cetaqua), and Universitat Politecnica de Valencia (UPV) to bring together the different KPIs from Group 1 cities. The teams worked to combine the indicators into one set. During these meetings, they made sure that project goals were covered. They also checked that all five UPs were included in final list. The process required careful review of each city's indicators. The teams looked at which KPIs could work for all cities in the group. They also identified where cities needed different indicators because of their local situations. This collaborative work helped create a unified set of KPIs that reflected both shared project goals and specific needs of each urban prototype.

Table 3 Group 1 Cities' Matching KPIs.

Common Group 1 Cities KPIs	Belfast	Münster	Budapest	Rotterdam	Thessaloniki	Rank (Matching)
Persons involved in the project	x	x	x	x		4
Number of urban plans that contain all 5 sustainability principles/elements of the plan (if the plans are digitalised and on the web then consider using automated web queries with semantics to examine these elements).		x	x		x	3
Number of tools implemented.		x	x	x		3

Number of people reached of dissemination through channels or number of interactions/participation generated in each channel (number of people, likes, comments, etc).			x	x	x	**3**
Common Group 1 Cities KPIs	**Belfast**	**Münster**	**Budapest**	**Rotterdam**	**Thessaloniki**	**Rank (Matching)**
Likert The extent to which the project has contributed to, or inspired, changes in rules and regulations.			x	x	x	**3**
Geographic scope, i.e., districts that have adopted the project, m² covered. Calculated as: [Number of neighborhoods implementing BoTu / Total neighborhoods in the city]*100			x	x	x	**3**
Likert The extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing.		x		x		**2**
Persons involved in the planning	x	x				**2**
Percentage of number of inventoried open datasets that are published. [Total number of open data sets published / Ttotal number of data sets] *100		x			x	**2**
Likert The extent to which the local authority provides financial support to the project.			x		x	**2**
Likert The extent to which the progress towards project goals and compliance with requirements is being monitored and reported.				x	x	**2**

Table 4 KPI filtering process.

Group	City	Reporting Answers	Baseline Answers	Survey KPIs	Confirmed KPIs	Checked KPIs	Original KPIs
1	Munster	11	11	14	6	11	25
	Budapest	13	13	14	7	11	33
	Belfast	0	13	14	9	11	60
	Rotterdam	0	10	14	11	11	36
	Thessaloniki	14	14	14	8	11	40
2	Zagreb	0	0	12	12	12	35
	Milan	11	11	11	11	11	37
	Granollers	0	46	50	48	48	40
	Istanbul	0	15	15	8	12	48
	Lisbon	22	22	25	23	23	34

Short KPI list

Long KPI list from their feedback

As shown in Table 4 the numbers of KPIs changed through this process. The "Checked KPIs" column shows the lists after reviewing with cities. The "Confirmed KPIs" column shows what cities agreed to track. The "Survey KPIs" column shows what went into the actual survey. Some cities got short KPI lists from the start, these appear in green in t**Error! Reference source not found.**. Other cities got long lists based on feedback from the cities these appear in orange in the table. The final Survey KPIs delivered in questionnaires came after checking and confirming with city partners. Cities reviewed the KPIs before they agreed on final versions.The process made sure that cities could realistically track and report on their KPIs, how frequently were the KPIs available, whether they were measurable or not, KPIs units and other specific details. The columns of Table 4 show the following information:

- **Group**: The identifier of the cluster or category to which the city belongs.
- **City**: The specific geographical location (city) being measured.
- **Reporting Answers**: The total number of answers recorded for the current reporting status.
- **Baseline Answers**: The total number of answers recorded for the initial or reference measurement.
- **Survey KPIs**: The count of KPIs collected or measured during a specific survey.
- **Confirmed KPIs**: The count of KPIs that have been officially verified or validated.
- **Checked KPIs**: The count of KPIs that have been reviewed or subjected to a quality check.
- **Original KPIs**: The initial count of all KPIs originally targeted or identified for the measurement.

The KPI reduction process starts with a large combined list of technical indicators from various international standards and frameworks. This process began with the 128 KPIs of Deliverable 4.4 and the changes are explained in Table 4. The purpose of this careful process is to create a clear method for monitoring, checking, and confirming that the project prototypes and tools performance matches the broad goals of the UP2030 project. The KPI development follows a structured, repeated sequence organised into phases. It begins with planning and design, moves through improvement and approval, and ends with putting the plan into action and reviewing the results. The improvement of this broad list into specific reporting blocks happens through several steps based on the project's overall method.

The three pillars of the UP2030 project are carbon neutrality, resilience, and spatial justice, often related to just transition. The indicators must reflect these three pillars. To make sure the indicators are practical and useful, the general list of KPIs is filtered based on the specific goals and urban contexts defined by the ten participating cities. These cities include Munster, Budapest, Belfast, Rotterdam, Thessaloniki, Zagreb, Milan, Granollers, Istanbul, and Lisbon. This makes sure the final indicators speak directly to local challenges. For example, addressing urban sprawl in Munster or balancing climate resilience and urban growth in Granollers. The KPI selection process follows the 5UP approach: Update, Upskill, Upgrade, Upscale, and Uptake. This approach works to bring solutions into urban planning and policy development.

An important selection rule requires that KPIs are measurable in an objective way, this means whether cities can collect the necessary data to calculate the indicators decides which KPIs are kept. Indicators are improved further when matched to the specific strategies and actions defined in the prototype phase of the city pilots. After creating preliminary city-specific KPI lists, from internal surveys and local data needs, the overall collection of indicators is reduced into a simplified general list. This creates the external KPI monitoring framework and allows **data collection from external open sources**.

The resulting data blocks, reduced from the broad initial list and finalised city questionnaires, relate directly to the key areas of urban transformation addressed in the project, they are transparency, greenhouse gas (GHG) emissions and climatic, resilience, transportation, and social inclusion data.

Transparency Data makes sure that relevant data and city information are shared openly and are available to stakeholders and the public. It also confirms that cities belong to climate responsive initiatives.

GHG Emissions Data and Climatic Data relate to the Carbon Neutrality pillar and reduction measures. This includes calculations of CO_2 emissions from various sectors, such as building operation and mobility. Climate data collection also supports modeling micro-climate effects, such as heat waves and flood hazard assessments.

Resilience Data covers the project pillar of climate resilience. This refers specifically to the capacity of urban areas to manage environmental stress. This is informed by tools that measure urban water systems, flood risk, and urban cooling.

Transportation Data relates to promoting sustainable mobility options and bringing together mobility assets. These are important areas for reaching carbon neutrality and addressing neighborhood quality of life.

Social Inclusion Data directly speaks to the Spatial Justice and Just Transition pillars. It measures socio economic impacts and checks equality aspects of urban planning actions.

This dual system also fits with the project's 5UP approach. The city-led KPI validation (Track 1) mostly looks at the immediate results of the prototypes. This reflects the **Updating** of plans, the **Upgrading** of tools, and the **Upskilling** of staff and stakeholders. On the other hand, the external KPI monitoring (Track 2) measures the long-term, city-wide impact. This track is more about the **Upscaling** of tested solutions and the **Uptaking** of these new methods into standard city policy and social norms.

2.3 External KPI Calculations

This section explains how the KPIs were calculated, it describes the data sources used and the methods applied. The section also shows the periods covered, and any assumptions made during the calculations. Understanding this methodology helps readers see how the results were obtained and how reliable they are.

The UP2030 project uses a two-track evaluation system. Track 1 involves city-led internal reporting. Track 2 collects External KPIs at the same time. The project relies on external, publicly available open data because it provides a complete and objective view. This view cannot be achieved through internal reports alone. The external analysis runs at same time as the city-led validation. It gives a broader, quantitative assessment of the project's impact beyond direct feedback from participants. This approach makes sure the project's performance is checked against verifiable, independent evidence. It confirms the internal claims of successful prototype implementation and allows for successful monitoring of the Upscaling phase results.

Internal KPIs in Track 1 measure the immediate, specific success of each prototype. They focus on elements like **Updating** of plans, **Upgrading** of tools, and **Upskilling** of staff and stakeholders. These are the first three "Ups" of the 5UP approach. External KPIs in Track 2 are structured to measure long-term, city-wide impact. This external monitoring directly checks the **Upscaling** of proven solutions and the **Uptaking** of new methods into standard city policy and social norms. The project uses universally available data sources like Copernicus, Organization for Economic Cooperation and Development (OECD), and the Global Covenant of Mayors. These sources let the project standardize metrics. They also allow credible comparisons across all ten European partner cities. This works regardless of their local data collection capacity.

External data has inherent limitations and biases. These relate especially to accuracy and detail. Internal data can help address these problems. For instance, citizen-science repositories like MIT Overpass data means that values may be corrected or updated by different users. This can lead to differences that do not reflect actual changes in physical infrastructure. Also, data collected at national or regional levels provides important social context. An example is the poverty rate from OECD indicators. However, this data may not precisely reflect the socio-economic conditions within a specific pilot neighborhood. Cities like Zagreb provided no internal reporting data for the requested period. This fact shows the importance of the independent external track. It can still provide a partial assessment of the situation where internal monitoring fails.

Despite these limitations, the dual approach makes sure the external analysis complements the internal KPIs well. This creates a trustworthy evaluation. For example, the Budapest prototype successfully reported a dramatic increase in resident and local authority involvement in Track 1. This confirmed the immediate, local effectiveness of its "Healthy Streets" approach. However, the external analysis in Track 2 reveals a contradictory national trend. Public concern about climate change in Hungary actually decreased by 6% during the same period. This contrast is an important finding. It shows that while local project wins are real, they are not yet generating a broader national shift in awareness. This illustrates the differing scales of impact measured by the two tracks.

Similarly, the external air quality analysis shows that eastern and port cities like Istanbul and Thessaloniki face greater pollution stress from sources like shipping. This provides essential context for the ambitious nature of their local decarbonisation prototypes. By combining direct participant validation with objective open-data analysis, the monitoring framework establishes a powerful model for future impact assessments.It is important to note that the 2025 data does not include information from the entire year. The data only covers the period up to September 15, 2025.

The project did not set specific periods for GHG, soil and population data. The GHG data comes from the Global Covenant of Mayors, which has reports for each city. The data also comes from Gouldson et al. (2020). This data shows emissions at one point in time. However, it does not give a specific date most of times. The data is assumed to be up to date.

For data availability, following sources were checked: the Cities' Open Data Portals, Atlas ITDP, EU Covenant of Mayors, Global Covenant of Mayors, and MIT Overpass. These sources provided publicly available information that could be used to measure external KPIs across all partner cities. The project reviewed each source to see what type of data was available and how current the information was. This check helped determine which external indicators could be measured reliably using open data.

Table 5 Own elaboration. Source: Tóth et al 2013 and European Commission Joint Research Centre 2016.

Soil Composition KPIs	Description
Clay_percent	It refers to the portion of soil made of clay.
Sand_percent	It refers to the portion of soil made of sand.
Silt_percent	It refers to the portion of soil made of the largest particles.
Coarse_Fragments_percent	It measures the volume of the soil made of particles larger than 2 millimeters, such as gravel, stones, or rocks. This material is measured separately from the sand, silt, and clay, which are all smaller than 2 millimeters.
Bulk_Density	It is a measure of how compact the soil is. It is the weight of dry soil in a specific volume. A high bulk density indicates a compacted soil with less space for air, water, and plant roots.

AWC	Available Water Capacity (AWC). This is a measure of the water that a soil can hold and supply to plants. It is the amount of water stored in the soil that plants can use before the soil becomes too dry (the wilting point).
TextureClass_1_percent	Sand. Scientists use a chart, often a triangle, to map the percentages of sand, silt, and clay to a name. The USDA system defines 12 standard classes. These percentages refer to the percentage chance that the soil fits into one of these named groups.
Soil Composition KPIs	**Description**
TextureClass_3_percent	Sandy Loam. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.
TextureClass_5_percent	Silt Loam. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.
TextureClass_6_percent	Silt. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.
TextureClass_8_percent	Sandy Clay Loam. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.
TextureClass_9_percent	Clay Loam. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.
TextureClass_12_percent	Sandy Clay. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.
TextureClass_11_percent	Clay. The USDA system defines 12 standard classes. These percentages refer to the chance that the soil fits into them.

Python was used to perform the climate clustering was by using the AgglomerativeClustering class, and the scaling was done using the MinMaxScaler function, both from the sklearn library. All climate data came from Meteostat, with no changes made to them. The soil information in Table 5 came from the European Commission Joint Research Centre. The Istanbul soil data was copied from Milan data because no real data existed for Istanbul. Both cities are in the same climate zone, so Milan data was used instead.

The data about how people view climate change came from several reports listed in the literature section. The Figure 37 and Figure 38 show this data, and Table 6 shows the sample size of each survey. No data was found for Turkey from 2023-2025, which is the period used for other countries. Instead, data from two years earlier was used for Turkey.

Table 6 Climate change importance perception surveys' sample size. Own elaboration. Source: DESNZ, Doğru et al. 2024, UNFCCC 2023 and European Commission 2023, 2025.

Country	Sample Size	Year
Hungary	1017	2025
Croatia	1022	2025
Italy	1019	2025
Spain	1004	2025
Germany	1510	2025
Greece	1003	2025
The Netherlands	1021	2025
Portugal	1053	2025
United Kingdom	3414	2025
Turkey	2833	2023
Hungary	1046	2023
Croatia	1027	2023
Italy	1032	2023
Country	Sample Size	Year
Spain	1016	2023
Germany	1505	2023
Greece	1012	2023
The Netherlands	1004	2023
Portugal	1035	2023
United Kingdom	4410	2023
Turkey	3000	2021

The analysis of SO_2 and CO concentrations used Copernicus Atmosphere Monitoring Service (CAMS) European Air Quality Reanalysis data. Annex II and Annex III includes some sample scenarios for different seasons of the year. The analysis period was also 2023-2025, this was explained in detail for the most relevant cases in Section 4 External KPI Results .

Most transportation data regarding accessibility was taken directly from ITDP Atlas from each of the cities involved, mostly for the 2023-2024 period. You can check in Table 7 the detail on the meaning of each of the KPIs which were covered. All cities were included but Granollers, Munster and Belfast because of data availability.

Table 7 Transportation KPIs directly taken from Atlas ITDP. Source: Atlas ITDP.

Transportation Atlas ITDP KPIs	Description
Pop. Near Bikeways (300m)	People Near Protected Bikeways: people in urban areas living within a 300m walk of a physically-protected bikeway.
Pop. Near Frequent Transit (500m)	People Near Frequent Transport: people in urban areas living within 500m of a transport stop where a bus or train comes every 10 minutes or sooner.
Pop. Near Rapid Transit (1km)	People Near Rapid Transport: people in urban areas living within 1km of high-capacity public transport running on a dedicated right-of-way

Pop. Near Education/Health (1km)	People Near Services: people in urban living within 1km of both healthcare and education services.
Pop. Near Bikeways & Transit	People Near Bikeways + Public Transport (Transit): percentage of people who live within 300m of protected bicycle infrastructure and also within either 500m of frequent public transport or 1km of mass rapid transport.

Other transportation data of Table 8 was calculated from the MIT Overpass query on the Annex II, applying the next formulas in Figure 3 to get KPIs for all cities but Milan, Thessaloniki and Lisbon (because of data availability), for the 2023-2025 period.

Table 8 Transportation KPIs formulas which takes MIT Overpass data as an input. Source: MIT Overpass.

Transportation MIT Overpass KPIs	Description
Total Destinations near Cycleway (200m)	This is a summary indicator, calculated as a ratio. It answers the question: "Of all the key destinations in the city (transport, education, parks, and supermarkets combined), what percentage of them are within 200 meters of a cycleway?" It measures the overall usefulness and connectivity of the cycling network.
% Transport Hubs near Cycleway (200m)	This measures how well the cycling network integrates with public transit. It shows what percentage of all transport hubs (like train stations or major bus stops) are easily accessible (within 200m) by bike.
% Education Facilities near Cycleway (200m)	This measures access to education. It shows what percentage of all schools, universities, and other education facilities are within 200m of a cycleway.
% Parks/Supermarkets near Cycleway (200m)	This measures access to daily needs and recreation. It shows what percentage of all parks and supermarkets are within 200m of a cycleway.
Cycleway (km per 10k Capita)	This measures the quantity of cycleways relative to the population.
Cycleway Density (km per Adjusted km²)	This measures the coverage or density of the cycling network.
Transit Stops per 10k Capita	This measures the quantity of transit stops relative to the population.
Transit Stops per km²	This measures the density of the transit network.

Resilience data was calculated using formulas based on Short-Wave Infrared images (SWIR). The Scene Classification Layer (SCL) was used to filter out invalid information and it was also used to separate permeable soil from other types of ground in the indicators that measure this, as It was done for Figure 1. The Normalised Difference Vegetation Index (NDVI) was adjusted using the NDVI values from natural parks near each city in the same climate zones. This adjustment allows the KPI to be compared across cities in different climate zones (Figure 2). The satellite images taken for the analysis were from the summer period. The dates for each of the year and city is shown in Table 12 Dates of SWIR cities satellite data used. Own elaboration. Source: Copernicus.and Table 13. The area covered was decided drawing the boxes around the cities described in Table 9 and Table 10.

Social inclusion data came directly from OECD reports and indicators.

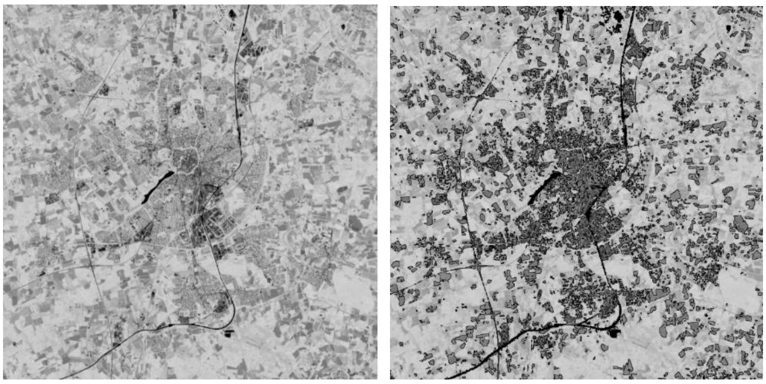

Figure 1 Example of NDVI calculation output for the entire city of Munster (left) and for only the permeable areas of the city of Munster (right). Source: own elaboration based on Copernicus satellite images.

Table 9 Surfaces and Cities' Satellite Bounding Boxes. 'Max clouds' refers to the maximum percentage of clouds allowed in SWIR satellite images. Own elaboration. Source: Copernicus.

City	Surface (km²)	Adjusted Surface (km²)	Min Lat	Min Long	Max Lat	Max Long	Max clouds
Rotterdam	177,03	177,03	51,864	4,398	51,9812	4,5964	15%
Granollers	4,43	4,43	41,59161	2,27839	41,61659	2,29745	15%
Thessaloniki	46,89	23,445	40,591835	22,981954	40,65444	22,90233	15%
Budapest	780,3	780,3	47,366401	18,930199	47,59437	19,33888	15%
Munster	327,51	327,51	51,85777	7,50001	52,02855	7,75104	15%
Istanbul	2351,89	1175,945	40,754017	29,391668	41,08505	28,63279	15%
Zagreb	294,8	294,8	45,74951	15,8345	45,872209	16,112663	15%
Belfast	88,16	88,16	54,56314	-6,02897	54,63401	-5,85567	15%
Lisbon	100,03	75,0225	38,69157	-9,21587	38,77469	-9,09138	15%
Milan	154,43	154,43	45,42712	9,10592	45,52997	9,27871	15%

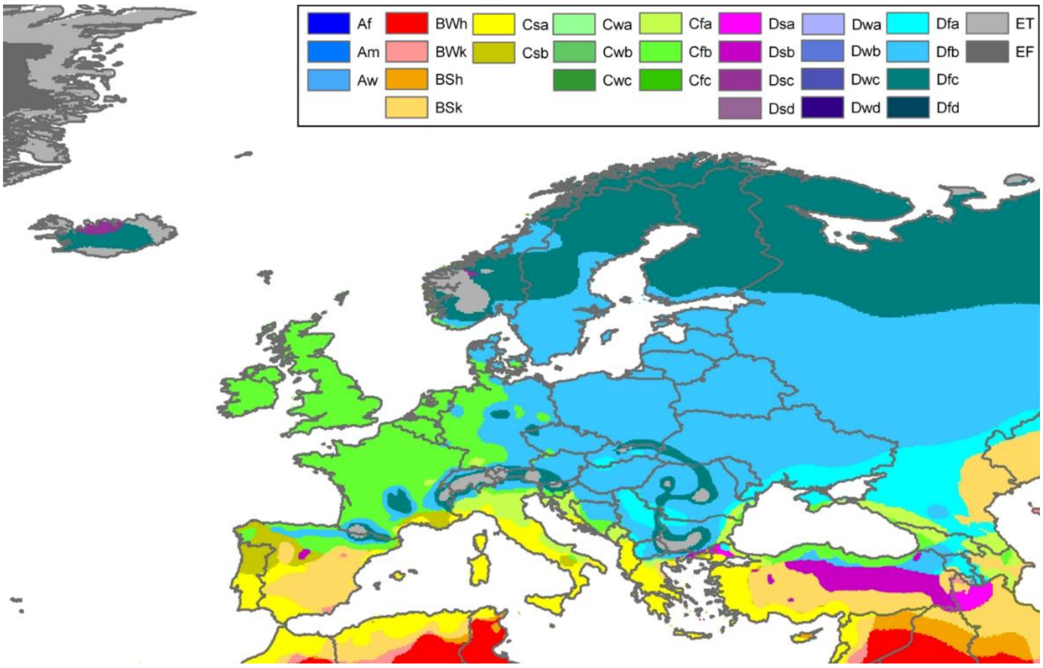

Figure 2 Climatic Zones Distribution in Europe. Source: Köppen 1900, and Beck et al 2018.

Table 10 Highly vegetated reference areas for NDVI calculation. Source: Own elaboration. Source: Copernicus, Köppen 1900, and Beck et al 2018.

Köppen-Geiger*	National Park Reference	Area km2	Reference Park Min Lat	Reference Park Min Long	Reference Park Max Lat	Reference Park Max Long
cfa	Krka National Park	0,99	43,85699	15,94717	43,8669	15,95833
bsk	Bardenas Reales Natural Park	2,75	42,20714	-1,55972	42,21853	-1,53337
csa	Doñana National Park	2,69	36,99827	-6,47078	37,01239	-6,49
dfb	Bialowieza Forest National Park	0,97	52,67106	23,79836	52,67903	23,81458
cfb	Lake District National Park	1,33	54,4604	-3,05085	54,47213	-3,03514

(*)bsk: cold semi-arid climate; cfa: humid subtropical climate; csa: mediterranean hot summer climate dfb: warm summer continental climate; cfb: oceanic climate

Table 11 Population data. Sources: ICLEI, Statista and Idescat.

City	Population	Year	Population Source
Rotterdam	634660	2016	ICLEI
Granollers	63897	-	Idescat
Budapest	1749734	2018	ICLEI
Thessaloniki	317778	2023	ICLEI
Zagreb	790017	2011	ICLEI
Munster	310039	2015	ICLEI
City	Population	Year	Population Source
Milan	1371499	2024	Statista
Istanbul	15655924	2023	ICLEI
Lisbon	504964	2016	ICLEI
Belfast	343542	2021	ICLEI

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

$$NDVI_{Adjusted} = \frac{NDVI_{KPI\ Area}}{NDVI_{Reference\ ClimateZone}}$$

- **NIR**: Pixel value from the Near-Infrared band.
- **Red**: Pixel value from the Red band.

Figure 3 Formulas for NVDI indicator before any masks. Source: Widely known.

Table 12 Dates of SWIR cities satellite data used. Own elaboration. Source: Copernicus.

City	Date	City	Date
Belfast	14/06/2023	Milan	19/06/2024
Budapest	18/06/2023	Munster	25/06/2024
Granollers	27/05/2023	Rotterdam	23/06/2024
Istanbul	18/07/2023	Thessaloniki	01/06/2024
Lisbon	03/07/2023	Zagreb	28/06/2024
Milan	25/06/2023	Belfast	13/07/2025
Munster	08/07/2023	Budapest	14/07/2025
Rotterdam	09/06/2023	Granollers	25/06/2025
Thessaloniki	22/07/2023	Istanbul	25/07/2025
Zagreb	29/06/2023	Lisbon	07/07/2025
Belfast	23/07/2024	Milan	26/06/2025
Budapest	12/07/2024	Munster	02/07/2025
Granollers	05/07/2024	Rotterdam	18/06/2025
Istanbul	17/07/2024	Thessaloniki	26/06/2025
Lisbon	02/07/2024	Zagreb	25/06/2025

Table 13 Dates of SWIR cities satellite data used for climate zones reference of NDVI. Own elaboration. Source: Copernicus.

Climate Zone	Date 2023	Date 2024	Date 2025
bsk	27/06/2023	01/07/2024	28/06/2025
cfa	26/06/2023	30/06/2024	27/06/2025
cfb	13/06/2023	18/09/2024	22/09/2025
csa	30/06/2023	24/06/2024	01/07/2025
cfb	13/06/2023	18/09/2024	22/09/2025

3 KPI Validation and City Actions Results

This section explains the validation of the KPIs and shows the results of actions done by the pilot cities. These indicators are needed to measure whether the project's prototypes have achieved the expected impact. The overall evaluation of performance and impact combines direct input from project participants with outside data analysis.

The process of monitoring performance starts with finding a baseline state. This is the initial status before the selected methods are put in place. Monitoring continues throughout the project to show how the pilot develops. The collection and analysis of measurable KPIs provide a base for judging the city's performance across many urban areas. The change seen in a KPI value shows the impact that the actions have had.

The set of questions used to gather this monitoring data is used to judge the results from the tools and prototypes of each city. The design of these KPIs follows a repeated validation process. This makes sure they match the cities' goals, visions, and defined strategies.

3.1 Budapest

The pilot city of Budapest focuses on creating the Healthy Streets Knowledge Center (HSKC). This center works to make public spaces healthier, better able to handle climate impacts, and built around what people need. The Knowledge Center is the city's main prototype. It acts as both a physical place and an online space where people can learn about and change the Healthy Streets method. This is an urban planning method that started in London. This work helps the city meet its Climate Strategy and carbon neutrality goals.

The HSKC in Budapest brings together tools for participation and communication that were made with UP2030 partners. These tools help more citizens take part and help professionals learn more about sustainable urban planning. One tool is the Community Maps, a local web map that collects citizen views on green space growth and Healthy Streets projects. One map for green projects got about 900 responses. A custom map will be put on the Knowledge Center platform. The HSKC also has a guide made by Design Clips (DC) for running workshops for youth and children about public spaces near schools. This guide was used at a primary school in the 14th district and will be available to professionals through the HSKC platform. The Neutrality Story Maps (NSM) is a digital tool from VUB and CERTH. It brings together data, pictures, and maps to show how climate change affects Budapest and how changes to street design can reduce harm. The city plans to add this finished tool to the Knowledge Center. The HSKC also plans to add the Citizens' Storytelling Tool and the Cost-Benefit Analysis (CBA) and Green Finance (GF) Guides. Budapest will use these as planning resources for urban development and make them available through the Knowledge Center platform.

The professional objective involves the adoption of the Healthy Streets methodology by professionals in urban development, including architects, designers, and engineers who learn and apply the Healthy Street approach widely in practice. This objective is directly supported by improvements in governance, which is a pillar of resilience. The HSKC tool was established to provide technical assistance and capacity building to these professionals. The monitoring reported an increase of 3 points in local authority participation, rising from 2 to 5 on the Likert scale, as shown in Table 15. This shows greater coordination between departments in project development. This increase validates that the city is developing the administrative structures necessary for the HS methodology to be integrated into urban planning and made available to professionals.

The governance objective centers on creating a Learning and Action Alliance (LAA) for Healthy Streets to spread and adapt the methodology, create discourse, and establish the HSKC. This is the city's prototype itself. The success of this objective is evident in the strong positive change in social norms, which increased from 1 to 3 in the reporting period. This change in social norms reflects that the city is succeeding in promoting public discussion about the health of its streets, aligning with the spatial justice pillar. Additionally, the city has redefined its performance measures to include the number of workshops and events intended to actively spread the methodology to external stakeholders. A conference held in June 2024 brought together 66 people, including experts from 13 districts and other urban planners and architects.

The participation objective focuses on testing community mapping instruments to collect public opinion, define potential projects, and increase awareness. This objective is reflected in the dramatic success of citizen participation. The measure for resident and user involvement in planning increased from an initial rating of 1 to 4, and involvement in project implementation also rose from 1 to 4. These significant increases show the successful uptaking of participatory planning methods and the implementation of tools like the Community Maps from Mapping for change (MfC), which on one occasion collected approximately 900 responses about the development of green spaces. This validation confirms that the goal of improving inclusive participation through tools offered by UP2030 is being achieved.

The monitoring and evaluation process tracks progress from a starting point to a reporting period. This gives proof that can be measured of the impact. The results collected from Budapest show large increases in several KPIs about participation and organisational involvement. These results show early success in the method of the prototype. The UP2030 project works on changes in laws and regulations and social norms. This includes supporting regulatory updates ("UP-Dating") and behavioral changes ("UP-Taking"). For Budapest, the KPI results recorded on July 17, 2025, show a small change in regulation but a strong positive change in how society views things, as It is shown in Figure 4.

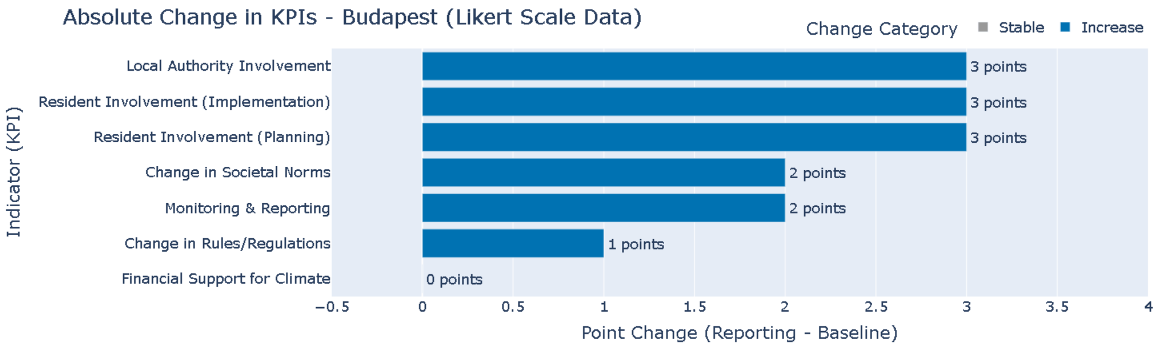

Figure 4 Change in Budapest KPI values (Reporting vs. Baseline). Own elaboration.

For example, two measures based on perception, measured on a scale of 1 to 5, showed large improvement in the reporting period. The measure of how much residents and users have been involved in the project planning in question 3 (Q3), increased from a starting rating of 1 to 4. The measure of how much residents and users have been involved in the project work (Q5) also rose from 1 at the start to 4 in the reporting period. These increases show the successful early start of participatory planning methods and tools. This fits with the overall project goal to involve the public and expand the Healthy Streets method.

The involvement of the local authority, beyond providing money, also reached a maximum score. The rating for how many departments are helping increased from 2 at the start to 5 in the reporting period. This suggests better internal coordination and more departments working together. For measurable results directly connected to the prototype activities, the number of tools put in place increased from 0 at the start to 2 in the reporting period. This measure connects to the adding and using of participatory resources, such as the first use of Community Maps (MfC) and DC guidance. These are important parts of the Knowledge Center prototype.

Dissemination showed mixed results. The total reach of information sharing through channels (People) stayed the same at 40 in both periods, as shown in Table 14. However, the involvement measure of total reach of information sharing through channels (Comments) increased from 0 comments at the start to 7 comments in the reporting period.

Table 14 Budapest Performance Scores for Tools , Public Reach, and Data Sharing. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q9 Does current urban plan contain all 5 sustainability principles?	4	4
Q11 Number of tools implemented	0	2
Q13 Total reach of dissemination through channels (People)	0	40
Q15 Total reach of dissemination through channels (Likes)	0	139
Q17 Total reach of dissemination through channels (Comments)	0	7
Q19 Total number of open data sets	0	0

Table 15 Budapest Performance Scores for Community Involvement and Local. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q3 To What extent have residents been involved in the project planning?	1	4
Q5 To what extent have residents/users been involved in the project implementation?	1	4
Q7 To what extent is the local authority involved in developing the project beyond just providing money, and how many departments are helping?	2	5
Q21 To what extent the local authority provides financial support to climate adaptation projects?	1	1
Q23 To what extent is the progress toward project goals and compliance with requirements being monitored and reported?	3	5
Q25 Has the project inspired changes in rules and regulations?	0	1
Q27 To what extent the project has contributed to, or inspired, changes in societal norms?	1	3
Q29 Total area of land transformed or influenced by the project in squared meters ($10^6 m^2$)	N/A	N/A

3.2 Munster

Munster city is making a plan for climate-friendly neighborhoods. The Frauenstraße area will be used as a test. This plan will help city workers create neighborhoods that fight climate change and can handle its effects. It will also include local people in the process. The city faces problems with urban spread, old buildings, and finding the right balance between cutting carbon and dealing with heat and flood issues. The goal is to make clear steps for city workers to follow when making green neighborhoods that are safe from climate problems and fair for everyone. Right now, this plan is still a draft. The city uses two main tools. The first is the Climate Proofing Method from Buro Happold (BH), which helps think about both reducing carbon and dealing with climate effects in a way that focuses more on policy. The second is the Urban Regeneration Carbon Accounting Method, which makes a starting point for measuring carbon from homes, how people move around, and green spaces. This second tool helps collect carbon data from different city departments for the final plan and helps update how the city manages its data.

Co-creating a neighborhood level roadmap for climate strategies and exploring the possibility of implementing temporary and mobile interventions connect to spatial justice, particularly procedural justice, and social resilience. These objectives measure success in acceptance and execution of actions. The measure for resident and user participation in implementation showed a substantial increase, moving from 1 at baseline, which indicated that "there was no implementation yet," to 4 in the reporting period, as shown in Table 17. This increase of 3 points reflects success in community acceptance and involvement in the actual execution of actions, which is fundamental for testing and scaling temporary or mobile interventions. On the other hand, the measure for resident participation in planning remained stable at 1. This goal is linked to creating a method that helps people involved put measures in place and accept them.

Table 16 Munster Performance Scores for Tools, Public Reach, and Data Sharing. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q9 Does current urban plan contain all 5 sustainability principles?	3	3
Q11 Number of tools implemented	0	0
Q13 Total reach of dissemination through channels (People)	40	60
Q15 Total reach of dissemination through channels (Likes)	N/A	N/A
Q17 Total reach of dissemination through channels (Comments)	N/A	N/A
Q19 Total number of open data sets	0	0

Table 17 Munster Performance Scores for Community Involvement and Local. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q3 To What extent have residents been involved in the project planning?	1	1
Q5 To what extent have residents/users been involved in the project implementation?	1	4

Q7 To what extent is the local authority involved in developing the project beyond just providing money, and how many departments are helping?	2	4
Q21 To what extent the local authority provides financial support to climate adaptation projects?	3	3
Q23 To what extent is the progress toward project goals and compliance with requirements being monitored and reported?	1	1
Q25 Has the project inspired changes in rules and regulations?	0	0
Q27 To what extent the project has contributed to, or inspired, changes in societal norms?	1	1
Q29 Total area of land transformed or influenced by the project in squared meters ($10^6 m^2$)		

Coordinating between mitigation and adaptation measures and harmonising the use of technical tools and planning instruments between departments relate to carbon neutrality and organisational resilience. The city must integrate carbon mitigation and adaptation to problems such as heat and flooding. The prototype addresses this through the Climate Proofing Methodology (BH), which systematically links these two pillars. The measure for local authority involvement, which evaluates project development beyond financing and the number of departments helping, improved notably, moving from 2 to 4. This increase of 2 points suggests better internal cooperation, a key objective for overcoming interdepartmental communication gaps and making the harmonisation of tools and instruments easier. How people saw the financial support provided by the local authority stayed at a rating of 3. This happens even though the city admits that its current budget structure gives few chances to offer financial support to outside projects. This situation has been noted to cause public dissatisfaction and slow down work.

Finally, monitoring progress toward project goals and following requirements stayed at a rating of 1 for both the starting and reporting periods. This is because careful evaluation against project goals is still in its first steps. The total reach measured by number of likes and number of comments kept reporting N/A because no data was collected ("No data") in both the starting and reporting periods, though there was an increase in the reach of dissemination as shown in Table 16. The rating for changes in rules and regulations stayed at 0, showing that no real changes in regulatory systems had happened, although discussions continue among people involved. Similarly, the rating for the project's contribution to changes in how society sees things stayed steady at 1, showing a minimal effect seen during this early stage.

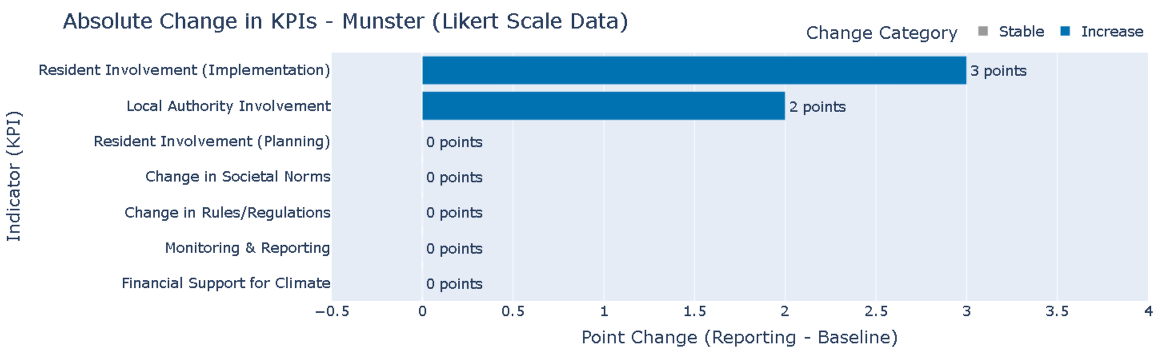

Figure 5 Change in Munster KPI values (Reporting vs. Baseline). Own elaboration.

3.3 Thessaloniki

The city of Thessaloniki is making a District Climate Action Plan (DCAP) for the Dioikitirion area. This plan helps the city reach its goal of becoming green, strong, fair, and lasting by 2030. The plan mixes environmental changes with social fairness and people taking part. At first, the project was about fixing energy poverty and making homes cheaper for people who need help most. It built on the Social Rental Agency. Later, it changed to making a full green neighborhood that thinks about fair change for both people who live there and businesses. As a new measure of success, the city is working on the DCAP itself. This plan works as a local guide that fits with Thessaloniki's Climate City Contract (CCC). The city uses many tools to help with this work. These include the DRAXIS Decision Support System (DSS) for looking at area data, the Urban Design Climate Workshop (UDCW) toolkit provided by the Urban Climate Change Research Network (UCCRN) to study weather effects, digital twin tools to check building energy use, NSM to help people share ideas with the city, and the Urban Green Economy Model (GEM) to figure out money details for social housing. This last tool shows why funding is needed to fight energy poverty.

Several organisational and technical indicators recorded an increase during the reporting period, the most relevant are shown in Figure 6. How much the local authority was involved in creating the project, beyond just providing funding, increased from a rating of 4 at the start to the maximum rating of 5 in the reporting period. Similarly, the number of tools put in place showed growth, moving from 3 to 4 tools. This technical work reflects real activity within the project, such as the use of the DRAXIS DSS or the UDCW Simulation Toolkit.

Increases were also recorded in indicators related to impact and internal processes, as we can check in Figure 6. The self-reported measure of how much the project added to changes in how society sees things rose a lot, starting at a rating of 1 and reaching 4. Monitoring and reporting of progress toward project goals improved, increasing from a score of 3 to 4. Also, even though starting from a low point, the amount of financial support provided by the local authority for climate projects moved from a rating of 1 to 2.

However, not all scores went up. The rating about whether the current urban plan includes all five sustainability principles saw a large decrease, falling from the highest score of 5 at the start to a score of 3 during the reporting period. This change may reflect a new internal review of the planning documents. Also, reported resident or user involvement in the actual project work phase decreased slightly from a perfect score of 5 at the start to a 4 in the reporting period.

Table 18 Thessaloniki City Performance Scores for Tools, Public Reach, and Data Sharing. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q9 Does current urban plan contain all 5 sustainability principles?	5	3
Q11 Number of tools implemented	3	4
Q13 Total reach of dissemination through channels (People)	12	700
Q15 Total reach of dissemination through channels (Likes)	0	180
Q17 Total reach of dissemination through channels (Comments)	0	5
Q19 Total number of open data sets	0	0

Public interaction experienced large growth in audience reach. The total number of people reached through sharing information channels recorded a large increase, rising from 12 at the start to 700 during the reporting phase. Feedback collected through these channels also began to appear, with the number of comments received moving from 0 to 5, and the number of likes increasing up to 180, as shown in Table 19.

Measures for institutional influence and outside output remained low or absent. The self-reported measure of how much the project inspired changes in rules and regulations stayed stable at a low rating of 1 in both periods. The number of open data sets published remained at 0 in both periods.

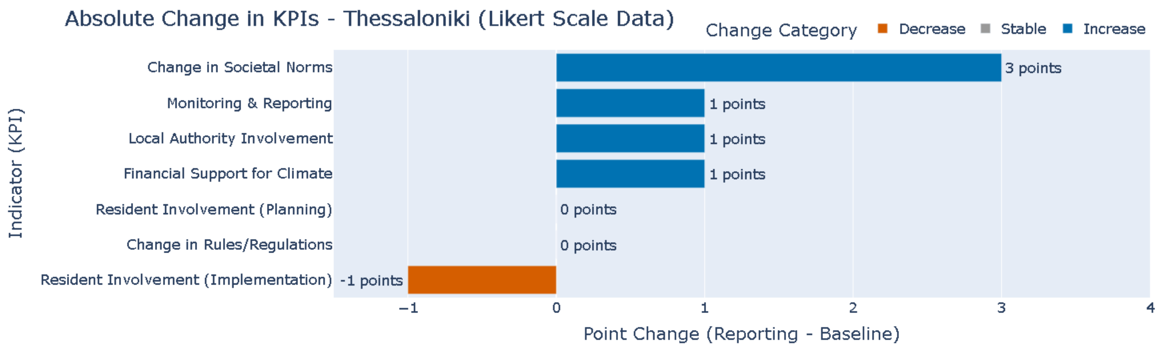

Figure 6 Change in Thessaloniki KPI values (Reporting vs. Baseline).

The first objective is to provide more green and open spaces and infrastructures by adding more natural elements. The DCAP addresses resilience through the introduction of integrated measures, such as increasing urban tree cover to reduce the urban heat island effect and expanding permeable surfaces. The DCAP establishes the creation of a network of green spaces that emerges from the conversion of former parking areas.

The second objective is to launch a new plan for the area with an integrated planning approach and to promote eco-friendly transport modes. The DCAP constitutes the integrated planning strategy that focuses on creating a neighbourhood that "breathes, walks, plays, and works." This is materialised in interventions to encourage low-emission mobility, including new pedestrian and cycling routes. The planning uses the perspective of proximity and sustainable mobility.

The third objective is to improve recycling efficiency and introduce a circular economy model. The DCAP prototype supports community-driven circular economy initiatives and plans awareness campaigns about waste reduction and composting.

Table 19 Thessaloniki Performance Scores for Community Involvement and Local. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q3 To What extent have residents been involved in the project planning?	5	5
Q5 To what extent have residents/users been involved in the project implementation?	5	4
Q7 To what extent is the local authority involved in developing the project beyond just providing money, and how many departments are helping?	4	5
Q21 To what extent the local authority provides financial support to climate adaptation projects?	1	2

Q23 To what extent is the progress toward project goals and compliance with requirements being monitored and reported?	3	4
Q25 Has the project inspired changes in rules and regulations?	1	1
Q27 To what extent the project has contributed to, or inspired, changes in societal norms?	1	4
Q29 Total area of land transformed or influenced by the project in squared meters ($10^6 m^2$)	0.57	0.57

The performance reported in D4.6 shows solid local authority involvement in project development, which increased from a rating of 4 to the maximum of 5 on the Likert scale, as shown in Table 18. This increase is important for the successful implementation of an integrated plan like the DCAP. Additionally, progress was recorded in the city's technical capacity, with an increase in the number of tools implemented from 3 to 4. These tools include the DRAXIS DSS for data visualisation and the Urban UDCW Simulation Toolkit, used to simulate heat wave effects and microclimate, as well as to evaluate photovoltaic (PV) potential. This indicates tangible progress in the adoption of validated methodologies for resilient and climate-neutral urban planning.

3.4 Belfast

In Belfast, the city monitoring results show a strong dedication to public involvement, which is essential to the city's prototype development. The overall evaluation of performance relies heavily on data collected when the city reported the project's initial status. The positive report on community participation matches directly with the established KPI status, where sixteen out of twenty planned involvement sessions had been completed by Month 18. However, participation concerning project work was rated low, scoring 1. The reason reported for this low rating was the absence of capital funding required to carry out the framework parts.

In terms of measurable results, the city recorded three tools put in place at the starting stage. The main project output for Belfast is the "Net Zero Neighbourhood Framework" (NZNF) document, made for general use across the city's regeneration projects. This Framework focuses on three major themes: active travel, greening, and the upgrading of buildings. The prototype document was in the final stages of improvement by March 2025.

Table 20 Belfast Performance Scores for Community Involvement and Local. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B
Q3 To What extent have residents been involved in the project planning?	4
Q5 To what extent have residents/users been involved in the project implementation?	1
Q7 To what extent is the local authority involved in developing the project beyond just providing money, and how many departments are helping?	2
Q21 To what extent the local authority provides financial support to climate adaptation projects?	2

Q23 To what extent is the progress toward project goals and compliance with requirements being monitored and reported?	5

The objective of achieving buy-in from residents measures the effectiveness of the participatory process and procedural justice, ensuring that the community has a voice in planning. The performance was high, with a score of 4 out of 5 for resident and user participation in planning, as shown in Table 20. This validates resident support for the NZNF vision.

The Framework requires the practical use and adding of several tools. The city has added tools such as Urban Regeneration Carbon Accounting and Management (URCAM). Progress shows that the function of the URCAM tool was changed to focus on calculating possible carbon reduction achieved through specific actions, like improved household insulation or increased cycle commuting. DC is a tool provider whose main contribution are specialised engagement resources. For Belfast, this material manifested as the "Safe Routes, Healthy Places Belfast toolkit" which supports activities and co-design with children and youth, and It also supports pilot activities, such as the Walking Bus action.The Community Maps (MfC tool) is being used to display information related to climate risks and social deprivation in the pilot area.

The city reported a high level of adding sustainability principles within its existing city documents. Specifically, the local authority confirmed that its current urban plan includes all five sustainability principles: Environmental, Economic, Social, Human, and Cultural Sustainability. Belfast confirmed that both the Land Development Plan and the city community plan, known as the Belfast Agenda, contain these five principles.

For broader city goals, the project's vision, which tries to address the scattered nature of governance and service delivery, has been successfully added to the update of the city's Community Plan, "The Belfast Agenda". However, the survey data confirms that the practical influence on city rules and regulations was limited at the time of reporting. City representatives made comments that it was too early to measure regulatory changes. This is consistent with the development stage, as the project was moving into the Upscale phase, with the NZNF document intending to provide final recommendations that would later produce such policy changes.

When asked about the amount of financial support provided by the local authority for climate projects, Belfast rated its involvement level at two on a five-point scale. The project was rated low for its contribution to changes in rules and regulations (zero) and changes in how society sees things (one on a scale of one to five). How much the local authority was involved in creating the project beyond simply providing money was rated as two out of five departments involved.

The objective to increase community cohesion through shared spaces relates to social resilience and distributive justice, which involves equitable access to quality public spaces. The creation of shared spaces is fundamental for social resilience and distributive justice. However, the measure for participation in implementation was 1 out of 5, which is low. This reveals a lack of physical execution perhaps linked to the absence of capital funding.

Table 21 Belfast Performance Scores for Tools, Public Reach, and Data Sharing. Own elaboration

Timestep (B Baseline Period, R Reporting Period)	B
Q9 Does current urban plan contain all 5 sustainability principles?	5
Q11 Number of tools implemented	3
Q13 Total reach of dissemination through channels (People)	0

Q15 Total reach of dissemination through channels (Likes)	0
Q17 Total reach of dissemination through channels (Comments)	0
Q19 Total number of open data sets	0

It is correct that Belfast did not report mass dissemination data, such as likes, comments, or total reach through public channels, given the nature and development phase of its prototype. The justification is based on the distinction between the methodological and governance development phase, which is Belfast's current phase, and the physical implementation and spreading phase, which is a later phase.

3.5 Rotterdam

The Rotterdam pilot focuses on the Bospolder-Tussendijken (BoTu) districts, which have been subject to the ongoing Resilient BoTu 2028 program since 2019. The city's participation in the project is focused on using energy transition as a reason for improving urban well-being in vulnerable areas, with social and community resilience at the center of the approach.

The KPI monitoring survey data reflects the project's focus on community involvement. Residents reported high scores of 4 on the scale for both project planning and work activities. This validates success in procedural justice and the strengthening of social resilience. This strong community support relates to the program's use of the Asset Based Community Development (ABCD) approach, which sees the importance of the community's strengths and talents. ABCD goal is to increase resilience, including diverse groups in participatory processes, and improving quality of life for residents connect to spatial justice, particularly procedural justice, and social resilience. However, internal governance indicators showed less strength, with the local authority involvement in project development scoring 3. This measure matches known internal challenges, including an empty project manager position and difficulties organising contributions from different city departments and partners.The pilot's intended output, initially called a blueprint, changed into the Resilient District Learning Toolkit. This prototype is a resource put together from the five years of practice and lessons gathered in the BoTu district. The toolkit provides eighteen lessons organised around four steps: explore, build, connect, and learn. The goal of the toolkit is to share the BoTu approach with other districts in Rotterdam and beyond, making clear that the lessons must be changed to fit local contexts.

In contrast, the local authority's internal operations received a medium rating. The involvement of the local authority beyond providing money, based on the number of helping departments, scored 3, as shown in Table 22. This lower score fits with project documents noting that some effort at the beginning of the project was put into preparatory administration work rather than in the development and piloting work packages. Co-creating and upscaling with other districts and programs, using an integrated approach with alignment to larger visions and systems in place, and building capacity and uptake within the municipality's way of working relate to governance and organisational resilience. Also, the difficulty of organising internal contributions and an open position for the project manager caused organisational challenges.

Table 22 Rotterdam Performance Scores for Community Involvement and Local. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B
Q3 To What extent have residents been involved in the project planning?	4

Q5 To what extent have residents/users been involved in the project implementation?	4
Q7 To what extent is the local authority involved in developing the project beyond just providing money, and how many departments are helping?	3
Q21 To what extent the local authority provides financial support to climate adaptation projects?	4
Q23 To what extent is the progress toward project goals and compliance with requirements being monitored and reported?	1
Q25 Has the project inspired changes in rules and regulations?	0
Q27 To what extent the project has contributed to, or inspired, changes in societal norms?	3
Q29 Total area of land transformed or influenced by the project in squared meters ($10^6 m^2$)	1

For technical progress, the city reported two tools put in place. The pilot's original goal was to build a blueprint of the Resilient BoTu 2028 program to copy the district-first approach elsewhere in Rotterdam. This blueprint idea was later changed to a Resilient District Learning Toolkit. The tools put in place, such as the NSM, support the goal of collecting lessons learned from impact assessments to inform urban policies and the copying process. The NSM tool is planned to be used to show the lessons learned through community stories.

The physical area influenced by the project was measured as one square kilometer (1 km^2). This matches the physical area of the BoTu neighborhoods, which have a high population density.

In information sharing efforts, the survey recorded a lack of data across all measurable channels for sharing reach, including the number of people reached, likes, and comments. Despite high public involvement in the local activities, this result suggests that organised tracking of sharing measures was not fully working at the time of the measurement.

Table 23 Rotterdam City Performance Scores for Tools, Public Reach, and Data Sharing. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B
Q9 Does current urban plan contain all 5 sustainability principles?	3
Q11 Number of tools implemented	2
Q13 Total reach of dissemination through channels (People)	N/A
Q15 Total reach of dissemination through channels (Likes)	N/A
Q17 Total reach of dissemination through channels (Comments)	N/A
Q19 Total number of open data sets	N/A

Rotterdam's decision not to report mass dissemination data such as likes, comments, or total reach through public channels, as shown in Table 23, makes sense given the nature and development stage of its prototype.

3.6 Milan

The City of Milan is also working on the improvement of ecosystem services (ES) within urban regeneration areas to support climate adaptation and mitigation efforts. The first prototype is the Ecosystem Services Assessment (ESA) and Method, which uses the open-source InVEST tool. The purpose of this prototype is to build a repeatable method and improve the knowledge and ability of city staff in getting the most environmental, economic, and social benefits from urban green areas. The ESA includes looking at the urban cooling effect and carbon storage and collection. The project outputs include maps that present the physical and economic assessments of ES at different scales, along with a complete handbook created by LINKS Foundation and the Municipality of Milan to make sure the method can be put in place and repeated within the city context.

The second prototype focuses on adding resilience principles into planning projects and initiatives. It uses a method based on the CRF created by the Resilient Cities Network (RCities). This qualitative approach was changed to fit Milan's local context and specific needs. It focuses on the climatic dimension of resilience and eight core goals identified for assessment. The method helps city staff add urban resilience in key activities such as strategy development. The wider purpose is to help the Urban Resilience Department structure a narrative and governance system.

Evaluating the environmental, social, and economic benefits of the climate adaptation measures included in the Air Climate Plan (PAC) connects to carbon neutrality through mitigation and resilience through adaptation. The evaluation of the benefits of Nature-Based Solutions (NBS), such as forestation and depaving, contributes directly to the pillars of mitigation, for example through carbon sequestration and storage, and adaptation, for example through urban cooling to reduce the urban heat island effect. This objective is validated by measures that confirm physical and technical progress. A total of 15,164 trees were planted at urban scale between 2023 and 2025, which is a direct measure of the forestation implementation defined in the PAC. Additionally, implementing the ESA required the analysis of 8 datasets, confirming the investment in the database needed for evaluation.

Table 24shows measurable progress in areas where organisational or method structures were being set up by the project. Specific KPI measurements show that Milan reported having ten people or groups involved in project activities and seven fields of knowledge represented within the LAA diversity. Also, Milan gave two training materials about the design of green areas and identified two city strategies, plans, or projects that were affected. Further results include ten total hours of training provided, two city technical departments involved in using ES assessments, and eight CRF goals looked at for the resilience assessment. Since the KPI validation analysis clearly talks about comparing the reporting period values to "null baseline values", the reported numbers for people or groups involved, training materials, hours of training, departments involved, and CRF goals looked at all represent positive increases. This successful collection of qualitative data shows initial progress in setting up organisational structures and using the new methods created through the two prototypes.

Providing urban designers and real estate operators with comprehensive guidance on green area benefits and enhancing the current methodologies used by real estate operators to account for impacts of their interventions on urban ES relate to carbon neutrality, resilience, and spatial justice. These objectives point to standardisation, capacity improvement (upskilling), and the inclusion of the private sector, contributing to distributive justice by ensuring compensation for the loss or increase of ES in urban transformations. KPI reported included 10 hours of training provided to municipal staff, improving capacity to maximize the benefits of green areas. Additionally, five real estate operators interested in the ESA approach confirm that the methodology is being adopted by the private sector, which is essential for replicability and long-term impact.

Table 24 KPI values for Milan. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
Q2 Number of planted trees at the city scale (Nº since last provided measure) *	15,164	15,164
Q4 Number of datasets analysed for ESA tool implementation (Nº since last provided measure)	0	8
Q6 Number of Climate City Contract real estate operators interested in considering the ESA approach for the assessment of their urban regeneration projects (Nº since last provided measure)	0	5
Q8 Development of an Impact of vegetation metric on reducing urban temperatures. [Temperature Reduction=Average Temperature Before– Temperature After (Estimated by ESA tool) (°C)]	0	1
Q10 Number of CRF objectives investigated for the resilience assessment (Nº since last provided measure)	0	8
Q12 Number of stakeholders involved in the piloting activities (Nº since last provided measure)	0	10
Q14 LAA diversity of fields of expertise, (for example: urban planning, energy, biodiversity and economy would be a 4) (Nº since last provided measure)	0	7
Q16 Number of training materials on the design of green areas provided to urban professionals (Nº since last provided measure)	0	2
Q18 Number of municipal strategies, plans and projects impacted by the testing of the methodology (Nº since last provided measure)	0	2
Q21 To what extent the local authority provides financial support to climate adaptation projects?	0	10
Q20 Total hours of training provided (h since last provided measure)	0	10
Q22 Number of municipal technical departments have been engaged in using the ES assessments as a framework for planning (Nº since last provided measure)	0	2

*Full season 2023-2025 (same trees)

3.7 Lisbon

The Lisbon pilot within the project is known as StepUP_LxALL, which is built on the city's goal to become a sustainable, resilient, and inclusive urban area that reaches climate neutrality by 2030. The city's vision focuses on a constant learning process for Lisbon and its neighborhoods as new difficulties appear. This work supports the Lisbon CCC 2030, which gives the direction for reaching climate neutrality.

The prototype involves pilot actions in four specific locations within the Alvalade parish: the National Laboratory for Civil Engineering (LNEC) campus, a rugby club (São Miguel Rugby Club), a city library

(Coruchéus Library), and the Alvalade Market. The design parts of the prototype focus on sustainable mobility, energy efficiency, water efficiency, infrastructure resilience, and supporting regenerative agriculture. The overall goal is to use solutions, such as intelligent monitoring and decision systems and updating buildings, to reduce carbon emissions through an inclusive community approach.

The project uses several tools for water, energy, and environmental management. The Resilience Assessment Framework (RAF ICARIA) tool from LNEC helps check urban water systems and shows results in graphs. This tool uses water flow models to look at ways to make water systems more natural, helping water soak into the ground and reducing overflow during heavy rain. LNEC also provides tools to measure water systems and check how accurate these measures are. The B-WaterSmart tool is used at the São Miguel Rugby Club. For energy and reuse, the Circular urban planning tool from ETH Zurich is used at four sites to help reuse building materials. Lisbon E-Nova keeps track of water and power use and checks where solar panels might work on roofs. For the environment, LINKS Foundation provides tools to check air quality and study how nature helps people. Lisbon City Council has its own air checking system with sensors that measure NO_2 twice a year. The project also uses NSM from VUB to show information in an easy-to-understand way.

The objective is central to the prototype, which seeks an inclusive and community-based approach to emission reduction. The performance measure for residents involved shows that, despite the centrality of this objective, participation of residents and users decreased significantly by 37.5% compared to baseline, dropping from 4,000 reported at the baseline to 2,500 reported during the progress monitoring period, this is also shown in Figure 7 and Table 25. This result highlights a major challenge in implementing active inclusion in the neighborhood, even though the city is promoting the active inclusion of the population to implement climate policies.

Table 25 KPI values for Lisbon. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B	R
To what extent residents/users have been involved in the project? Mark the answer, where 1 is “not involved at all” and 5 is “very involved”	5	5
How many residents/users have been involved in the project? (Nº since last provided measure)	4000	2500
Number of participative events (Nº since last provided measure)	15	15
Existence and reach of a coordinated public relations and education campaign, with structured messaging and channels to ensure hazard, risk and disaster information is disseminated to the public (Nº since last provided measure)	N/A	1,000,000 (2024)
Number of volunteers and civil society organisations acting as focal points for citizens after a disaster, and regularly thereafter, to confirm safety issues, needs etc	N/A	2000
Is there a formal mechanism (e.g., Office, Committee, National/Regional Platform) to coordinate actions between city(ies) and other international, national, regional or local governments, which ensures integrated and flexible communication and collaboration between them?	1	1
Does the resilience plan consider climate change (projection, scenarios, impacts, etc.)?	1	1

Are there agreed climate change scenarios setting out area-wide exposure and vulnerability from each hazard, or groups of hazards?	1	1
Beyond just an awareness of the natural assets, is there an understanding of the functions that this natural capital provides?	1	1
Are design solutions tasked to improve resilience being implemented?	1	1
Solutions for stormwater management are adequately used (promoting, interception, infiltration, storage, flow routing, avoiding flooding in routes, pathways, and facilities)	1	1
Percentage of variation in drinking water consumption compared with the reference year (2019) (%)	-3,2	1,3
Is water from alternative sources being used for non-potable uses? *	Irrigation	Irrigation
Occurrence of major rainfall related flooding incidents frequency (Nº since last provided measure)	8 (2020-2022)	4
Selective Waste Rate (%)	25 (2022)	26 (2023)
Is waste separation implemented in the facilities?	1	1
Percentage of renewable energy consumed in the facilities. [Total consumption of electricity from renewable sources (MWh/yr) / Total electricity consumption (MWh/yr)] (%)	N/A	N/A
Percentage of renewable energy produced in the facilities. [Total production of electricity from renewable sources (MWh/yr) / Total electricity consumption (MWh/yr)] (%)	N/A	N/A
Greenhouse Gas Emissions (ktCO2eq since last provided measure)	1918 (2022)	N/A
Estimated green area in the city (Green area km2 / Total city's area km2) (%)	29	44
Estimated Blue area in the city (Blue area km2 / Total city's area km2) (%)	15	15
Is green and blue infrastructure being promoted on major urban development and infrastructure projects through policy?	1	1

However, the reported number of participative events stayed the same at 15 in both the baseline and the reporting period as shown in Figure 7 Change in Lisbon KPI values (Reporting vs. Baseline). Own elaboration.. The reach of public relations and education campaigns was counted as 1,000,000 participants in 2024, and the answer provided for the Likert scale on user involvement in the project was the maximum of 5 since the beginning of the project.

It was reported that 2,000 volunteers and civil society organisations act as focal points for citizens after a disaster from the first reporting period. From the beginning, the survey shows a concern about stormwater management, natural capital, and coordination between governments.

Lisbon's performance reflects physical and technical progress in the pillars of resilience, through increased green area and carbon neutrality, and also through improvement in waste and water management. For major rainfall related flooding incidents, the city recorded 8 events during the period from 2020 to 2022, with no related incidents in 2023 noted in the baseline measure. The next progress report showed 4 major rainfall related flooding incidents since the last provided measure.The status of drinking water use showed a notable change between the baseline measurement and the progress monitoring. Compared to the reference year of 2019, drinking water use in 2022 was 3.2% lower. However, the progress report showed that drinking water use in 2023 saw an increase of 1.3% when measured against the 2019 reference year. Data from the baseline showed that in 2022, total drinking water use was 53,185 m3.

The objectives toward a carbon neutral neighborhood, toward a carbon neutral neighborhood with benefits of green initiatives, and toward a carbon neutral and resilient neighborhood connect to carbon neutrality and resilience. The prototype specifically seeks to encourage synergies between adaptation and mitigation in underserved areas. A large increase was seen in the city's green area. The estimated green area in the city, measured as a percentage of the total city area of 100.05 km2, was 29% in 2023 according to the baseline data. The first progress monitoring reported a large rise in this measure, showing that the estimated green area reached 44% (equal to 44km2 green area). In contrast, the estimated blue area stayed constant between the two reports at 15% (equal to an estimated area of river front).

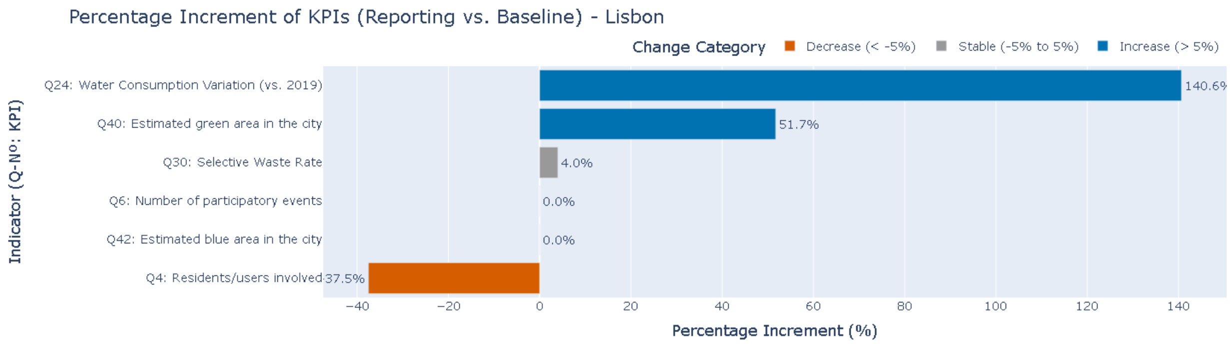

Figure 7 Change in Lisbon KPI values (Reporting vs. Baseline). Own elaboration.

Other indicators also showed slight movement. The selective waste rate improved slightly, rising from 25% in 2022, as recorded in the baseline, to 26% in 2023, as noted in the progress report, although 2024 data was not available at the time of the progress report. For GHG Emissions, the baseline was reported in 2022, but the progress report noted that there was no data available for 2024 emissions.

Table 26 Change in Lisbon Infrastructure KPI values (Reporting vs. Baseline). Own elaboration.

	Baseline	Reporting
The design of the infrastructure incorporate the use of the following solutions to improve the resilience of the area:	Soakaways and porous pavement Parks that function as flood zones Green roofs Green areas Shadowing Water reuse and recycling Renewable energy generation Protective walls against river or coastal high water levels Control of vegetation growth in a buffer next to the facilities	Soakaways and porous pavement Parks that function as flood zones Green roofs Green areas Shadowing Public sprinklers Water reuse and recycling Renewable energy generation Protective walls against river or coastal high water levels Control of vegetation growth in a buffer next to the facilities

What type of measures were implemented in mobility infrastructure design to address climate change mitigation and adaptation?	Physical barriers to overland flows Decentralised energy supply stations (e.g. electrical) Efficient water use devices Efficient energy use components (e.g. electric vehicles suppliers) Bicycle pathways Public sharing bicycle terminals Soakaways and porous pavement	Physical barriers to overland flows Decentralised energy supply stations (e.g. electrical) Efficient water use devices Efficient energy use components (e.g. electric vehicles suppliers) Bicycle pathways Public sharing bicycle terminals Soakaways and porous pavement
	Baseline	**Reporting**
What type of solutions were implemented in natural areas' design to address climate change mitigation and adaptation?	Creation of clearings where all flammables are removed Promote urban-rural interactions in the peri-urban areas, as open areas at the urban fringe may favour species richness Promote the use of available space in peri-urban areas under development to implement larger scale NBS Well connected network of natural areas, which form ventilation channels, facilitates the circulation of fresher and cleaner air Creation of green corridors that reduce traffic emissions, mitigate noise and provide a cooling effect Associate green and blue natural areas to promote interactions Diversify the use of NBS for the same Ecosystem to enhance the overall effect Use of adequate vegetation species to reduce maintenance, water consumption, and promote biodiversity and shadowing	Creation of clearings where all flammables are removed Promote urban-rural interactions in the peri-urban areas, as open areas at the urban fringe may favour species richness Promote the use of available space in peri-urban areas under development to implement larger scale NBS Well connected network of natural areas, which form ventilation channels, facilitates the circulation of fresher and cleaner air Creation of green corridors that reduce traffic emissions, mitigate noise and provide a cooling effect Associate green and blue natural areas to promote interactions Diversify the use of NBS for the same Ecosystem to enhance the overall effect Use of adequate vegetation species to reduce maintenance, water consumption, and promote biodiversity and shadowing

The city reports that it has implemented only the public sprinklers as infrastructure. However, it lists public car sharing pooling terminals and underground parking garages used as holding tanks for storm water as pending infrastructure that is not yet available, as It is shown in Table 26.

3.8 Granollers

Granollers did not change their initial KPI set and did not try to reduce the number of possible KPIs after the first definition phase. This is unlike other cities that updated their KPIs based on a changed focus, resource limits, and a more accessible and understandable evaluation reference to adjust the projects developed in the city by the officials responsible.

Initial KPI selection has long-term impacts on project implementation. Cities that do not review and adjust their indicator lists may face greater administrative burden. This can affect the quality of monitoring and the ability to demonstrate project results clearly.

Granollers is the smallest city in size and population among the project partners. This likely means the city has fewer resources available for project activities. Despite this, Granollers had to collect data for many indicators at same time. This work required more staff time and resources than a smaller set of KPIs would need. The high number of KPIs made the monitoring process more complex for the city. City officials had to track and report on 48 different measures throughout the project period, . The workload was significant for a small city with limited staff. Each indicator needed data collection, analysis, and documentation.

The decision also made it harder to focus on the most important outcomes. With so many indicators to monitor, it is difficult to identify which results were most significant for the city's goals. The workload for data collection and reporting is considerably higher than in cities that have reduced their KPI numbers. Other cities that simplified their indicator sets could concentrate their efforts on fewer, more relevant measures. This allowed them to provide more detailed and accurate reporting for each indicator. It also made it easier for city staff to understand what they were measuring and why it mattered.The Granollers prototype, "Set of guidelines for a greener city with opportunities for everyone," is a standard guide for city planning that can be used by other medium and small cities. This guide offers practical rules and resource plans that can be used when making new city areas. It focuses on cutting carbon, making city systems stronger, and helping people connect. The prototype brings together results from working with local people, plus data from technical tools used in the La Bòbila area. The main goal is to make technical rules for future neighborhoods based on three things: having no climate impact, handling climate problems (mixing built, water, and plant systems), and being fair and money-wise.

Two main tools shape what is in the prototype. The RESCCUE tool helps make suggestions by looking at different flood control plans. It found that water holding tanks, while good for slowing water flow, are not the best choice since they do not help the environment or people in other ways. Green roofs, though the most expensive option, are seen as good because they offer many side benefits. The City Scan tool (TSPA Parametric Design tool) helps local leaders design and check different city plans, showing options based on how dense an area is, which way buildings face, and how much green space exists. Studies using this tool looked at plans that mix nature-focused and people-focused growth. One study showed green roofs had small benefits but high costs compared to other nature options, so a people-focused plan left them out for cheaper methods. The final rules will include lessons learned from studying these design choices.

The baseline report gives multiple measurements. All of them are shown in Table 27. Water use per person is 107 liters per day, which is below the Eurostat median for Spain in 2010 of 161.64 liters per day. However, the 2024-2025 Catalonia drought and water restrictions over summer periods in some parts are widely known. The city's electricity use is 1,065 kWh per year per person (2023 data). The total GHG emissions are 3.89 Tons CO_2 per inhabitant, slightly higher than the 3.55 Tons CO_2 per inhabitant in GHG emissions reported to Global Covenant of Mayors.

Table 27 KPI values for Granollers. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B
Q2 Percentage of households with safety managed drinking water service. Calculate as: [Number of city households with a safety managed drinking water / Total number of city households] *100 (%)	100
Q4 Number of greywater systems being implemented (Nº since last provided measure)	0
Q6 Permeable surface area km² (km²) *	8.29
Q8 Total water consumption per capita (l/day*person)	107
Q10 Percentage of renewable energy consumed in the city. Calculate as: [Total consumption of electricity from renewable sources (MWh/yr) / Total city electricity consumption (MWh/yr)] (%)	0.164
Q12 Solar energy production (MWh/yr)	6,9
Q14 Electricity consumption per capita (kWh / year * person)	1,065 (2023)

Q16 Total GHG emissions (Tons CO2 / Total number of city inhabitants)	3.89
Q18 Number of services involved in the LAA (Nº)	17
Q20 Stormwater runoff volume generated per built area (m^3 / m^2)	0.52
Q22 m^2 of SUDS implemented in the neighbourhood (m^2)	26,099
Q24 Number of modelling scenarios quantifying the flood risk of La Bobila sector (Nº since last provided measure)	11 (RESCUE + CityScan 4)
Q26 Number of resilience alternatives for La Bobila neighbourhood (Nº since last provided measure)	6
Q28 Average percentage of the population within a 300-meter radius of accessible green spaces (%) *	41.15
Q30 Percentage reduction in projected Kw/m^2 compared to last provided measure (%)	N/A
Q32 Kilometers of new or improved bicycle and pedestrian paths connecting key areas (km since last provided measure)	17
Q34 Percentage of housing units designed to be affordable for low- and moderate-income households (%)	3
Q36 Tons of CO_2 per year that can be absorbed by green infrastructure (Tons of CO_2)	368
Q38 Percentage of existing green areas conserved (% since last provided measure)	12
Q40 Percentage of new developments allocated to green spaces with climate-resilient vegetation (% since last provided measure)	100
Q42 Number of green roofs or walls installed (Nº since last provided measure)	5,830
Q44 Green m^2 per capita	10.9
Q46 Percentage of public areas with sufficient shading (e.g., through tree planting or artificial structures) (%)	49.94
Q48 Average surface temperature (ºC)	14.5
Q50 Maximum surface temperature (ºC)	40
Q52 Length of new green corridors developed (km since last provided measure)	2.2
Q54 Percentage of underserved populations (e.g., low-income, elderly) within walking distance (300m) of conserved areas (%)	N/A
Q56 Number of pedestrians or cyclists using the corridor (Nº since last provided measure)	N/A
Q58 Connectivity index for green corridors (Average distance between green patches, meters)	300-700
Q60 Number of mobility hubs (last mille) (Nº)	1
Q62 Vehicles with emission standards. Percentage of vehicles that enter a low-emission zone and comply with the established emission standards. The calculation compares the total number of vehicles entering the zone to the number of vehicles that comply with the	N/A

defined emission standards (e.g., electric vehicles, hybrids, or vehicles meeting specific emission norms such as Euro 6). (%)	
Q64 European Air quality index (EAQI) based on reported value of PM10, PM2.5, nitrogen dioxide, sulphur dioxide, and ozone (Nº)	*Table 28
Q66 Access to public transport stop (m)	3 train stations and 1 intercity bus station, 95% of Granollers' population has access to interurban mobility options within a 1-kilometer radius, urban bus lines provide nearly complete coverage across Granollers
Q68 Number of bike parking (Nº since last provided measure)	919
Q70 Number of connection points with the rest of the city (Nº)	3 train stations and one intercity bus station + 5 urban lines
Q72 Km of bicycle paths or lanes (km)	17
Q74 Number of new projects aligned or based on the new guidelines (Nº since last provided measure)	N/A
Q76 To what extent the local authority provides financial support to the project? Mark the answer, where 1 is "no financial support" and 5 is "high financial support"	3
Q78 To what extent the prototype (guideliness) project is integrated in the activities of the third parties (instead of copied by other commercial parties)? Mark the answer, where 1 is "no integration" and 5 is "high integration"	5
Q80 Percentage of number of inventoried open datasets that are published. Calculate as: [Total number of open data sets published / [Total number of data sets] *100 (%) *	70
Q82 Percentage of mixed typology housing (%)	The city does not have specific initiatives but there is an axis of the PAM, axis 2 which includes actions focused on housing issues with objectives 5 and 7, with actions highlighted for this mandate
Q84 Percentage of social housing units (%)	1
Q86 To what extent platform collects disaggregated data by race, ethnicity, gender, income level income distribution, housing affordability, access to healthcare, education quality, employment rates, and geography, providing detailed insights into disparities in access to resources and opportunities? Mark the answer, where 1 is "highly aggregated" and 5 is "highly granular"	3
Q88 Access to public services (m)	100
Q90 Access to green spaces (m)	100

Q92 To what extent the progress towards green projects goals and compliance with requirements is being monitored and reported? Mark the answer, where 1 is "no monitoring" and 5 is "very carefully monitored"	5
Q94 Total financial resources (public, private, and philanthropic) allocated annually to the development and maintenance of social and affordable housing (€/year) *	Municipal Housing Expenditure (Last 3 Budgets): Municipal housing expenditure, as allocated in the Housing Plan, can be detailed for the last three budgets: 2023: €1,055,000.00; 2024: €228,000.00; 2025: €1,049,825.41
Q96 To what extent the project has contributed to, or inspired, new forms of public procurement procedures. Rate your answer from 1 to 5, where 1 means "no contribution" and 5 means "important contribution"	4
Q100 To what extent the local authority provides financial support to the project? Mark the answer, where 1 is "no financial support" and 5 is "high financial support"	5

Identifying the balance between gray and blue-green infrastructure and linking the urban green grid through La Bòbila's green infrastructure relate to resilience and upskilling. These objectives focus on adaptation to flood risks and high temperatures. Stormwater run-off volume was estimated at about 0.52 m3 per m2 per year. A permeable surface area of 8.29 km2 was reported. 26,099 m2 of Sustainable Urban Drainage Systems (SUDS) were put in place in the neighborhood. 11 scenarios were modeled to measure flood risk with 6 resilience options for La Bòbila sector, as shown in Table 27.

Preventing gentrification, maintaining inclusion and equity, and creating a citizen laboratory focused on the urban transformation of the city connect to spatial justice. Granollers pursues distributive justice by seeking to limit prices, establish social housing, and subsidize social rents to prevent gentrification. The procedural justice approach centers on creating a CityLab for participation and policy co-design. The percentage of social housing units was reported to be 1%, with a goal set for 2030 of 15%. City housing spending, as shown in their Housing Plan, had a budget of €1,055,000 for 2023, €228,000 for 2024, and €1,049,825.41 for 2025.

Table 28 Reported pollution KPIs in Granollers baseline reporting. Own elaboration.

KPI	µg/m³
PM2.5	7
PM10	12
NO	2
NOX	11
NO_2	13
O_3	45

Table 28 shows data on emissions and air quality for the partner cities. The measurements cover the baseline period. It was reported to have 10.9 green m² per capita. Based on the most recent Idescat data of 63,897 inhabitants, this equals about 696,477 m². Around 50% of public areas have enough shading through tree planting or artificial structures. 41.15% of the population is reported to be within 300 meters of green spaces they can access. The reported kilometers of bike lanes are 17 km and 2.2 km of new green corridors. Data on the number of pedestrians or cyclists using the corridor is not available because the work is still being done.

The percentage of renewable energy used in the city was reported to be 0.164, with 6.9 MWh/yr.

Local authority financial support to the project was rated 5 on the Likert scale at the baseline. New forms of public procurement procedures were reported with a rating of 4. Progress toward green project goals and following requirements is being monitored and reported, which received a rating of 5. The number of services involved in the LAA, which also shows involvement in the project, was reported to be 17.

3.9 Istanbul

The Istanbul project focuses on reaching positive energy districts through digital twin screening. This especially involves finding where solar panels could work on buildings and adding this to urban transportation. The project uses two main prototype actions: the Integrated Digital Twin Framework and PV-integrated urban furniture for public awareness and sustainable energy. These two tools were reported as put in place in the survey.

The digital twin framework has three main parts: MIRA Digital Twins Platforms, a Building Information Modeling (BIM) module and building life cycle assessment (LCA) module, and the Urban Building/Transport Energy Model (UBTEM), an AI-powered decision-making tool for reducing carbon. The project reported that two tools were put in place. The digital twin framework models nearly 2,500, mostly residential, buildings in the Kadıköy region. It does baseline and simulation studies. The goal is to find where solar panels could work and produce scientific results that add this to urban transportation. Data for the monitoring of these actions is shown in Table 29.

Table 29 KPI values for Granollers. Own elaboration.

Timestep (B Baseline Period, R Reporting Period)	B
Q2 Total reach of dissemination through channels (number of people since last provided measure)	3200+
Q4 Total reach of dissemination through channels (number of likes since last provided measure)	500+
Q6 Total reach of dissemination through channels (number of comments since last provided measure)	100+
Q8 To what extent residents/users have been involved in the project? Mark the answer, where 1 is "not involved at all" and 5 is "very involved".	4
Q10 How many residents/users have been involved in the project? (Nº since last provided measure)	200+
Q12 Number of tools implemented (Nº)	2
Q14 European Air Quality Index (EAQI) based on reported value of PM10, PM2.5, nitrogen dioxide, sulphur dioxide, and ozone (Nº)	*Table 30
Q16 Total GHG emissions (Tons CO2 / Total number of city inhabitants)	Kadıköy total GHG emissions (baseline): ~1,006,741 tons CO_2 /Kadıköy population (est.): ~361,000 - Per capita GHG emissions: ≈ 2.79 tons CO_2/person/year
Q18 Non-polluting vehicles are considered to be those that do not emit any type of pollutant, such as electric vehicles. Hybrids are not taken into account. Calculate as: non-polluting vehicles with respect to the total volume of vehicles (%)	Estimated % of fully electric vehicles in Kadıköy: ≈ 2.5%

Q20 Percentage of local renewable electricity production as a percentage of total final electricity consumption. Calculate as: [Local renewable electricity production (MWh) / Total electricity consumption (MWh)] *100 (%) *	23.62 (2025)
Q22 Measures the total installed power generation capacity through photovoltaic systems, reflecting the potential for solar energy production (MW)	45.55
Q24 Number of PV systems installed in a given period (Nº since last provided measure)	30
Q22 Measures the total installed power generation capacity through photovoltaic systems, reflecting the potential for solar energy production (MW)	45.55
Q24 Number of PV systems installed in a given period (Nº since last provided measure)	30
Q26 Percentage of renewable energy consumed in the city. Calculate as: [Total consumption of electricity from renewable sources (MWh/yr) / Total city electricity consumption (MWh/yr)] *100 (%)	38.2 (2025)
Q28 Measure the impact of energy efficiency improvements in refurbished buildings. Energy Consumption Reduction =((Consumption Before Renovation−Consumption After Renovation)/ Consumption Before Renovation)×100 (%)	43.85
Q30 Number of public services available through online services. Number of shares / number of participants (Nº)	82

Istanbul is reported in Table 29 to emit 2.79 tons CO_2/person/year. This is slightly lower than what was reported for all of Istanbul to Global Covenant of Mayors (3.26 tons CO_2/person/year). The pollution data figures were also reported, as we can check in Table 30.

Table 30 Reported pollution KPIs in Istanbul baseline reporting. Source: Own elaboration.

KPI	µg/m³
PM2.5	14.2
PM10	36.2
NO_2	33.5
SO_2	5.1
O_3	33.5

Inclusion through positive behavioral change and education relates to spatial justice and uptaking. The pilot seeks to increase social awareness and increase the acceptability of PV use. This is driven by installing urban furniture with integrated PV in the most active location of the pilot region. This furniture can also serve as a backup energy source after an earthquake, contributing to community resilience. It is estimated that 2.5% of the vehicles in Kadıköy are electric. Local renewable electricity share is around 23.62%. Kadıköy total installed PV capacity in 2025 is estimated to be 45.55 MW. City-level total renewable use share is estimated to be 38.2%. Energy use reduction from building updates is about 43.85%.

Measuring social benefits connects to spatial justice, particularly distributive justice. The city has an explicit objective to measure social benefits. This includes measuring social benefits to reduce energy poverty and health risks related to overheating. The total reach of information sharing through channels (measured by the number of people since the last provided measure) was 3,200+. Social media interaction numbers reported included 500+ likes and 100+ comments since the last measure was provided. Also, the project recorded that 200+ residents and users have been involved in the project. The record also shows about 82 users were involved in the context of the number of public services available through online services. For users and residents involvement in the project, it was rated as 4in the answer to the survey for the baseline.

3.10 Zagreb

Zagreb reported that baseline data for its project was not available or was recorded as zero. This happened probably because of the uniqueness of their project's prototype. Zagreb's project works on creating a low-carbon city food system based on circular economy ideas. The main goal is to reduce carbon dioxide emissions in the city food system and improve food security. The approach tries to close the circle. It starts with growing food at schools, then moves through eating and waste, composting, and back to growing at schools again. The project runs in two locations: the Sesvete District and the Maksimir District.

Zagreb's commitment, shown in the external KPIs of section 4 and the data availability summary in section 5's discussion, is reflected in its prototype's ambition. The prototype addresses social and technical transition in an area where standard measures did not work well initially. This clarifies why baseline data reporting posed challenges. The questionnaire and external data cannot provide the prototype-specific information that is missing, but they can establish a strong numerical background. Satellite image analysis of the prototype area might produce useful findings and is suggested for future monitoring if questionnaires become inadequate or impractical, though this falls outside this document's scope. The absent information is important for internal assessment, which evaluates how effectively the prototype's particular actions perform in the short term, including skill development, plan updates, and tool application. These activities correspond to the **U**pdating, **U**pgrading, and **U**pskilling phases of the 5UP approach.

4 External KPI Results

This external KPI analysis was done at the same time as the KPI validation led by the cities, it is the second track of the two-track approach. By combining direct feedback from participants with external data, the framework offers a complete and reliable evaluation of project performance and impact. The results of this external analysis add to the findings of the KPIs validated by the cities by providing measurable evidence based on data of the wider influence of the project. This analyzes how the KPI values changed over time.

Using external data is necessary for several reasons. First, external sources make comparisons between cities more reliable when applying strategies like city twinning and strategic learning. This allows for successful monitoring of Upscaling phase results. When cities can compare their progress using the same metrics, they learn from each other more effectively. They can see which approaches work best in similar contexts. Second, external data covers broader geographic areas and longer time periods. This helps cities in prioritising the most promising measures to get the highest possible impact in an efficient way. Cities can see which interventions produced the best results at regional or national levels. This information is valuable for the Uptaking phase. Cities can focus their resources on measures that data shows are most effective. They can avoid spending time and money on approaches that have not worked well elsewhere. Third, external sources are independent from the project partners. This independence means the data cannot be influenced by the cities' desire to show positive results. Internal reporting may emphasise positive outcomes while external data provides an unbiased view. External data shows trends across entire cities, regions, or even countries. This wider view helps put local project results into context. A city might report good results in a pilot neighborhood. However, external data might show that the same improvement happened across the entire region. This context is important for understanding whether the prototype caused the change or whether other factors were responsible. Fourth, external data allows the project to measure impacts that cities themselves may not track. For example, national surveys about climate concern provide information that individual cities do not collect. Regional economic data shows employment patterns and income levels. Environmental monitoring networks measure air and water quality across wide areas. These data sources give information about outcomes that go beyond what project activities directly measure. Finally, some cities face difficulties providing internal data. Resource limits, staff changes, or technical problems can prevent cities from completing their reporting as was observed during the project period. In these cases, external data can still provide a perspective of the prototypes impact. The project can still assess what happened even when internal monitoring fails.The methodology for doing the external KPI calculations is based on the use of external open data sets. The KPI blocks for external monitoring include transportation data, climate data, data availability information, resilience data, pollution and GHG emissions data, and social inclusion data.

4.1 Climate data

To allow comparison, efforts were made to group the different cities in different ways, based on their climate characteristics. The first trial, shown in the first scatterplot of **Error! Reference source not found.** used for this analysis, tried to group the cities using only climate data from the last available year. This first grouping placed the cities far from their real climate zones.

A second grouping attempt included soil data along with the climate data for the last available year. When the soil information was included, the resulting city groups were closer to the known climate zones. A final trial was done using soil data combined with the average values of the climate variables collected over the 2023-2025 period. Using the average values between years did not improve the grouping results when compared to the trial that used soil data for a single year.

The purpose of these grouping trials was to check for a possible change in the classification of the climate zones over time. We can see the main outcomes in Figure 8. However, this possible change was not seen through these attempts. As a result, the most reasonable groups to use for further analysis appear to be the historical classifications found in the literature which are shown inTable 31.

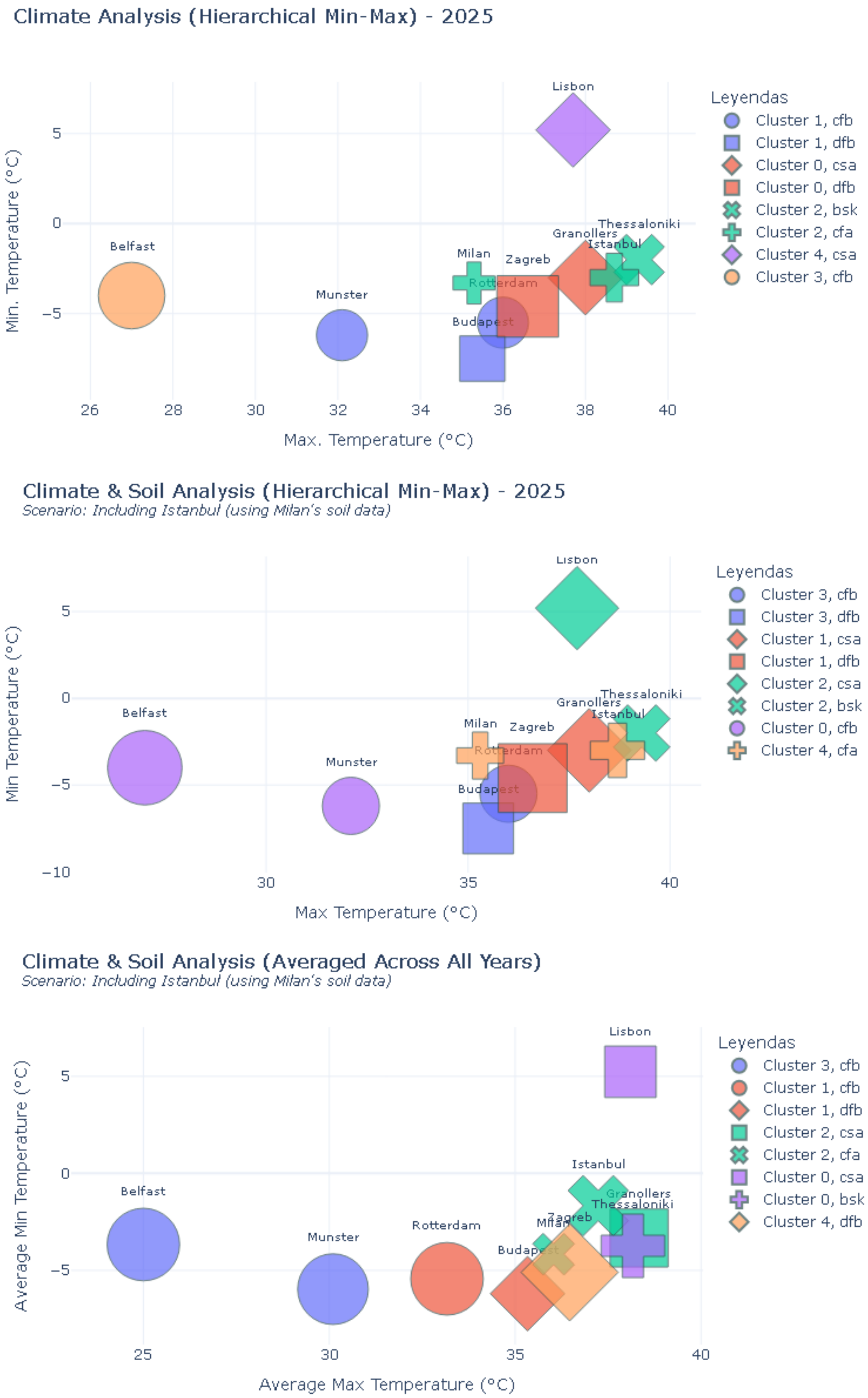

Figure 8 Trials on Climate Clustering Alternatives. Own elaboration. Source: Copernicus, Köppen 1900, Beck et al 2018, Meteostat, Tóth et al 2013 and European Commission Joint Research Centre 2016.

Table 31 Correspondence between cities and their climate zones.

City	Köppen-Geiger
Milan	cfa
Istanbul	cfa
Thessaloniki	bsk
Granollers	csa
Budapest	dfb
Lisbon	csa
Belfast	cfb
Zagreb	dfb
Munster	cfb
Rotterdam	cfb

4.2 Pollution and GHG emissions

Annex II and Annex III includes further sample scenarios for different seasons of the year, but in Figure 9 and Figure 10 you can find plots for 2024 data.

For CO concentrations, as shown in Figure 9, clear seasonal differences can be seen. January 2024 shows concentration levels ranging from 200 to 1400 µg/m³ or higher in some areas. July 2024 shows the lowest concentrations, with levels ranging from 100 to 900 µg/m³. October 2024 shows values between these two, with levels from 200 to 1200 µg/m³. This pattern suggests that CO concentrations are higher during colder months and lower during summer months. Most of the mapped area shows relatively low concentrations, with the purple color showing the lowest levels across most regions.

For SO_2 concentrations, Figure 10 presents similar seasonal changes, the values are much lower overall compared to CO. January 2024 shows concentrations ranging from about 5 to 70 µg/m³. July 2024 shows the lowest levels, with concentrations between 0 and 35 µg/m³. October 2024 shows moderate levels, ranging from 0 to 60 µg/m³. Similar to CO, SO_2 concentrations follow a seasonal pattern with higher values in winter and lower values in summer. The purple color covers most of the mapped area, showing that SO_2 concentrations remain low across most of Europe.

Based on the maps, most of the study cities are located in areas with low concentrations of both CO and SO_2, shown by the purple color covering most of Europe.

For CO concentrations, the eastern regions of the mapped area show somewhat higher values, particularly in January and October. This suggests Istanbul, being located in the eastern part of the study area, may experience slightly higher CO concentrations compared to other cities. Some areas in central Europe also show moderately elevated values, which could affect cities like Budapest and Milan.

For SO_2 concentrations, the pattern is similar but with overall lower values. The eastern and southeastern regions show some spots with higher concentrations, particularly visible for January. This again suggests Istanbul may have somewhat higher SO_2 levels. Some areas in southeastern Europe also show elevated spots, which could affect Thessaloniki.

Western cities like Belfast, Rotterdam, and Lisbon appear to be in areas with the lowest concentrations of both pollutants. Central European cities like Munster also appear to be in low-concentration areas.

It is important to note that the maps show regional patterns rather than city-level measurements. The resolution makes it difficult to identify precise values for individual cities. Overall, all the study cities are located in regions where both CO and SO_2 concentrations remain relatively low by European standards, though eastern cities appear to experience slightly higher levels than western cities.

For CO concentrations, clear seasonal patterns appear in most cities, as shown in Figure 11, Figure 12, Figure 13, Figure 14 and Figure 15. Winter months show higher average and maximum values, while summer months show lower values. This cycle is especially visible in the dfb zone, which includes Milan and Istanbul. The winter increases are likely due to heating systems burning more fuel during cold months. Milan shows sharp increases in winter average CO levels, and Istanbul follows a similar pattern, as you can check in Figure 11. The maximum CO concentration plot in Figure 12, shows these seasonal cycles even more clearly, with peak values appearing regularly during winter months.

When comparing cities within the same climate zone, some behave similarly while others differ. In the csa zone, Granollers and Lisbon show different patterns. Figure 15 shows how around July 2022 to January 2023, their CO/SO_2 ratios start to separate. Granollers grows much more compared to Lisbon during this period. Looking at the SO_2 plots in Figure 13, this difference appears to be caused by a greater increase in SO_2 concentrations in Granollers compared to Lisbon. The maximum CO plot also shows a large increase in Lisbon CO concentration compared to Granollers over the study period.

A similar pattern happens with Zagreb and Budapest in the cfb zone. Starting around the same period between July 2022 and January 2023, their paths begin to differ. The average (Figure 13) and maximum (Figure 14) SO_2 plots show that Budapest experiences greater increases in SO_2 concentrations during this time, which explains the change in the CO/SO_2 ratio between these two cities.

Looking at individual cities, Istanbul stands out in the csa zone for having much higher SO_2 concentrations than other cities in the same group. The average SO_2 plot shows Istanbul reaching values around 15-20 $\mu g/m^3$, while other cities in this zone stay between 2-8 $\mu g/m^3$. The maximum SO_2 plot shows even more extreme values for Istanbul, with peaks reaching above 150 $\mu g/m^3$ compared to 10-20 $\mu g/m^3$ for other cities. This large difference suggests Istanbul has different emission sources or less strict pollution controls compared to other Mediterranean cities.

Rotterdam and Belfast in the cfb climate zone show interesting differences. Rotterdam generally has higher CO and SO_2 concentrations compared to Belfast throughout the study period. Both cities show seasonal patterns, but Rotterdam's baseline values stay consistently above Belfast's levels. This difference may be due to Rotterdam's position as a major port and industrial center compared to Belfast's smaller size and industrial activity.

The CO/SO_2 ratio plots provide useful information about the relative sources of these pollutants in each city. Cities with high ratios have more CO relative to SO_2, which suggests traffic and transportation are the main pollution sources. Cities with lower ratios have more SO_2 relative to CO, which suggests industrial sources or fuel burning with higher sulfur content. The Csa zone shows the most stable ratios over time for most cities, except for the noted divergence between Granollers and Lisbon. The Dfb zone shows more variable ratios, particularly for Milan, which has consistently higher ratios suggesting traffic is a major source there.

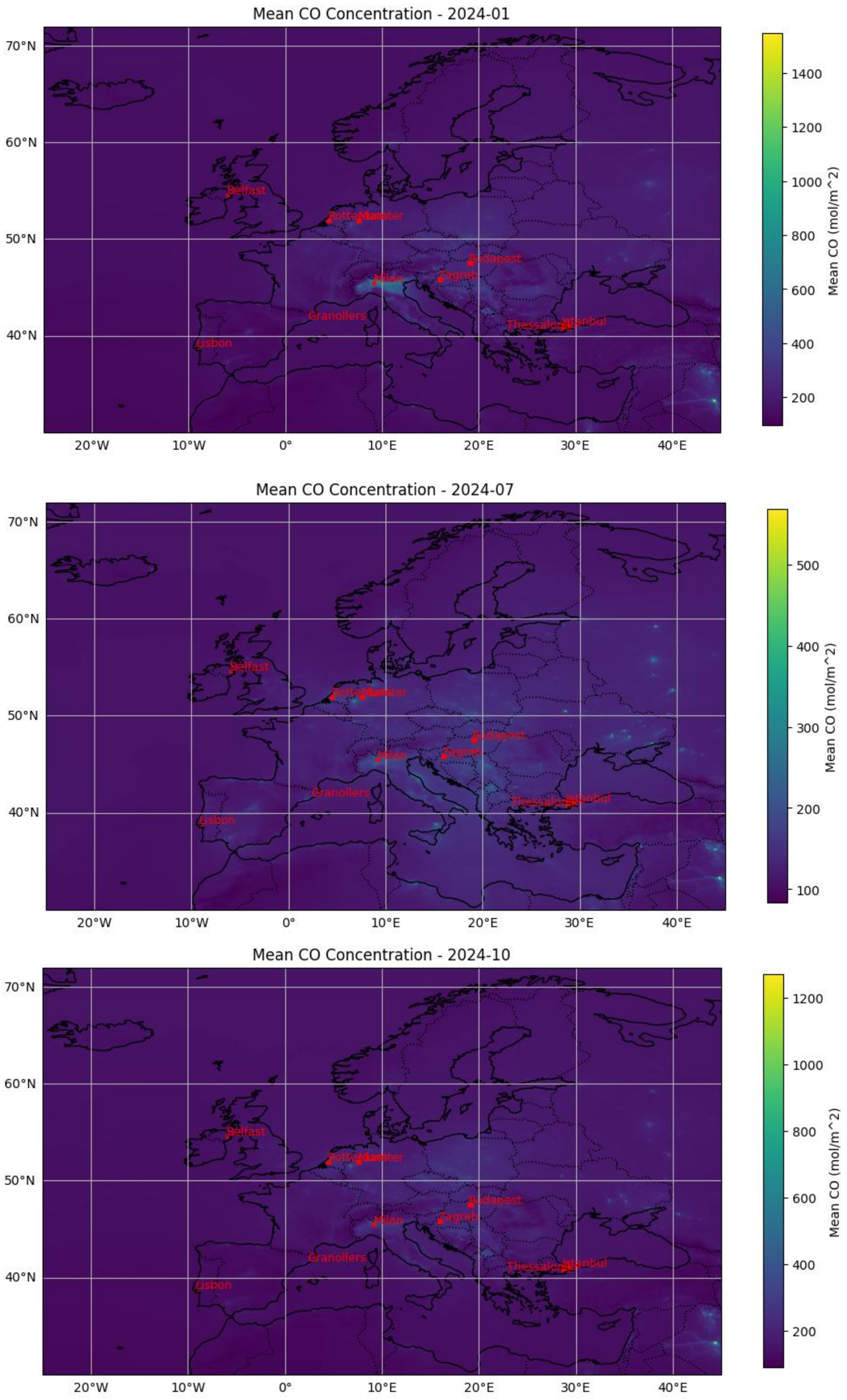

Figure 9 Mean CO concentration in Europe in the different cities in different seasons of 2024. Own elaboration. Source: CAMS European Air Quality Reanalysis.

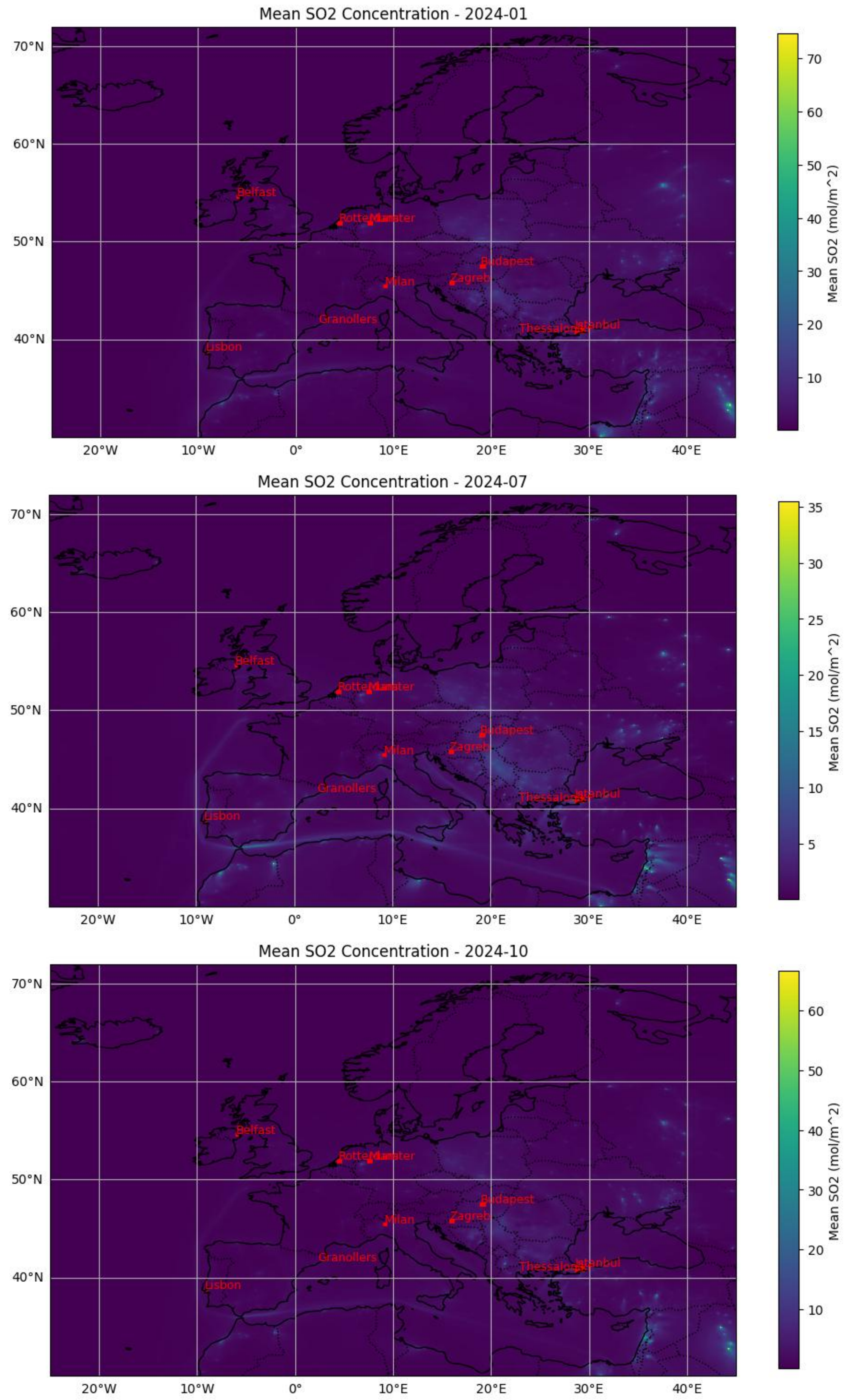

Figure 10 Mean SO2 concentration in Europe in the different cities in different seasons of 2024. Full period data is plotted in Annex III. Own elaboration. Source: CAMS European Air Quality Reanalysis.

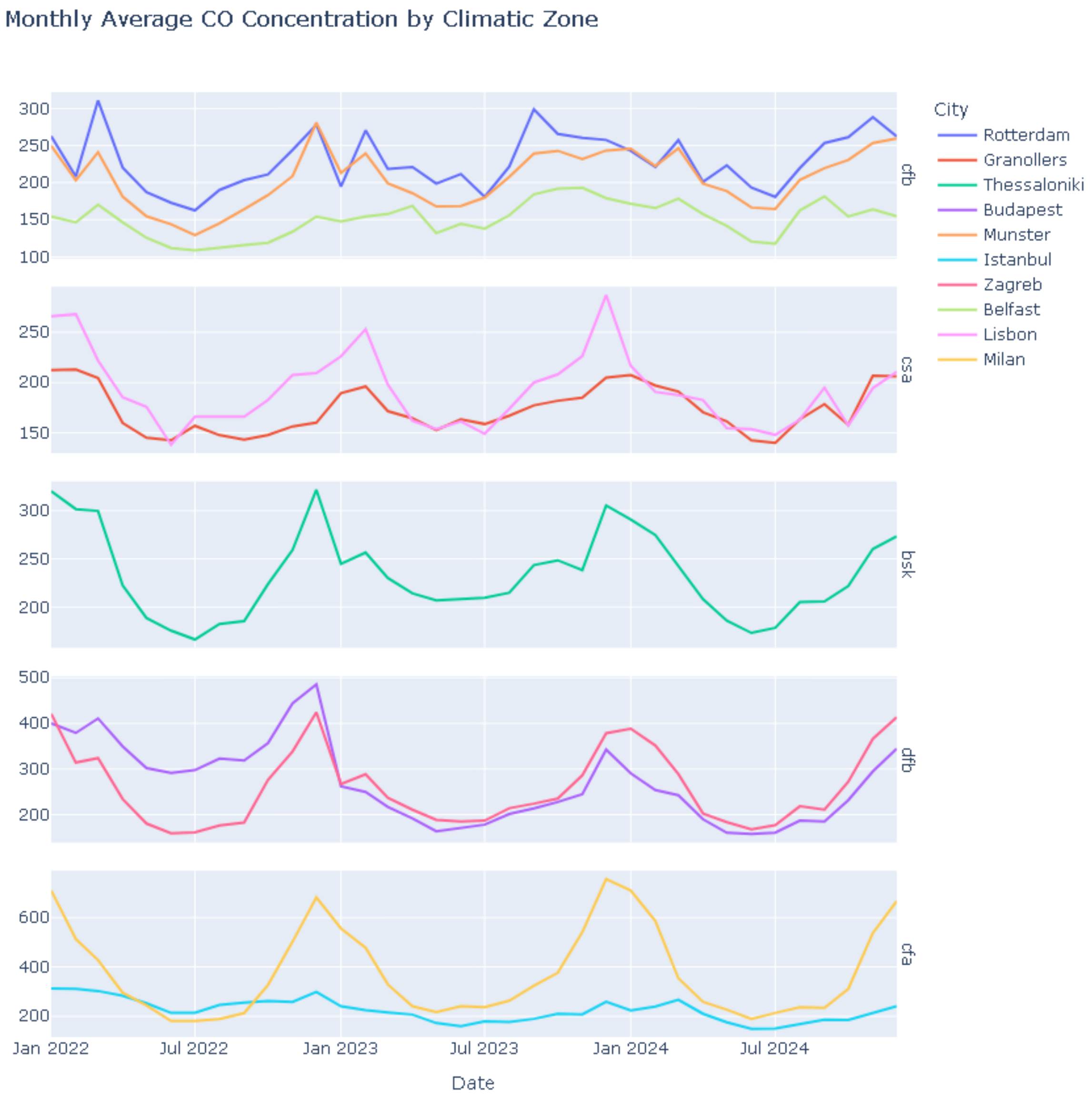

Figure 11 Monthly Average CO concentration in Europe in the different cities from 2022 to 2024 split by climatic zone. Own elaboration. Source: CAMS European Air Quality Reanalysis.

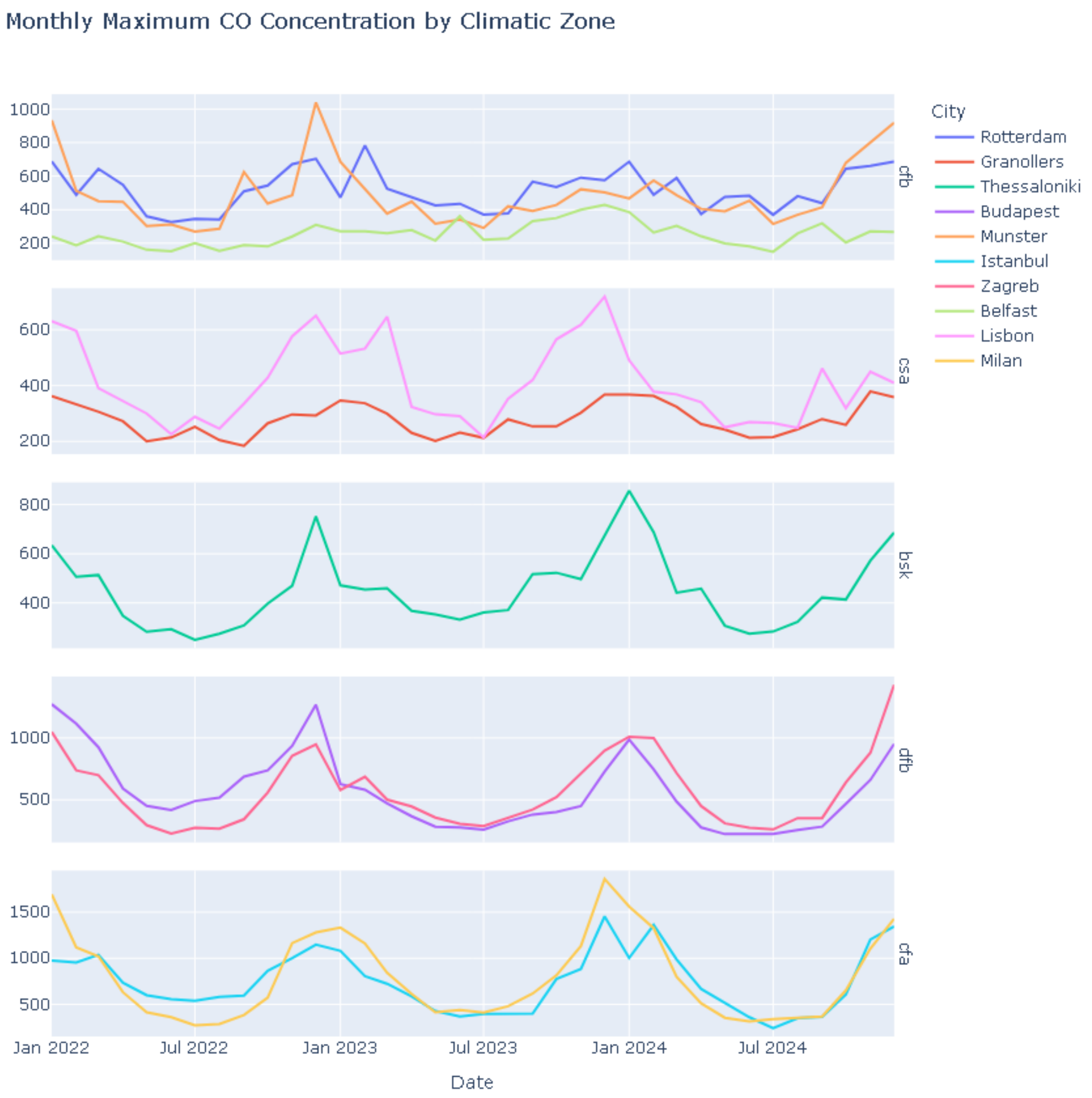

Figure 12 Maximum CO concentration in Europe in the different cities from 2022 to 2024 split by climatic zone. Own elaboration. Source: CAMS European Air Quality Reanalysis.

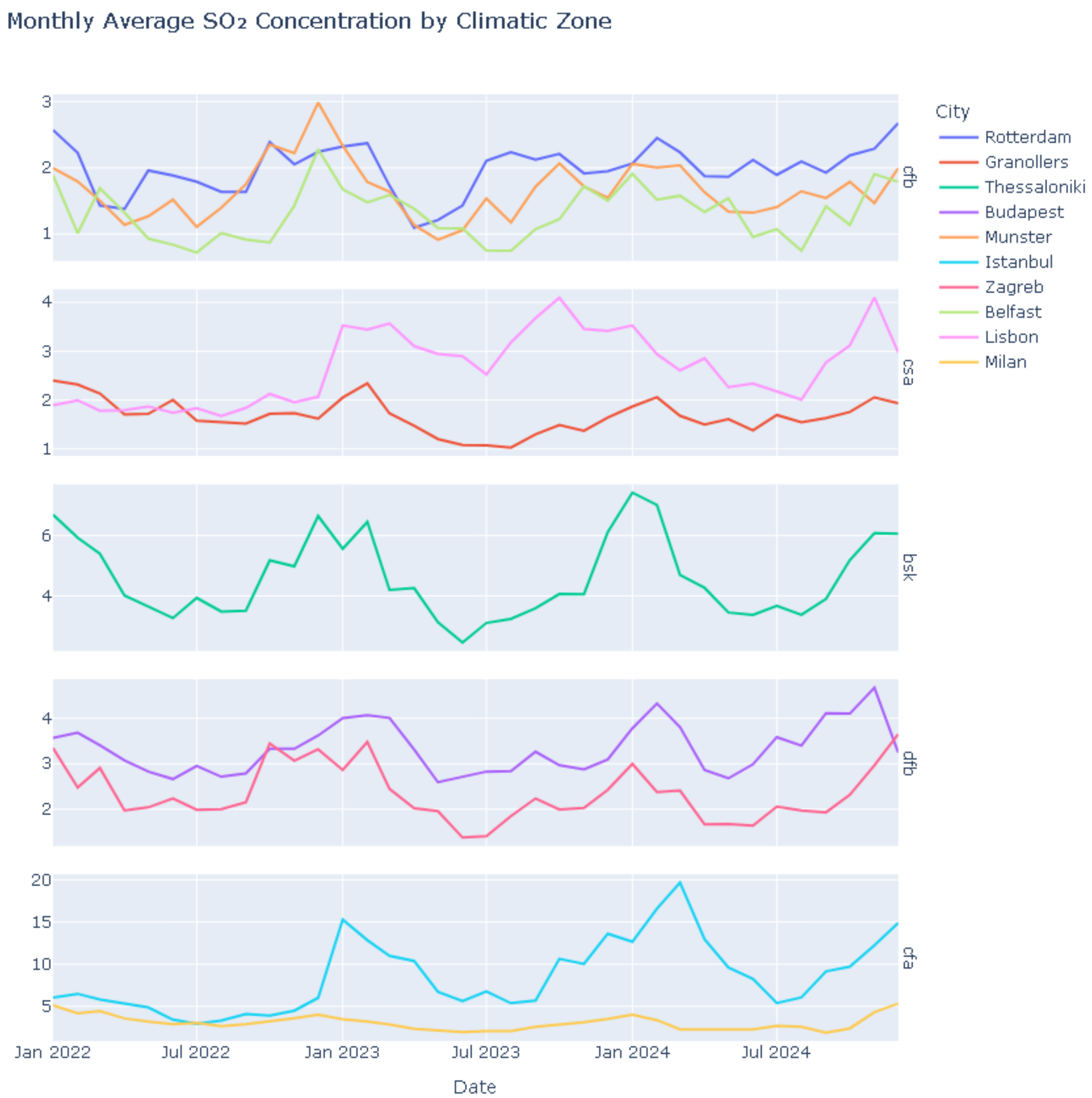

Figure 13 Monthly Average SO2 concentration in Europe in the different cities from 2022 to 2024 split by climatic zone. Own elaboration. Source: CAMS European Air Quality Reanalysis.

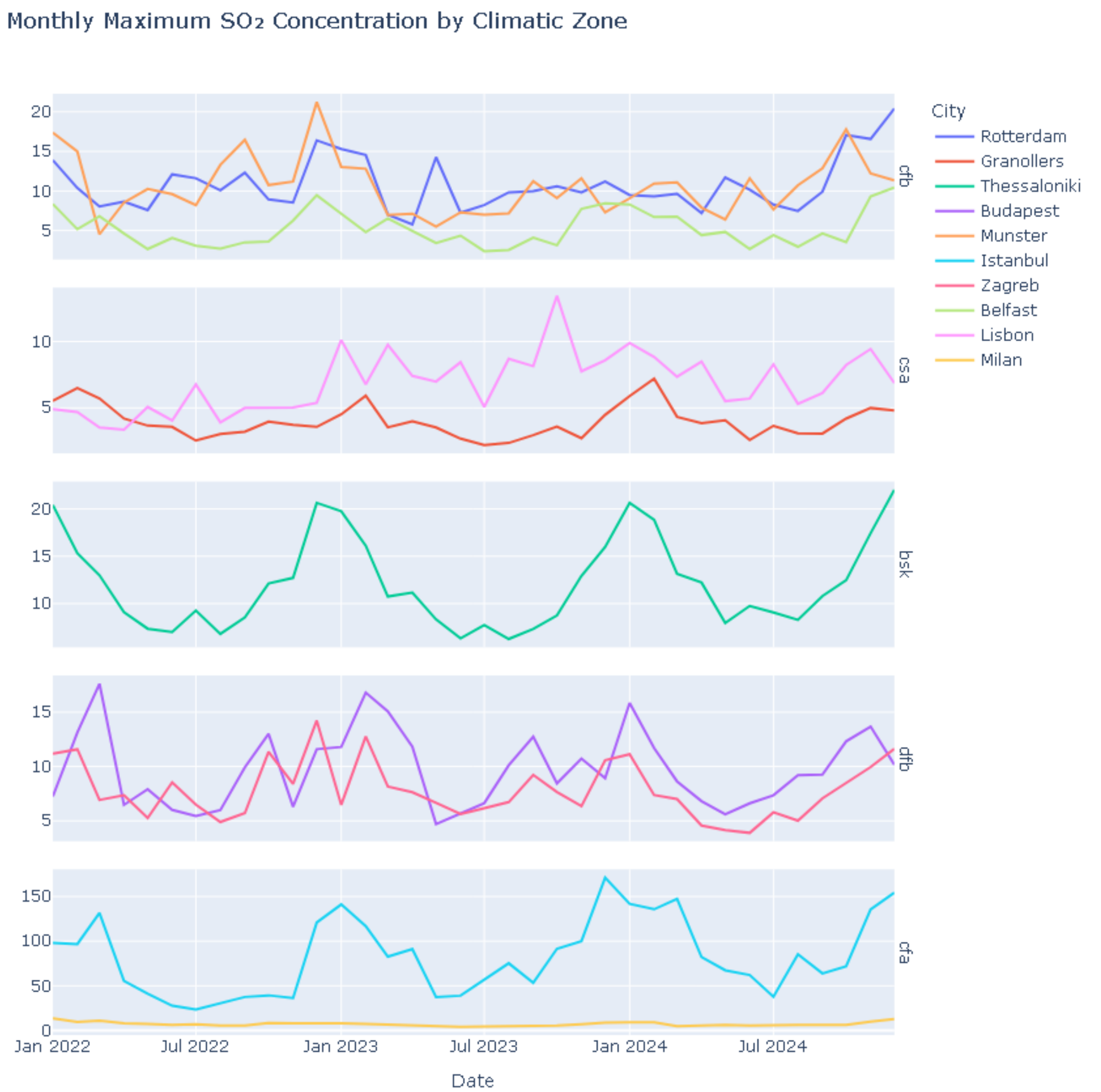

Figure 14 Maximum SO2 concentration in Europe in the different cities from 2022 to 2024 split by climatic zone. Own elaboration. Source: CAMS European Air Quality Reanalysis.

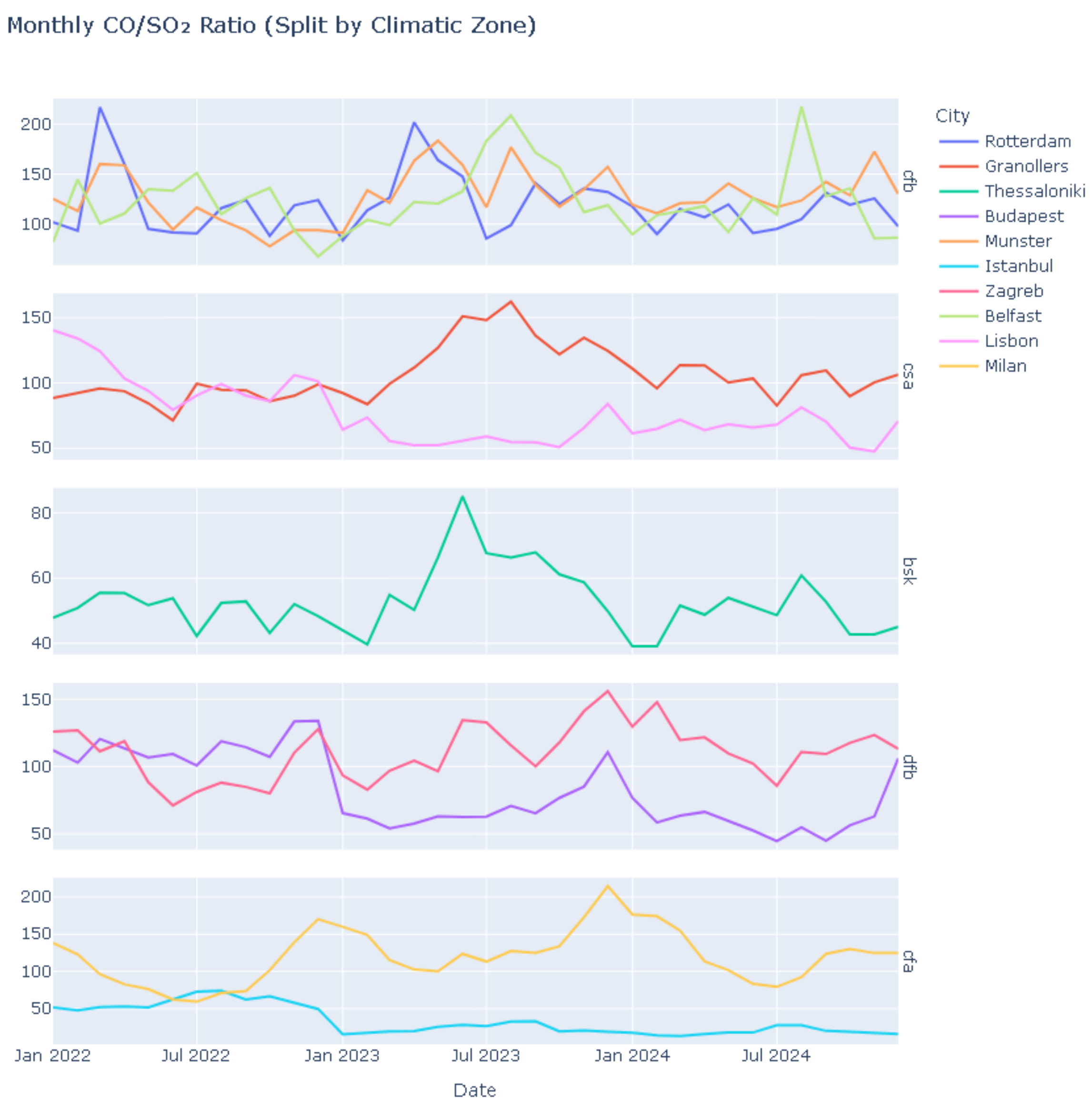

Figure 15 Monthly CO/SO2 Ratio. Own elaboration. Source: CAMS European Air Quality Reanalysis.

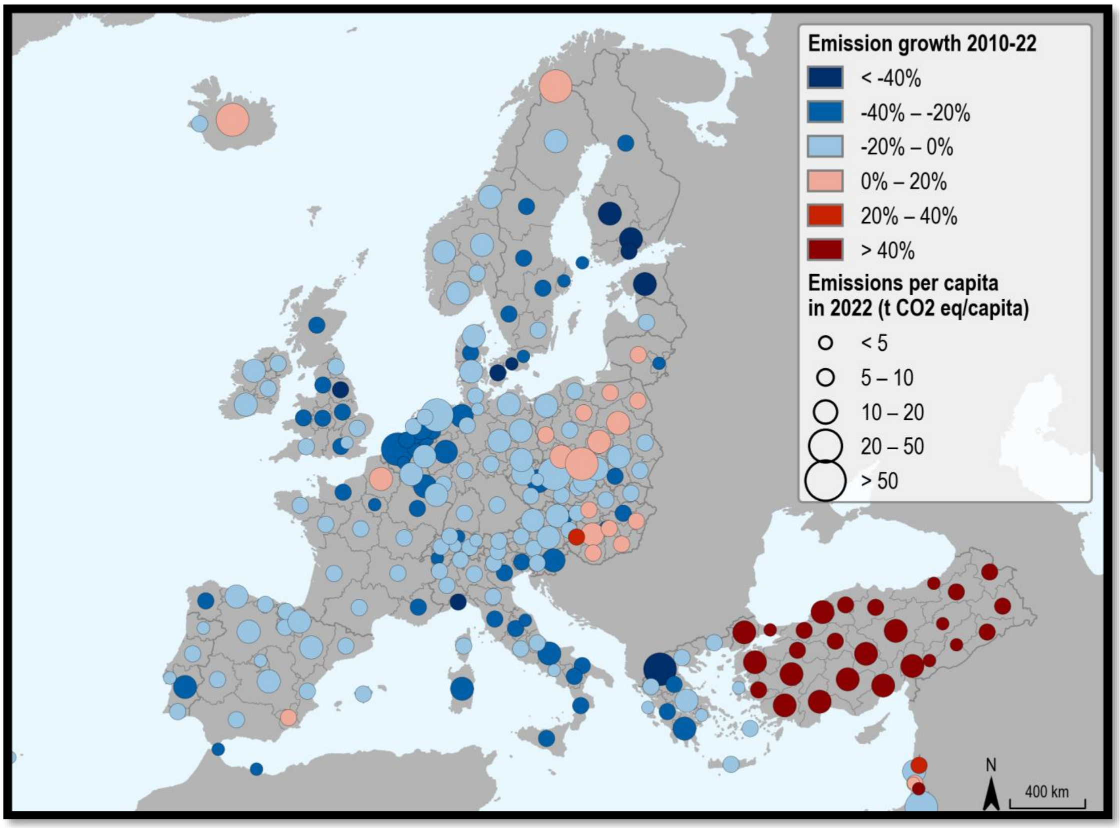

Figure 16 Growth of CO2 emissions from 2010 TO 2022. Source: OECD 2024.

Looking at the study cities specifically, most appear to be in areas with blue coloring, suggesting they reduced emissions between 2010 and 2022. Cities like Rotterdam, Munster, Belfast, and Granollers are in regions showing emission decreases. Milan and other Italian cities also appear to be in blue zones. Lisbon is located in a region showing emission reductions as well. Budapest, in Central Europe, appears to be in a zone with emission decreases, though possibly smaller decreases than Western European cities.

Istanbul stands out as the exception among the study cities. It is located in the red zone covering Turkey, meaning it likely experienced emission growth rather than reduction during this period. This matches the earlier observations about Istanbul having higher pollution concentrations compared to other study cities. The combination of emission growth and high current concentrations suggests Istanbul faces different challenges than the other cities in the study.

Figure 16 also shows that emission changes were not uniform across Europe. The strongest reductions, shown in dark blue, appear concentrated in certain areas like parts of Spain, Germany, and the United Kingdom. Other areas show more moderate reductions in light blue. This variation suggests that local policies, economic changes, and energy transitions happened at different speeds across Europe.

The circle sizes reveal that reducing emissions and having low per capita emissions are two different things. Some cities achieved large emission reductions but still have relatively high per capita emissions shown by larger circles. Other cities have smaller circles, showing lower per capita emissions, regardless of how much they reduced emissions during this period.

4.3 Resilience

Figure 17 shows average temperatures, and most cities show an increasing trend from 2023 to 2025. The Dfb climate zone, Zagreb and Budapest, shows temperatures rising from around 14-16°C in 2023 to about 16°C by 2025. The Cfb zone, Belfast, Munster and Rotterdam, shows similar upward movement, starting around 11-13°C and reaching 12-13°C by 2025. The Thessaloniki cfa zone shows temperatures around 16-17°C with a slight increase over time. The Cfa and Csa zone of Milan, Istanbul, Granollers, and Lisbon, shows the warmest average temperatures, 15-18°C, with most cities showing upward trends.

According to Figure 18, Maximum temperatures show more variation between years and cities. The Dfb zone shows maximum temperatures around 35-37°C. The cfb zone shows lower maximum temperatures (25-32°C) for Belfast and Rotterdam, with some year-to-year changes. Munster shows a notable drop between 2023 and 2024, falling from about 32°C to 25°C, before recovering slightly. Istanbul in the Cfa zone shows maximum temperatures with an upward trend (35-38°C) while Milan maximum temperatures tend to decrease over time. The Csa zone shows a declining over time, around 35-40°C. Thessaloniki in the bsk zone shows maximum temperatures with an increasing trend toward 2025 (36-39°C).

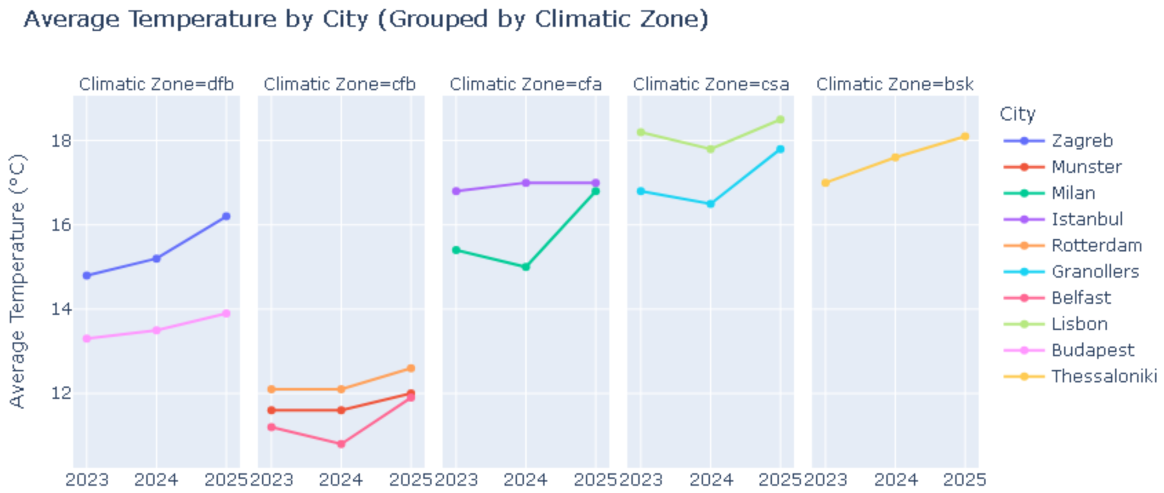

Figure 17 Average temperature evolution from 2023 to 2025 . Own elaboration. Source: Meteostat.

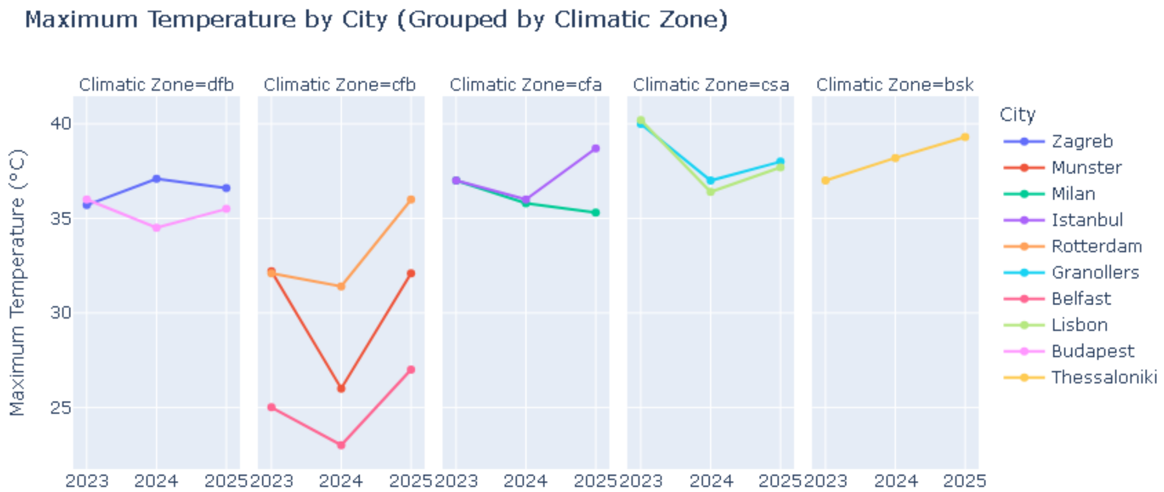

Figure 18 Maximum temperature evolution from 2023 to 2025 . Own elaboration. Source: Meteostat.

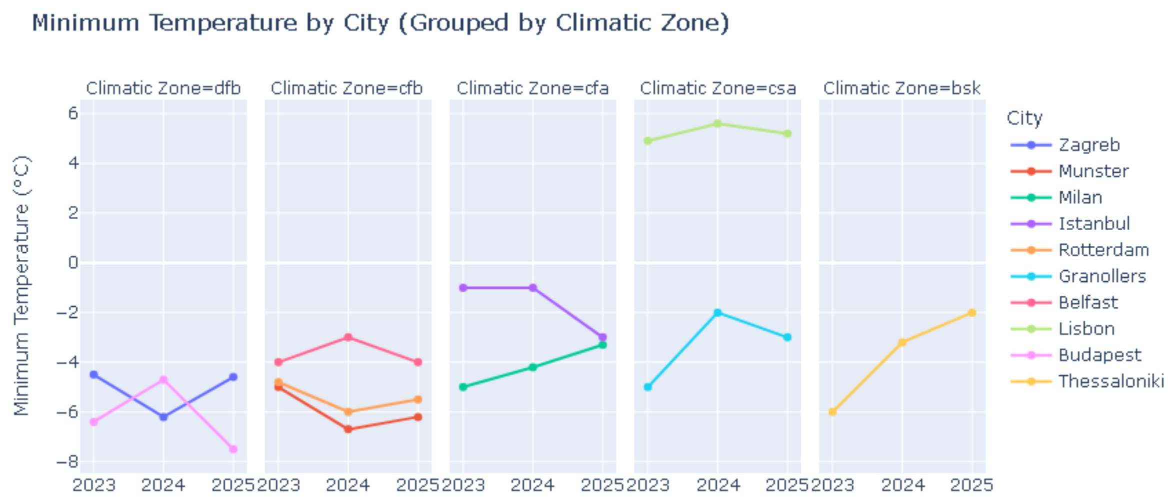

Figure 19 Minimum temperature evolution from 2023 to 2025 in the different cities split by climate zones. Own elaboration. Source: Meteostat.

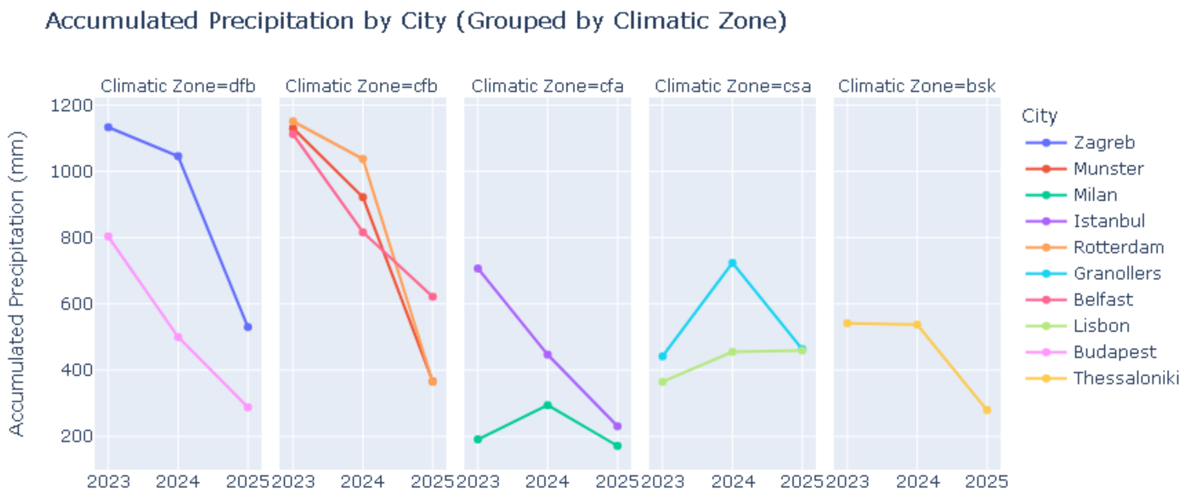

Figure 20 Accumulated precipitation evolution from 2023 to 2025 in the different cities split by climate zones. Own elaboration. Source: Meteostat.

As shown in Figure 19, minimum temperatures reveal important patterns about winter conditions and warming trends, though they show great variation as well. The Dfb zone shows minimum temperatures around -4 to -7°C. The cfb zone shows milder minimums around -4 to -6°C, typical of maritime climates. Belfast shows slightly warmer minimums than Rotterdam and Munster. Istanbul in the cfa zone shows minimum temperatures dropping from around -1°C to about -3°C over the period, while the minimum temperatures of Milan grow over time. The Csa zone shows the mildest winter conditions, with minimum temperatures ranging from about 4-6°C. Lisbon shows the warmest minimums in this group, staying above 4°C. Granollers shows minimum temperatures around -5.5 to -2°C, with a notable warming trend toward 2025, reaching about -1°C.

The warming of minimum temperatures is particularly important because it suggests milder winters across most cities. This pattern appears strongest in the csa zone cities. Milder winters can reduce heating needs and energy use, which may help explain some of the emission reductions seen in earlier data. However, warmer winters can also affect ecosystems and water resources.

Precipitation patterns vary greatly between climate zones and show year-to-year changes. This is shown in Figure 20. The Dfb zone shows high precipitation levels, with Zagreb starting around 1100mm in 2023 and dropping sharply to about 550mm by 2025. Budapest shows even more dramatic changes, starting around 800mm and dropping to about 300mm by 2025. These large decreases suggest these cities may be experiencing drier conditions over time, which could affect water resources. The Cfb zone also shows declining precipitation. These western coastal cities typically receive reliable rainfall, so these decreases are important and may indicate changing weather patterns.

Milan in the Cfa zone shows accumulated precipitation around 200-300mm, which is much lower than the northern European cities. This reflects the drier conditions typical of southeastern European climates. The values show some variation between years but no clear trend.

The Csa zone shows moderate precipitation levels. Lisbon and Granollers show accumulated precipitation around 400-700mm, with Granollers showing an increase from 2023 to 2024 before declining again. Mediterranean cities naturally have less precipitation than northern European cities, and the summer dry period is a defining feature of this climate. The specific data from Granollers highlights a key challenge for Mediterranean cities. The baseline report notes low average water use per person at 107 liters per day, yet it also acknowledges the severe 2024-2025 regional drought. This situation, where a region faces both water scarcity and flood risk, is visible in the external data. Figure 20 shows the variable and declining precipitation for Granollers' climate zone. This context makes the city's pilot project, which uses the RESCCUE tool to model flood control options like green roofs, particularly important. The resulting city guidelines must manage both too much water from floods and too little water from droughts.

Thessaloniki in the Bsk zone shows precipitation around 550-280mm, with a notable decline from 2024 to 2025. This semi-arid climate typically has lower and more variable precipitation, which makes water management particularly important.

It is important to note that this data comes from citizen science repositories such as MIT Overpass. This type of data may be corrected or updated from year to year, and the values may not always match real conditions on the ground. Different users can add or update information at different times, which can lead to changes in the reported values even when physical infrastructure stays the same. The data has been changed to show relative measures that account for changes in the KPIs. This means the values focus on comparing trends and patterns between cities and years rather than showing exact absolute measurements. While these relative measures are useful for understanding general patterns and progress over time, readers should keep in mind that the exact values may not be completely accurate and may change as the data source is updated. Despite these limits, the data provides valuable information about transportation infrastructure trends across the study cities.

4.4 Transportation infrastructure and connectivity

Starting with bikeway access, Figure 21 shows the population living within 300 meters of bikeways. Rotterdam leads by far, with about 0.88 of its population near bikeways in both years. This shows Rotterdam already had a strong bike infrastructure before the project. Milan comes second with about 0.52 in both years. Zagreb shows values around 0.36-0.39, with a slight increase from 2023 to 2024. Budapest, Lisbon, and Thessaloniki show lower values between 0.17-0.23. Istanbul shows the lowest value at around 0.03-0.04. Most cities show either stable values or small increases between the two years, suggesting that expanding bikeway networks is a slow process that requires time and investment.

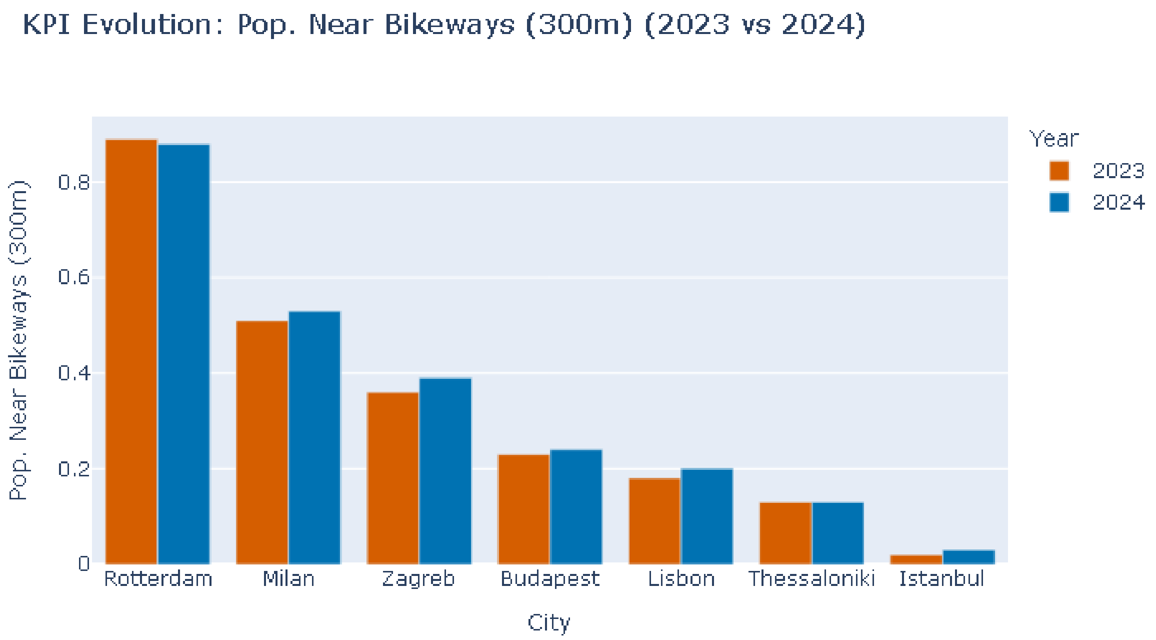

Figure 21 Population near bikeways evolution from 2023 to 2024 in available cities. Own elaboration. Source: Atlas ITDP.

Moving to combined access, Figure 22 shows the population near both bikeways and transit. Zagreb leads with values around 0.33-0.38, showing an increase from 2023 to 2024. This suggests Zagreb invested in improving connections between bike infrastructure and public transit during the project period. Milan follows with about 0.28-0.30, staying relatively stable. Budapest and Rotterdam show values around 0.23, with Rotterdam showing an increase from 0.22 to 0.23. Lisbon shows values around 0.17-0.16, with a slight decrease. Istanbul again shows the lowest values at around 0.01. The increases in Zagreb and Rotterdam suggest these cities focused on making it easier for people to combine biking with public transit, which is an important part of green transportation planning.

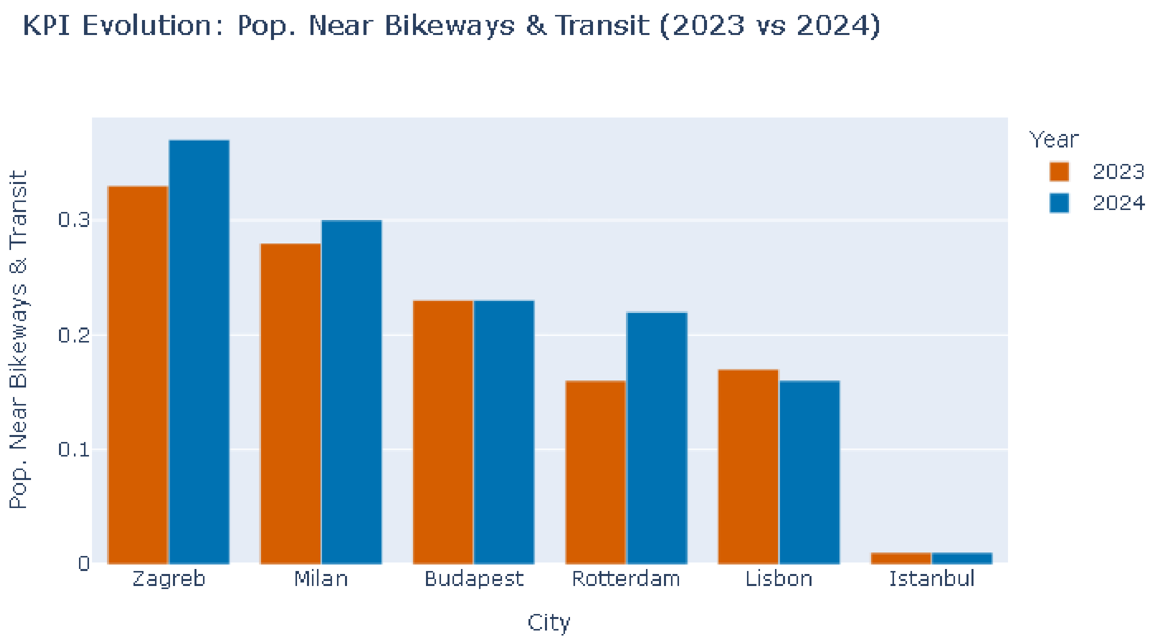

Figure 22 Population near bikeways and public transport evolution from 2023 to 2024 in available cities. Own elaboration. Source: Atlas ITDP.

Turning to public transit frequency, Figure 23 shows the population near frequent transit within 500 meters. Frequent transit means buses, trams, or trains that come often enough to be convenient for daily use. Budapest leads strongly with values around 0.84, showing no change between years. Zagreb follows with about 0.76-0.78, staying stable. Lisbon shows a important decrease from about 0.76 in 2023 to 0.43 in 2024. This large drop could mean transit service was reduced, routes were changed, or the measurement method changed. Milan shows values around 0.50, staying stable. Istanbul shows the lowest values at around 0.03-0.04. The stability in most cities suggests maintaining frequent transit service requires consistent investment, while Lisbon's decrease raises questions about service changes during this period.

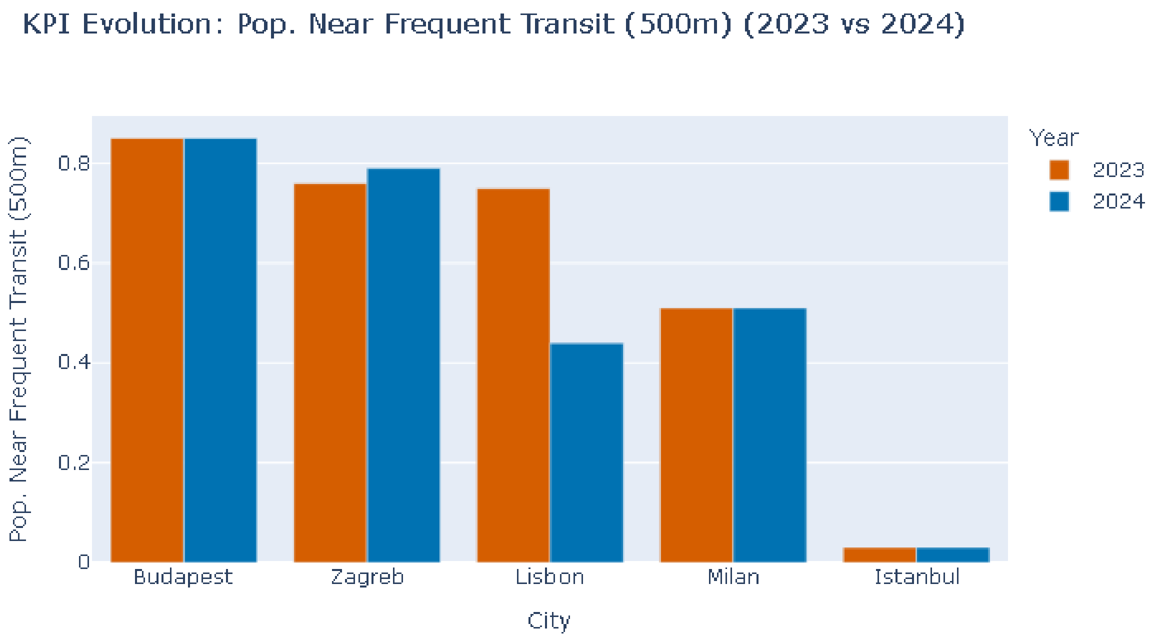

Figure 23 Population near frequent public transport evolution from 2023 to 2024 in available cities. Own elaboration. Source: Atlas ITDP.

Regarding access to essential services, Figure 24 shows the population near education and health facilities within 1 kilometer. Most cities show very high values between 0.75-0.88, which means most residents can reach schools and health centers within a reasonable walking distance. Thessaloniki and Budapest lead at around 0.87, followed by Lisbon, Istanbul, and Milan at around 0.81-0.83. Zagreb and Rotterdam show slightly lower values at around 0.76-0.80. All cities show very stable values between 2023 and 2024, with minimal changes. This stability is expected because schools and hospitals are permanent infrastructure that rarely moves. The high values across all cities suggest good basic accessibility to essential services.

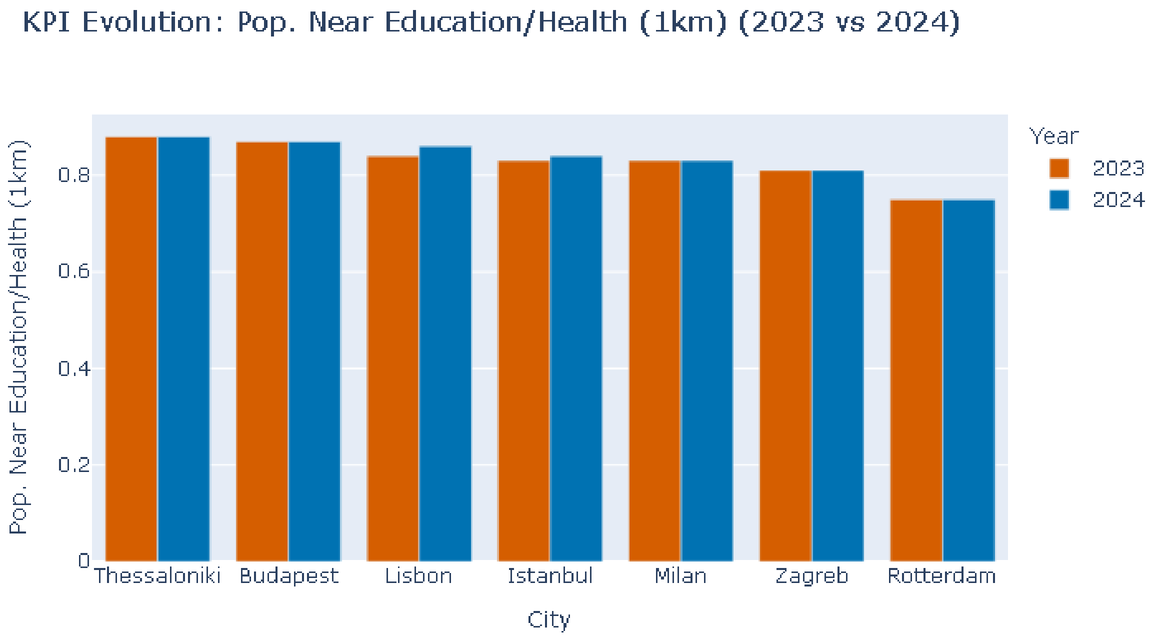

Figure 24 Population near education and health services from 2023 to 2024 in available cities. Own elaboration. Source: Atlas ITDP.

Finally, looking at rapid transit systems, Figure 25 shows the population near rapid transit within 1 kilometer. Rapid transit includes metro systems, light rail, and other fast public transport. Istanbul leads with values around 0.39-0.43, showing an increase from 2023 to 2024. This increase suggests Istanbul expanded its rapid transit network or coverage during the project period. Milan shows values around 0.32-0.34, staying stable. Budapest and Lisbon show similar values around 0.31-0.22, with Budapest steady and Lisbon showing a decrease. Rotterdam shows values around 0.21-0.22, staying steady. Thessaloniki shows a remarkable increase from 0 in 2023 to about 0.24 in 2024, probably because it just started getting data from users.

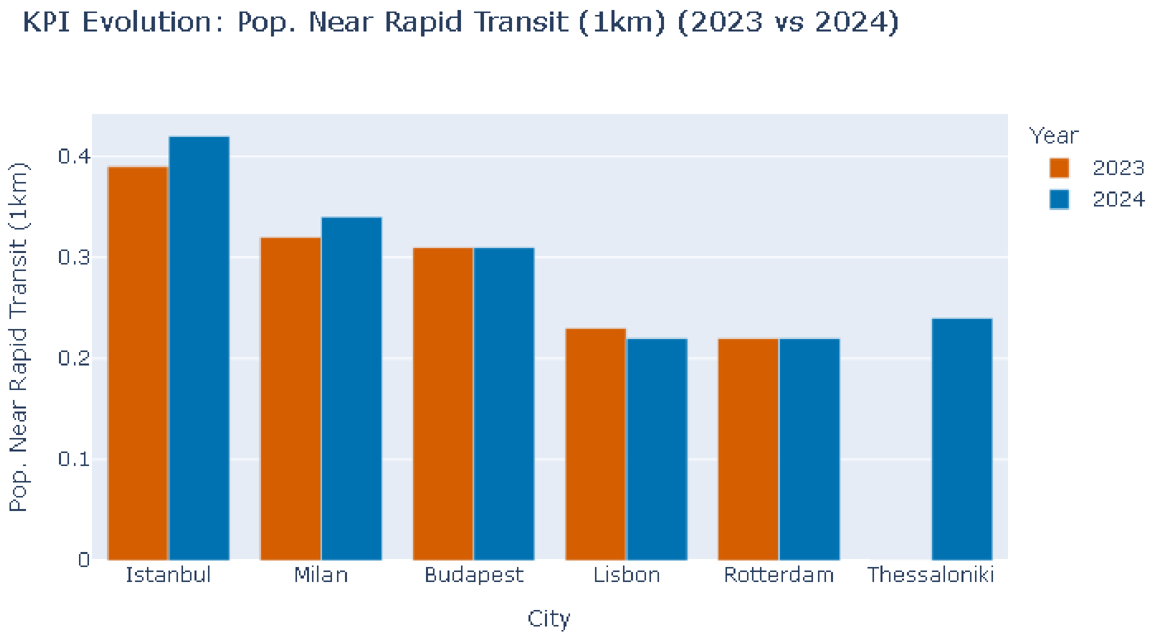

Figure 25 Population near fast public transport evolution from 2023 to 2024 in available cities. Own elaboration. Source: Atlas ITDP.

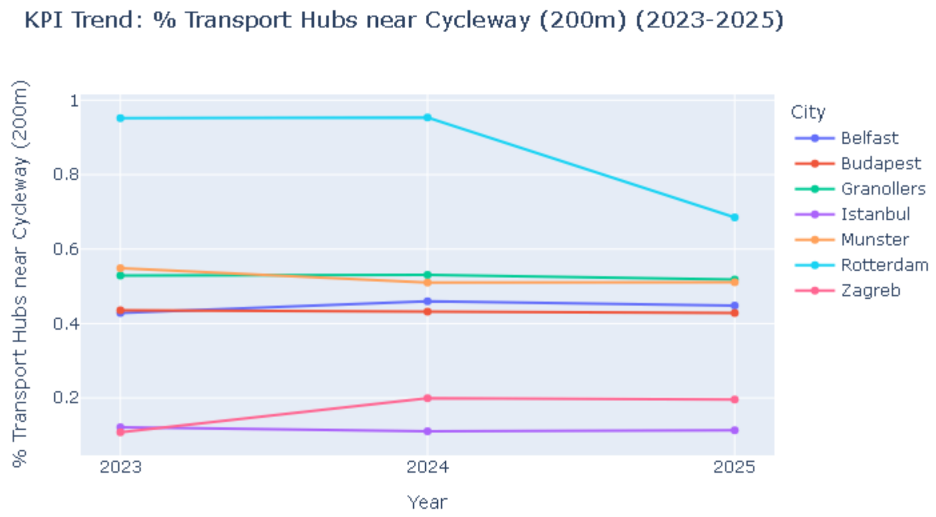

Figure 26 Percentage of transport hubs located within 200 meters of cycleways across study cities from 2023 to 2025. Values show what portion of transport hubs can be easily reached by bicycle. Own elaboration. Source: MIT Overpass.

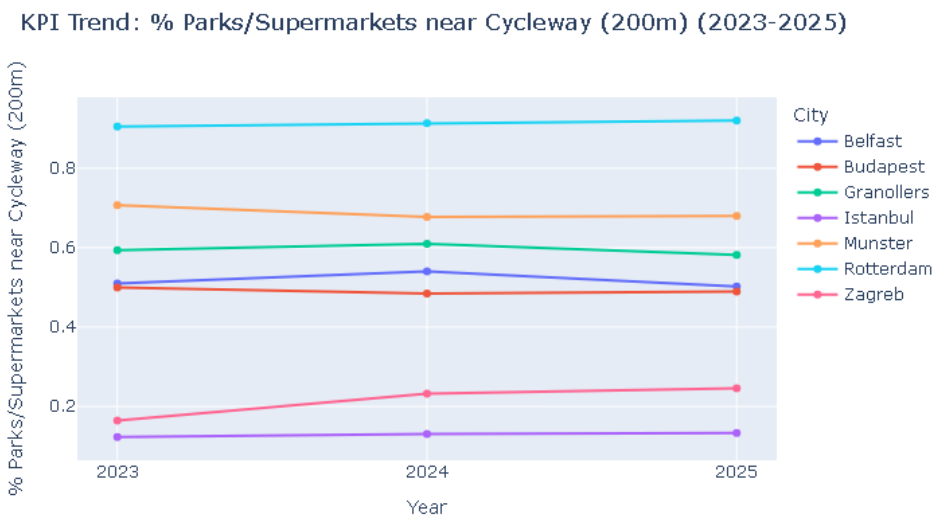

Figure 27 Percentage of parks and supermarkets located within 200 meters of cycleways from 2023 to 2025. This shows how well bike networks connect to daily destinations like grocery stores and green spaces. Own elaboration. Source: MIT Overpass.

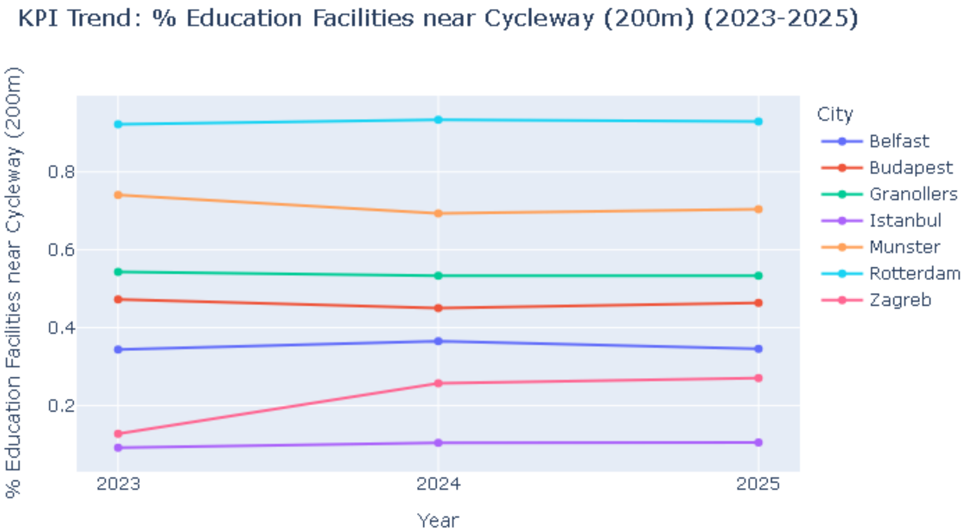

Figure 28 Percentage of education facilities located within 200 meters of cycleways from 2023 to 2025. This shows how well bike networks connect to schools and universities. Own elaboration. Source: MIT Overpass.

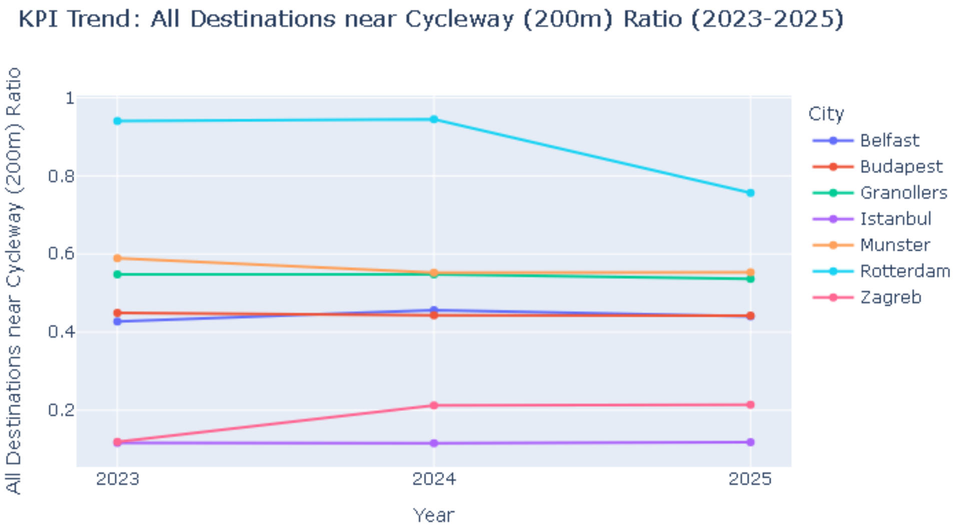

Figure 29 Ratio of all destination types located near cycleways within 200 meters from 2023 to 2025. This combined measure shows overall connectivity between bike infrastructure and various urban destinations. Own elaboration. Source: MIT Overpass.

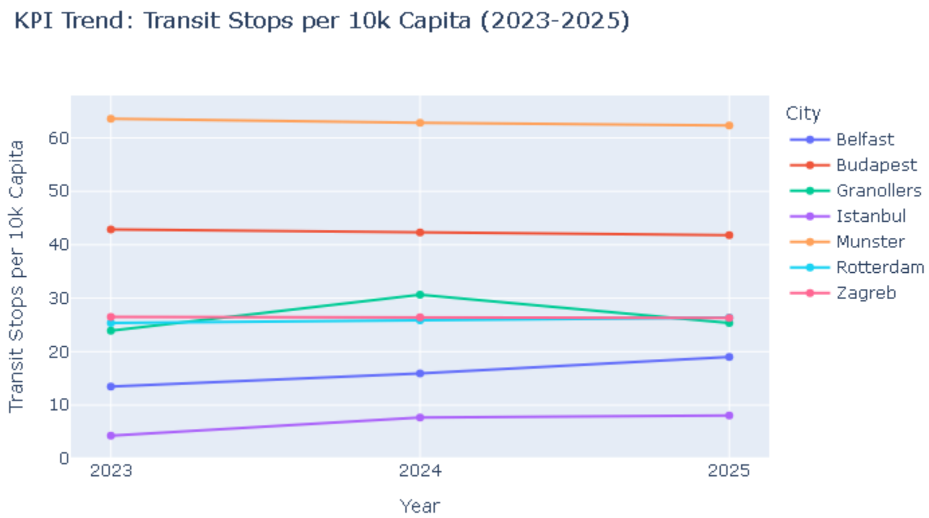

Figure 30 Number of transit stops per 10,000 inhabitants in each city from 2023 to 2025. Higher values indicate denser public transportation networks relative to population size. Own elaboration. Source: MIT Overpass.

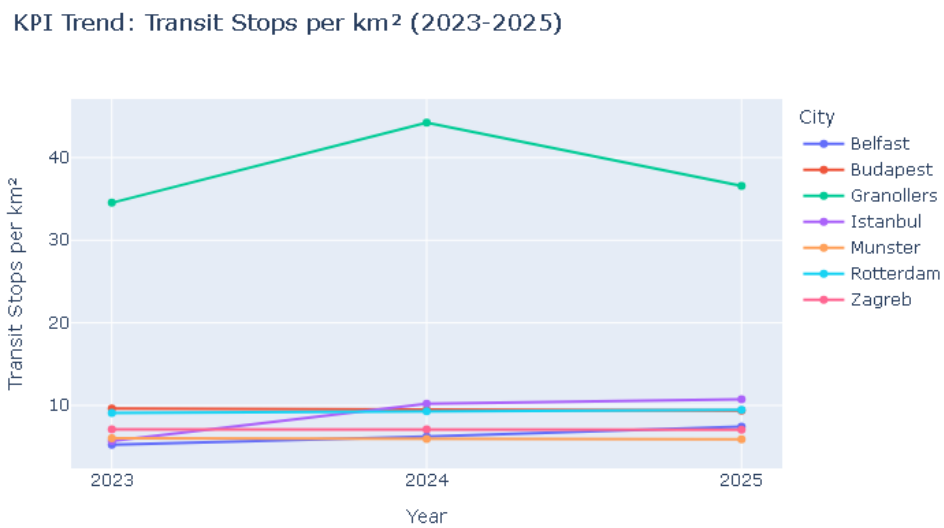

Figure 31 Number of transit stops per square kilometer from 2023 to 2025. This density measure shows how closely spaced public transportation stops are within each city's area. Own elaboration. Source: MIT Overpass.

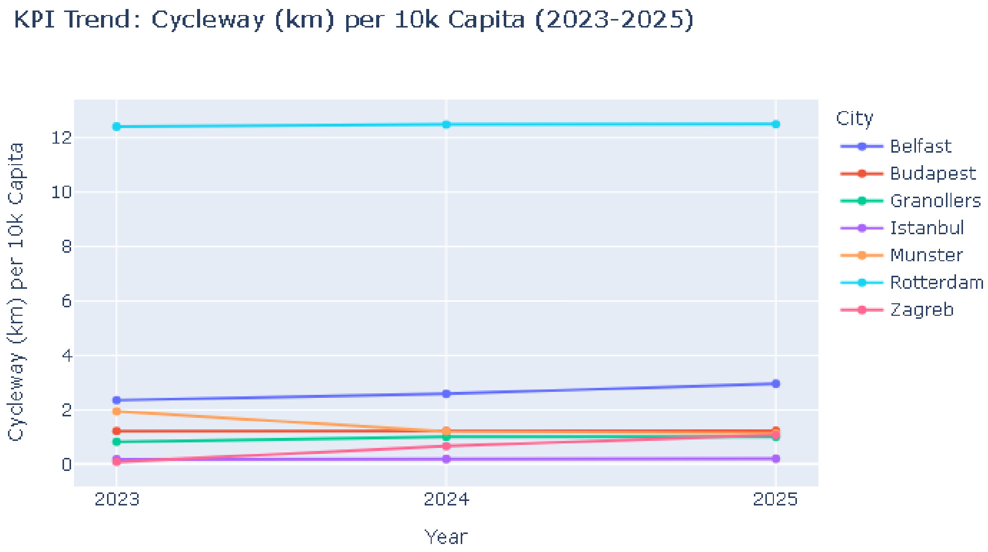

Figure 32 Length of cycleways in kilometers per 10,000 inhabitants from 2023 to 2025. This measure shows how much bike infrastructure exists relative to the city's population. Own elaboration. Source: MIT Overpass.

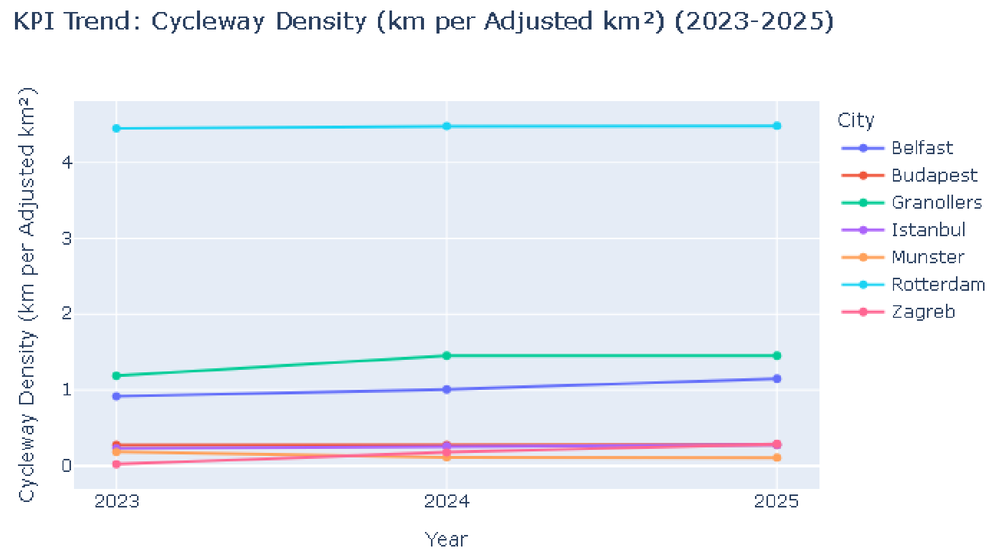

Figure 33 Cycleway density measured as kilometers of bike paths per adjusted square kilometer of city area from 2023 to 2025. This shows the concentration of bike infrastructure in urban space. Own elaboration. Source: MIT Overpass.

Rotterdam stands out as very different from all other cities. This Dutch city shows the highest numbers in almost every measure as displayed in Figure 26, Figure 27, Figure 28 and Figure 29. Rotterdam keeps about 90 % of its parks, shops, and schools within 200 meters of bike paths. The city also has about 12 kilometers of bike paths for every 10,000 people. This is much more than any other city in the study. However, Rotterdam shows one big drop. The share of transport hubs near bike paths fell from 95% in 2023 to about 67% in 2025. This is the largest single change in the whole data set.

Munster shows strong performance too, but at a lower level than Rotterdam. The German city keeps stable access to services, with about 70% of parks and shops near bike paths, as shown in Figure 27. Munster leads all cities in transit stops per person, with around 63 stops for every 10,000 people, though the spatial density is the lowest among all the cities. This number stays steady across all three years and it is clear in Figure 30 and Figure 31.

A middle group appears in most charts. This group includes Granollers, Istanbul, Belfast, and Budapest. These cities show similar patterns, with about 50 to 60 % of their services within 200 meters of bike paths. Most of their numbers stay steady over time. For instance, this contrasts with Granollers reporting the construction of 17 km of bike lanes and 2.2 km of new green corridors, though this could be due to the citizen science initiative the data comes from. However, Granollers shows some growth in transit stop density, reaching a peak of 43 stops per square kilometer in 2024 before dropping to 37 in 2025 as shown in Figure 30 and Figure 31.

Zagreb forms its own group at the bottom of most measures. The Croatian city starts with only 12 to 17 % of services near bike paths in 2023. By 2025, these numbers grow to 20 to 28 percent. While this shows progress, Zagreb still trails far behind other cities. The city also has very few transit stops, with only about 8 stops per 10,000 people by 2025.

Belfast sits at the lower end alongside Zagreb in some measures. Its numbers stay mostly stable across the three years, showing little change in any direction.

The most stable data appears in several areas. As seen in Figure 32 and Figure 33, bike path length per person changes very little in most cities. Only Istanbul shows a small increase from 2 kilometers to 2.7 kilometers per 10,000 people. Bike path density also stays steady, with Rotterdam keeping its lead at 4.5 kilometers per adjusted square kilometer while other cities remain below 1.5. Access to education and parks shows steady patterns too, with most cities keeping the same percentages year after year.

Transit stop counts show more change than bike path measures. Granollers experiences the biggest shift, with stops per square kilometer first going up and then coming back down. Istanbul shows steady growth in stops per person, moving from 13 to 19 over three years, as shown in Figure 32.

Three clear groups form across these measures. Rotterdam makes up a high-performing group by itself. A middle group with four cities shows similar patterns and stable service access. A low-performing group includes Zagreb and Belfast, though Zagreb shows more improvement over time than Belfast does.

The data shows that most numbers stay steady rather than changing. Cities rarely see big jumps or drops in their scores. The exception is Rotterdam's fall in transport hub access and Granollers' changing transit density. This stability suggests that bike path systems and service access patterns are not suffering any substantial change, even over a three-year period.

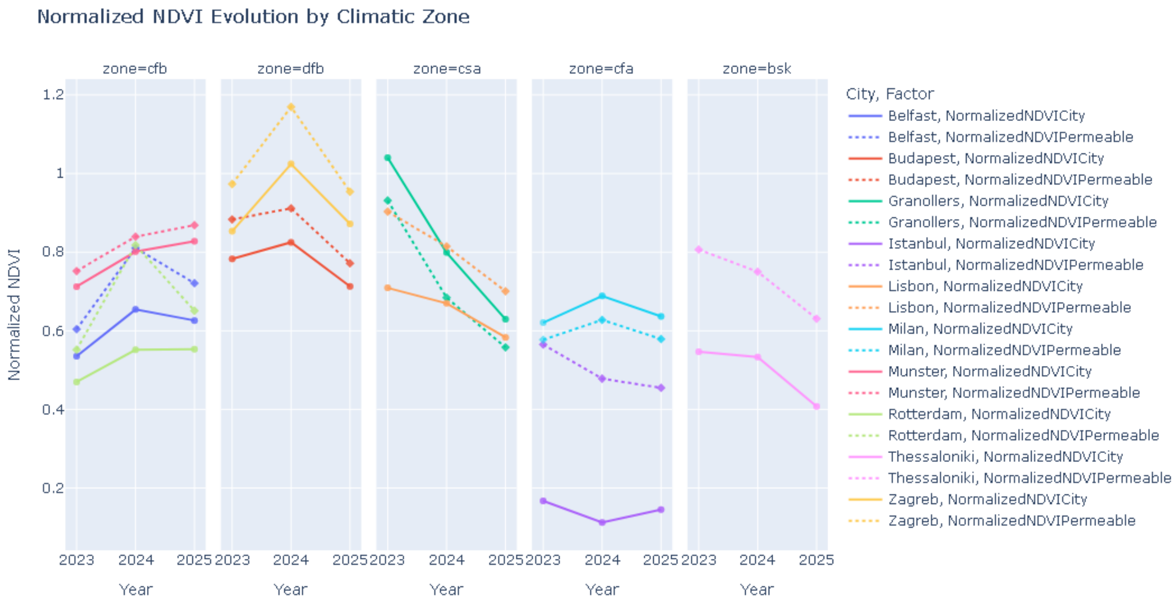

Figure 34 Changes in normalised plant cover index and permeable surfaces from 2023 to 2025, organised by climate zone. It was adjusted to be comparable between cities disregard of their climate zone. Own elaboration. Source: Copernicus.

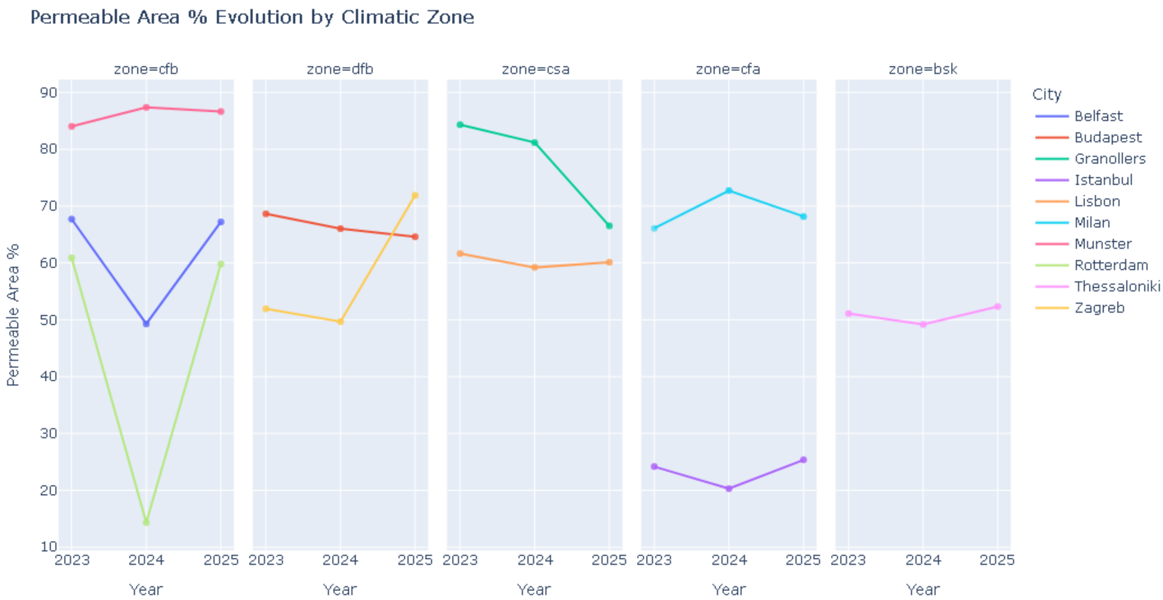

Figure 35 Changes in permeable area percentage across ten European cities from 2023 to 2025, organised by climate zone. Reference satellite images taken on summer days. Own elaboration. Source: Copernicus.

The data on plant cover and permeable surfaces reveals clear patterns when looking at ten European cities from 2023 to 2025. Some cities show major changes during this time, while others remain very stable. This pattern is clear in Figure 34.

Rotterdam experiences the most dramatic shift in the entire data set. The city's permeable area drops from about 65% in 2023 to roughly 15% in 2024, as shown in Figure 35. This represents a fall of 50 percentage points in just one year. However, the city recovers by 2025, climbing back to about 60 percent. This sharp V-shaped pattern appears in the cfb zone data. No other city shows anywhere near this level of change. The drop and recovery may point to major building work, changes in how the city measures these areas, or issues with data collection during 2024.

Granollers shows the second biggest change, though much smaller than Rotterdam. The Spanish city's permeable area falls from about 85% in 2023 to around 67% by 2025. This decline of roughly 18 percentage points happens steadily across the three years. The drop suggests ongoing development or changes in land use that reduce the amount of ground that can absorb water.

Belfast also displays important movement in permeable surfaces. The city starts at about 68% in 2023, drops to around 50% in 2024, then rises back to 67% in 2025. This pattern resembles Rotterdam's changes but with a smaller range. The variation may reflect seasonal differences in measurement dates or actual changes in surface conditions.

For plant cover, most cities show remarkable stability. Values change very little from year to year. Munster stays around 0.81 to 0.84 across all three years. Budapest holds steady between 0.77 and 0.88. Milan maintains values between 0.59 and 0.64. This stability suggests that the amount of green vegetation near bike paths does not shift quickly, even over several years.

Zagreb stands out for having the highest plant cover values of any city, ranging from 0.87 to 1.05 depending on the year and climate zone. The city clearly leads all others in vegetation coverage. However, Zagreb's plant cover shows more variation than most cities. The values peak in 2024 at around 1.05 in some zones before dropping to about 0.87 by 2025. This change of about 0.18 represents the biggest shift in plant cover among all cities.

Istanbul shows the opposite pattern, with the lowest plant cover values ranging from 0.10 to 0.60. The city's plant cover also varies more than most others. Istanbul's values climb slowly from 2023 to 2024 but then fall back in 2025. The variation may result from the city's hot, dry climate making vegetation growth less predictable year to year.

Lisbon demonstrates interesting behavior with its plant cover. The city shows a steady increase from about 0.64 in 2023 to around 0.73 in 2024 in some climate zones. This upward trend suggests successful efforts to add or maintain green spaces over time.

The most stable data appears in several cities. Munster keeps both its plant cover and permeable area very consistent. The city's plant cover stays within a narrow band of 0.81 to 0.84, while permeable surfaces remain between 84 and 88 percent. Budapest also shows stable plant cover between 0.77 and 0.88. Milan's plant cover barely moves from its median of 0.63. Rotterdam's plant cover holds steady around 0.55 to 0.57, even while its permeable area changes dramatically. Thessaloniki maintains consistent values with plant cover around 0.53 to 0.75 and permeable surfaces near 50% to 52%.

4.5 Social Inclusion

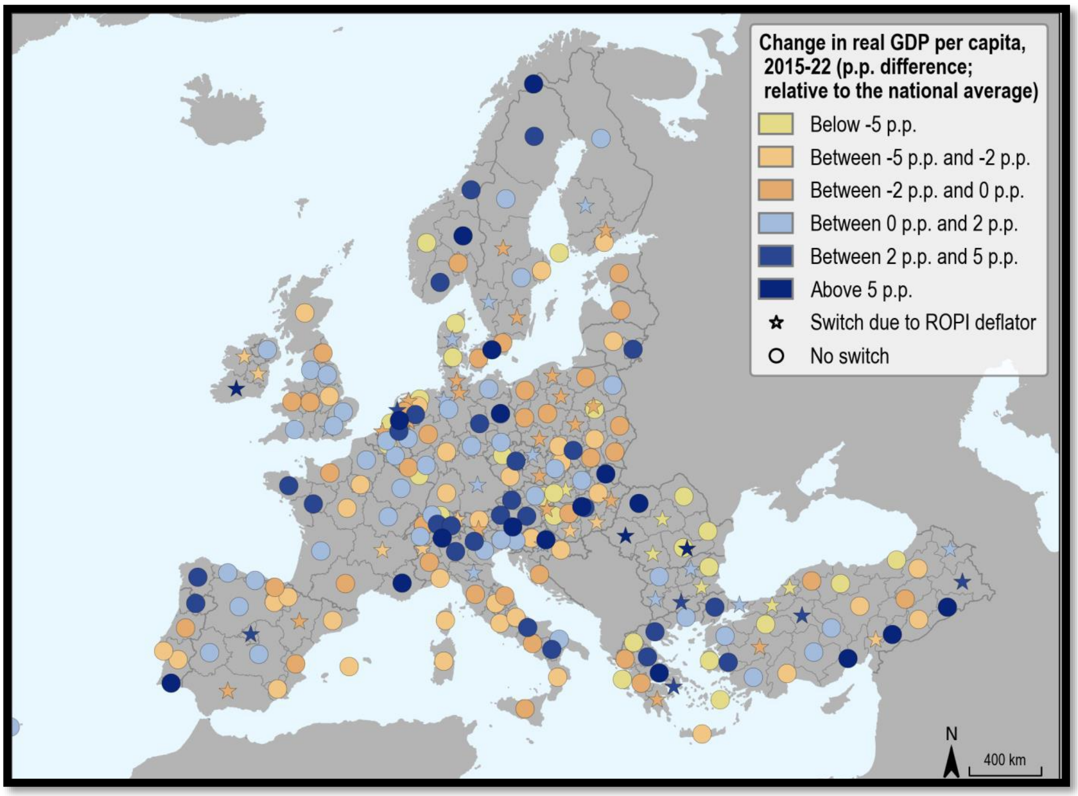

Figure 36 Change in real GDP per capita relative to the national average across large regions, 2015-22 – Europe. Source: OECD 2024.

The map of Figure 36 shows how real economic output per person changed in cities across Europe from 2015 to 2022. The data compares each city's growth to its country's average, measured in percentage point differences.

Three cities stand out for showing the strongest growth compared to their national averages. Budapest, Thessaloniki, and Istanbul all appear in dark blue on the map, indicating growth above 5 percentage points higher than their country's average. These cities clearly outperformed their nations during this time. Budapest's strong performance suggests the Hungarian capital pulled ahead of other regions in Hungary. Thessaloniki grew faster than the Greek average, while Istanbul exceeded Turkey's overall growth rate by a significant margin. This group represents cities that attracted more economic activity or recovered faster from earlier downturns compared to their countries as a whole.

Milan shows moderate positive growth, appearing in light blue on the map. This indicates the Italian city grew between 0 and 2 percentage points faster than Italy's national average. Milan performed better than its country but not by a large amount. The city maintained steady economic conditions without major jumps.

Rotterdam also displays light blue coloring, suggesting similar moderate growth between 0 and 2 percentage points above the Netherlands' average. The Dutch city kept pace with or slightly exceeded national trends during this period.

A group of cities performed below their national averages. Belfast, Lisbon, Granollers, Zagreb, and Munster all show orange or light orange colors on the map. These shades indicate growth between 2 and 5 percentage points below their country's average, or in some cases between 0 and 2 percentage points below. Belfast grew more slowly than the United Kingdom average. Lisbon lagged behind Portugal's overall growth. Granollers, located near Barcelona in Spain, also fell short of the Spanish average. Zagreb trailed Croatia's national performance. Munster grew less than Germany's average during this period.

The cities that grew below their national averages share some common features. Many serve as secondary cities rather than national capitals. While they remain important regional centers, they may have missed out on growth that concentrated in other parts of their countries. Some of these cities may have older industrial bases that struggled during this period, or they may have faced local challenges that slowed their economies.

The pattern reveals a clear split between cities. Some pulled ahead of their countries with strong growth, while others fell behind the national average. Very few cities matched their country's average exactly. This suggests that economic growth concentrated unevenly within countries during 2015 to 2022.

4.6 Lessons

The KPI results provided by the pilot cities show a link to the trends observed in the external data analysis, which looks at climate, pollution, and urban mobility. Many cities reported increases in resident involvement and organisational participation, which reflects their active work in implementing new methods and tools. For example, the strong increases in participation KPIs in Budapest align with external data that shows it is a city experiencing significant economic growth compared to its national average. Similarly, the stability in transportation indicators for cities like Rotterdam, which already has a high density of bike paths, corresponds to its consistent self-reported metrics, such as the high initial resident involvement scores. The external analysis, such as the temperature evolution trends and pollution patterns, helps put these local efforts into a wider context.

A key finding from the external data is the high variability in climate and environmental challenges across the cities. Cities in warmer climate zones, such as Granollers and Thessaloniki, face steep declines in precipitation and higher pollution levels for Thessaloniki, which makes managing water resources and air quality challenging. Granollers' high-level baseline water usage, combined with its drought risk, directly justify the focus of its prototype on flood control options like green roofs. Conversely, cities in cooler zones, like Belfast and Munster, show less dramatic changes in environmental data, and their focus appears more on improving governance and community buy-in. For example, the low emissions per capita for Belfast and Rotterdam suggests their efforts can shift from reducing emissions to increasing access to services and public transit.

The different rates of change in the external data also point to varying levels of urban development pressure and institutional capacity. Istanbul, which is the only city showing emission growth from 2010 to 2022, also shows some of the lowest scores in public transport access, suggesting to make significant environmental improvements will require large-scale infrastructure investment and regulatory change. In contrast, cities with moderate economic growth, such as Milan, show stable or improving transportation metrics, indicating their projects are able to consolidating existing systems. This synthesis shows that the internal project progress is much affected by the baseline external realities of each city, from their climate to their transport network density.

Zagreb presents an uncommon situation. The city provided no direct data, suggesting commitment without specific operational measures. The following section examines what type of commitment the available information indicates and explores whether the gaps in measurement can be addressed through external sources and questionnaire responses. Zagreb reported that baseline metrics were unavailable or zero. Even so, the city has shown sustained engagement with the global climate agenda over many years, indicating robust institutional capacity and support of sustainability objectives. ICLEI membership began in 2000, while participation in the EU Covenant of Mayors and Global Covenant of Mayors started in 2008. This history across multiple international climate initiatives reflects strong open data commitment and willingness to align local strategies with worldwide objectives, despite challenges in tracking progress locally.

Between 2023 and 2024, Zagreb improved sustainable transport accessibility, with growing numbers of residents living near combined cycleway and public transport networks. Roughly 76% to 78% of the population now lives close to frequent transit services. This is significant given that transport produces 27% of the city's GHG emissions. In terms of physical resilience, Zagreb achieves a plant cover index NDVI of 0.96, surpassing all other cities in this study. Permeable surfaces cover approximately 52% of the urban area, a moderate value. The broader context shows that public concern about climate change in Croatia fell by 9% between 2023 and 2025, potentially weakening support for climate policies in the years ahead. With Croatia's poverty rate exceeding 12%, Zagreb's prototype approach could link climate action with poverty reduction if implemented successfully. Effective improvements in food security and cost reductions through local food systems and circular economy principles could address environmental and economic challenges together.

5 Discussion

This section brings together two different ways of measuring how cities perform on environmental and planning goals. The first approach uses open-source data that anyone can access. This includes information from satellite images that measure plant cover and permeable surfaces, mapping data that shows where bike paths connect to services, and geographic information about flooding patterns. Researchers can gather this data independently without needing cities to provide it. The measurements come from the same sources for all cities, making direct comparisons possible.

Table 32 Cities Validation of Voluntary Reporting Results. Own elaboration.

Group	City	Baseline	1st Progress Monitoring
1	Budapest	x	x
1	Munster	x	x
1	Thessaloniki	x	x
1	Belfast	x	N/A
1	Rotterdam	x	N/A
2	Milan	x	x
2	Lisbon	x	x
2	Granollers	x	N/A
2	Istanbul	x	N/A
2	Zagreb	x	N/A

The cities were divided into two main groups based on their prototype typology. Group 1 includes Budapest, Munster, Thessaloniki, Belfast, and Rotterdam. These five cities provided both starting data and first progress updates. This pattern suggests a stronger commitment to tracking changes over time and sharing results publicly. Cities in this group demonstrated follow-through by returning to update their initial reports with new information. Group 2 contains Milan, Lisbon, Granollers, Istanbul, and Zagreb. These cities provided starting data but did not submit progress updates during the study period. However, the lack of progress monitoring data alone does not tell the full story about data availability. Looking at program participation reveals important differences within this group because many prototypes have just finished being implemented and the reporting period reading would be in many cases the same as the baseline.

Table 33 Open Data Availability. Source: Open Data Portals, ICLEI, Atlas ITDP, EU Covenant of Mayors and Global Covenant of Mayors, MIT Overpass.

City	Up to date City's Open Data Portal	ICLEI (member since)	Atlas ITDP	EU Convenant of Mayors (member since)	Global Convenant of Mayors	MIT Overpass
Rotterdam	x	1992	x	2009	x	x
Granollers	x	N/A	N/A	2008	x	x
Budapest	*x	2019	x	2008	x	x
Thessaloniki	*x	2023	x	2011	x	N/A

City	Up to date City's Open Data Portal	ICLEI (member since)	Atlas ITDP	EU Convenant of Mayors (member since)	Global Convenant of Mayors	MIT Overpass
Zagreb	x	2000	x	2008	x	x
Munster	x	1995	N/A	2008	x	x
Milan	x	N/A	x	2008	x	N/A
Istanbul	x	2024	x	N/A	x	x
Lisbon	x	2015	x	2008	x	N/A
Belfast	x	2021	N/A	N/A	N/A	x

* The latest data is 5 years or older or there were accessibility issues.

The relationship between actual conditions and reporting data availability matters for several reasons. Cities that both perform well and report openly demonstrate the strongest overall commitment to environmental goals. They combine real progress with accountability. Cities that perform well but report little may be doing good work without seeking recognition or may lack resources for international engagement. Table 32 presents the data availability for each city participating in the project. This assessment serves two main purposes for future project phases. First, it helps identify which measures can be prioritised during the Uptaking phases based on the existing data infrastructure in each location. Second, the Table 33 shows which broad scale KPIs are accessible for the Upscaling phase from an external KPI perspective.

Data availability and quality are a central factor for the success of the UP2030 project, which works on helping cities reach climate neutrality by 2030. The project addresses the challenge that cities often lack coordinated and timely data to make complete assessments and inform investment decisions. A key strategy is addressing the data gaps that some European cities experience, which limits their capacity of applying tools and making informed decisions. The UP-Skilling phase focuses on the strategic integration of technical solutions and data, helping cities improve data governance and establish organisational information flow maps for carbon. This is fundamental for getting a system-level understanding of carbon consumption and reduction opportunities. UP2030 commits to Open Science practices and open data (FAIR principles), making data and validated tools openly available through the UP2030 Services Platform so that results become standard practice in urban planning and support other EU Mission cities.

Regarding climatic issues, in Lisbon rainfall and water use data show volatile water pressure. The city recorded 8 major flood incidents related to heavy rainfall between 2020 and 2022, followed by 4 additional incidents reported in the later period. This external frequency of extreme events justifies the internal investment in specialised adaptation tools. Consistent with this constant threat, the Lisbon project uses the RAF ICARIA, a tool to verify urban water systems and model water flow in order to reduce overflow during intense rainfall. In addition, the strong internal social commitment, reflected in the maximum score of 5 for user participation (Table 25), shows an internal effort to ensure public acceptance of water management solutions, which are vital in the face of these recurring external climate risks.

Another consistency pattern is found in Granollers, where the need to manage rainfall impacts is quantified externally. The city reported that the volume of stormwater runoff was estimated at approximately 0.52 m3 per m2 per year. This hard and precise data on water management is the main justification for the internal development of its guideline prototype, which uses the RESCCUE tool to model different flood control plans and evaluate six resilience options.

Table 34 City Performance Scores for Tools, Public Reach, and Data Sharing. Own elaboration.

City	Rotterdam	Belfast	Budapest	Budapest	Munster	Munster	Thessaloniki	Thessaloniki
Timestep (B Baseline Period, R Reporting Period)	B	B	B	R	B	R	B	R
Q9 Does current urban plan contain all 5 sustainability principles?	3	5	4	4	3	3	5	3
Q11 Number of tools implemented	2	3	0	2	0	0	3	4
Q13 Total reach of dissemination through channels (People)	N/A	0	0	40	40	60	12	700
Q15 Total reach of dissemination through channels (Likes)	N/A	0	0	139	N/A	N/A	0	180
Q17 Total reach of dissemination through channels (Comments)	N/A	0	0	7	N/A	N/A	0	5
Q19 Total number of open data sets	N/A	0	0	0	0	0	0	0

Table 35 City Performance Scores for Community Involvement and Local. Own elaboration.

City	Rotterdam	Belfast	Budapest	Budapest	Munster	Munster	Thessaloniki	Thessaloniki
Timestep (B Baseline Period, R Reporting Period)	B	B	B	R	B	R	B	R
Q3 To What extent have residents been involved in the project planning?	4	4	1	4	1	1	5	5
Q5 To what extent have residents/users been involved in the project implementation?	4	1	1	4	1	4	5	4
Q7 To what extent is the local authority involved in developing the project beyond just providing money, and how many departments are helping?	3	2	2	5	2	4	4	5
Q21 To what extent the local authority provides financial support to climate adaptation projects?	4	2	1	1	3	3	1	2
Q23 To what extent is the progress toward project goals and compliance with requirements being monitored and reported?	1	5	3	5	1	1	3	4
Q25 Has the project inspired changes in rules and regulations?	0	0	0	1	0	0	1	1

City	Rotterdam	Belfast	Budapest	Budapest	Munster	Munster	Thessaloniki	Thessaloniki
Q27 To what extent the project has contributed to, or inspired, changes in societal norms?	3	1	1	3	1	1	1	4
Q29 Total area of land transformed or influenced by the project in squared meters ($10^6 m^2$)	1	N/A	N/A	N/A	N/A	N/A	0.57	0.57

Finally, the external climate challenge, which covers heat and flooding problems in addition to carbon reduction, is the driving force behind the internal organisation in Münster. To confront this external climate threat that directly affects quality of life, the city developed the URCAM and the Climate Proofing Method. The effort to implement these internal adaptation and mitigation tools forced a pattern of significant improvement in interdepartmental cooperation, reflected in the increase of Local Authority Participation from 2 to 4 points from Table 17. This illustrates a pattern where external climate risk pressure forces internal governance to become more coordinated, the lack of progress in regulatory planning is probably due to the early stage of the project implementation.

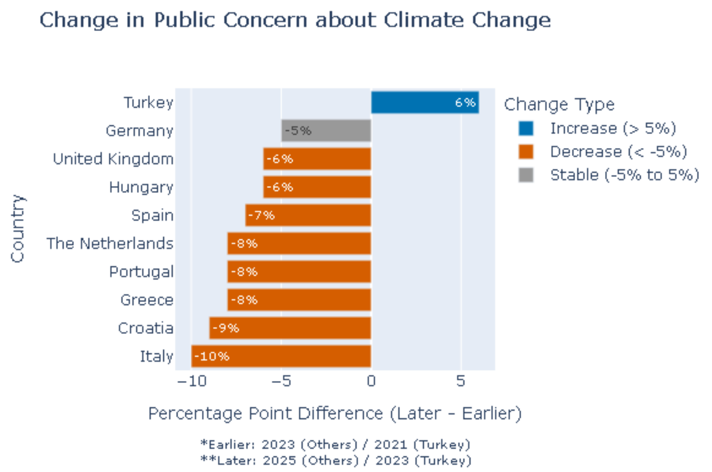

Figure 37 Change in Public Concern about Climate Change by Country. Own elaboration. Source: DESNZ, Doğru et al. 2024, UNFCCC 2023 and European Commission 2023, 2025.

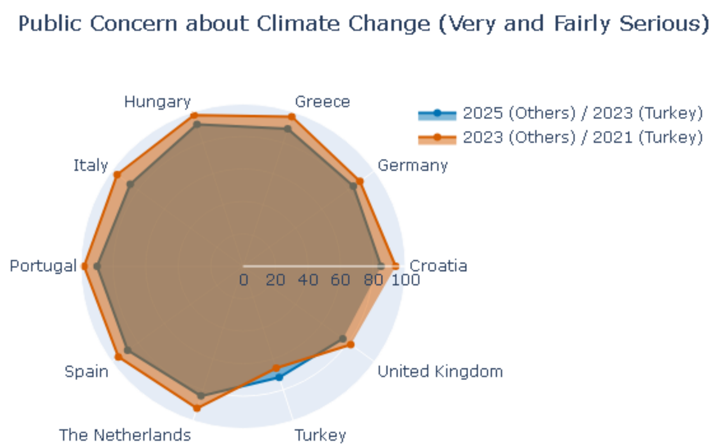

Figure 38 Public Concern about Climate Change Across Countries (Very and Fairly Serious). Own elaboration. Source: DESNZ, Doğru et al. 2024, UNFCCC 2023 and European Commission 2023, 2025.

The data from different European cities shows an interesting gap between local project progress and national public opinion about climate change. While city-level projects report better results in community involvement and tool use, most countries have seen a drop in how worried people are about climate change between 2023 and 2025. This trend is visible in Figure 37 and Figure 38.

In Budapest, the data, as shown in Table 35, reveals the project results show clear progress. People got more involved in both planning and actual work. The city went from almost no citizen participation to strong involvement, with scores rising from 1 to 4. More city departments started working together, going from 2 to 5 departments. The number of tools being used increased from zero to two. However, in Hungary as a whole, public worry about climate change went down by 6% during this same time. This means that even though local projects were doing better and getting people involved, the general public became less concerned about the climate issue.

Munster in Germany shows a similar pattern. The city saw big improvements in how people felt about being part of the project work, jumping from a score of 1 to 4. More departments got involved, rising from 2 to 4. But across Germany, concern about climate change dropped by 5%. The city made progress with its climate-friendly neighborhood plan, but this did not match what was happening at the national level.

As shown in Table 34, Thessaloniki in Greece recorded strong gains in several areas. The city's reach to people through information sharing grew from 12 people to 700 people. Comments went from 0 to 5, and likes increased to 180. The number of tools being used grew from 3 to 4. People felt the project had more impact on how society thinks about these issues, with scores going from 1 to 4. Still, Greece saw an 8% drop in public concern about climate change. The local project's success did not stop the national trend of decreasing worry.

Belfast in Northern Ireland showed strong commitment to getting the public involved from the start. The city scored 4 for resident involvement in planning. Three tools were already in place. The city's framework addressed active travel, greening, and building upgrades. Yet the United Kingdom as a whole experienced a 6% decrease in climate concern.

Turkey stands apart from this pattern. The country shows a 6% increase in concern about climate change. This different direction happens because Turkey's data covers an earlier period. For Turkey, the comparison runs from 2021 to 2023. For the other countries, the data runs from 2023 to 2025. This means Turkey's increase happened before 2023, while other countries measured their change after 2023. After 2023, a shift occurred. Other issues likely became more pressing for people in these European countries, which pushed climate change lower on their list of worries.

The radar chart shows that most European countries maintain fairly high levels of concern when people are asked if climate change is very or fairly serious. The brown area representing 2025 data covers most countries at levels between 60 and 100 on the scale. But the direction of change tells a different story. Almost all countries moved toward less concern between the two periods shown.

The tangible progress in local climate projects while seeing a decrease of general public concern at national level identifies a key systemic barrier that UP2030 works to overcome: the disconnect between localised technical action and broad socio-political transformation. The main goal of UP2030 is to support cities in pushing forward the socio-technical transitions needed to reach climate neutrality by 2030. The project recognises that the neutrality challenge cannot be solved with only a technological solution but requires to renovate urban planning practices and design, together with social innovation. To achieve city-wide impact, cities must go beyond of technical designs and overcome social barriers, such as the lack of society involvement and resistance to changing habits.

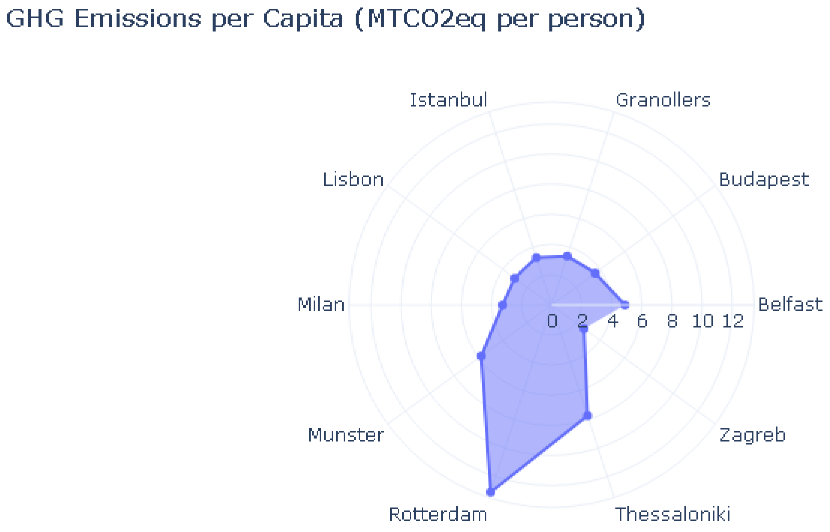

Figure 39 GHG Emissions per km² in each city (MTCO2eq). Own elaboration. Source: Global Covenant of Mayors.

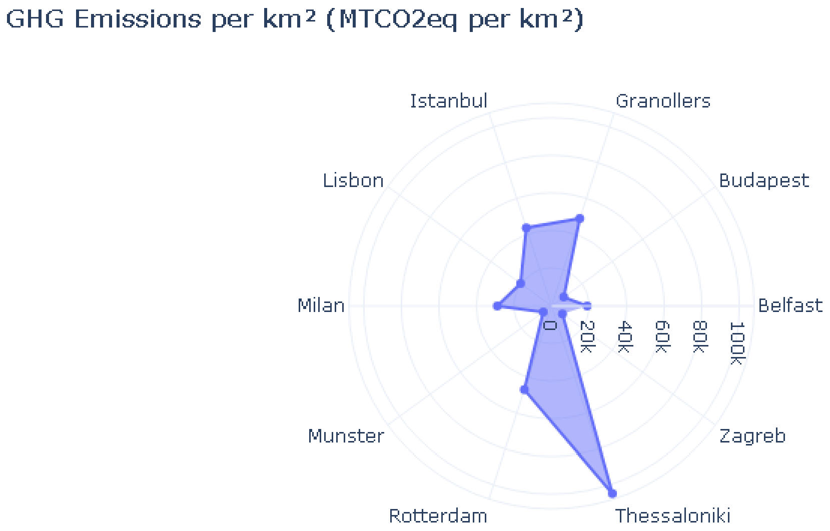

Figure 40 GHG Emissions per Capita in each city (MTCO2eq).Own elaboration. Source: Global Covenant of Mayors.

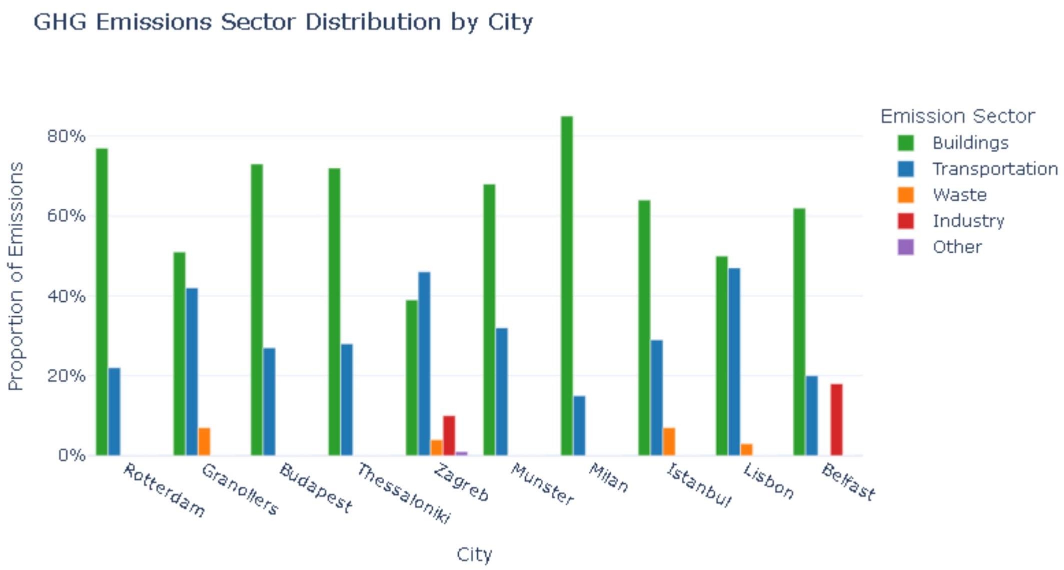

Figure 41 GHG Emissions by Sector. Own elaboration. Source: Global Covenant of Mayors, Gouldson et al 2020.

The specific GHG emissions data from the "KPI Validation" section can be understood better by looking at the sector breakdown in Figure 41. Granollers reports 3.89 tons of CO_2 per inhabitant, while Istanbul reports 2.79 tons. These self-reported numbers are slightly different from what was reported to the Global Covenant of Mayors. More importantly, Figure 41 shows their sources are very different. Granollers' emissions profile is heavily weighted toward transportation (42%), one of the highest in this study. In contrast, Istanbul's emissions come mostly from buildings (64%). This explains the different pilot actions. Istanbul's project on digital twins for solar panels targets its largest emissions source directly. Granollers' guidelines for new neighborhoods will need a strong focus on sustainable mobility to address its specific emissions profile.

If we compare data availability through the external and internal KPI routes, in the case of Granollers and Istanbul, the cities provided a robust internal baseline with total emissions and air pollution, the same that is available in the external sources analysed, although the analysis was limited to the most relevant indicators linked to the economic activities developed in the cities.

Port and coastal cities often have shipping activity that can add to air pollution. Ships use heavy fuel that releases both CO and SO_2. Istanbul, being a major port city connecting Europe and Asia, has heavy shipping traffic in the Bosphorus strait. This shipping activity, combined with road traffic and industrial zones, may explain the slightly higher concentrations seen in the eastern part of the maps of Figure 9 and Figure 10. Thessaloniki, also a port city in southeastern Europe, shows similar patterns. Rotterdam, one of Europe's largest ports, is located in an area that shows low concentrations in the maps. This may be due to strong winds from the Atlantic Ocean that help spread pollutants, or to cleaner fuel regulations in Western European ports.

Inland cities face different pollution sources. Milan is located in the Po Valley, a region known for air quality problems. The valley geography traps pollutants, and the area has high industrial activity and road traffic. Budapest is also located in a basin area along the Danube River, which can trap air pollution. These geographic features may lead to higher local concentrations even if the regional maps show moderate levels. Cities like Munster and Granollers are smaller inland cities with less heavy industry, which may explain why they are in areas showing lower concentrations.

Transportation plays a major role in both CO and SO_2 emissions. Road traffic from cars and trucks produces CO, especially from diesel engines. SO_2 comes mainly from burning fuels with sulfur content, which happens in industrial processes, power plants, and shipping. The seasonal pattern seen in the maps of Figure 9 and Figure 10, with higher concentrations in winter and lower in summer, relates to increased fuel use for heating during cold months and different weather conditions that affect how pollutants spread.

Industrial activity is another important factor. Areas with steel production, chemical plants, refineries, and power plants tend to have higher SO_2 emissions. The maps show that some areas in Central and Eastern Europe have slightly elevated concentrations, which may relate to industrial zones in these regions. Western European cities benefit from stricter environmental regulations and cleaner technologies, which may explain the lower background concentrations seen in those areas.

The GHG emission data from the Global Covenant of Mayors adds another layer to understanding pollution in European cities. The data shows total emissions and breaks them down by source. This helps to see if the patterns match what was found for CO and SO_2.

Looking at total emissions, Istanbul stands out with very high numbers. The city reports over 51 million metric tons of CO_2 equivalent per year. This is much higher than other cities in the group. Rotterdam comes second with about 8.3 million tons, followed by Budapest with 6.3 million tons. Milan reports 4.5 million tons. The smaller cities like Granollers, Lisbon, Munster, and Belfast all report between 1.5 and 2.2 million tons. These numbers partly reflect city size and population.

Istanbul's participation in projects like this aligns with efforts to reduce reported GHG emissions, though the focus leans heavily toward soft data collection methods such as artificial intelligence and data solutions. This approach stands in contrast to limited investment in infrastructure that produces real impact, particularly regarding green area expansion, as shown in Figure 43, or bikeway path development, as displayed in Figure 21, Figure 22, Figure 26 and Figure 29. The area receiving concentrated investment appears to be rapid transport connectivity, as shown in Figure 25 and Figure 30. In the case of this project, to maintain and improve this data and reach positive energy districts, the internal response was the implementation of UBTEM, a model driven by Artificial Intelligence designed for carbon reduction. This is a clear alignment pattern: the external reality of emissions drives internal investment in modeling and technology to ensure that urban development follows a low-emission trajectory. The inclusion in the internal KPI map of the percentage of electric vehicles, reported as 2.5% of vehicles in Kadıköy, is an example of this concern.

When looking at emissions per square kilometer, the radar chart shows Thessaloniki and Istanbul with higher density. This matches what was seen in the CO and SO_2 maps where both port cities showed raised levels, as shown in Figure 9 and Figure 10. Rotterdam also appears in the higher range for density, which is interesting because the CO and SO_2 maps showed lower concentrations there. This difference might be because total GHG emissions include all sources, while CO and SO_2 come from specific activities like shipping and industry.

According to Figure 40 the per capita emissions chart shows a different picture. Belfast and Zagreb appear higher when looking at emissions per person. Rotterdam also shows elevated per capita emissions. This suggests that while some cities may have lower pollution concentrations in the air, their total carbon footprint per resident is still high. The difference between area density (Figure 39) and per capita measures (Figure 40) shows that population size and city layout matter.

Belfast adapted the URCAM tool internally to focus on calculating the possible carbon reduction through actions such as housing insulation or increased bicycle use. Taking into account the rating of 2 in Climate Financial Support shown in Table 35, It could be an efficient tool to face this kind of challenge.

Figure 41 shows sector breakdown and this provides important information. Buildings are the main source of GHG emissions in all cities. The proportion ranges from 39% in Zagreb to 85% in Milan. Most cities report that 60% to 75% of their emissions come from buildings. This includes heating, cooling, and electricity use in homes and offices. This finding is different from the CO and SO_2 analysis, which pointed to shipping, industry, and road traffic as major sources.

Transportation is the second largest source but varies between cities. Lisbon reports 47% of emissions from transportation, while Zagreb reports 46% and Granollers 42%. These are higher than other cities. Milan reports only 15% from transportation, which is the lowest in the group. Most other cities fall between 20% and 32%. This pattern does not fully match the CO pollution maps, which suggested road traffic was a major factor everywhere. The difference may be because CO comes mainly from vehicles, while total GHG include many other sources.

Industry shows up as a small contributor in the GHG reports. Only Belfast reports an important share at 18%, and Zagreb reports 10%. All other cities report zero or very low industrial emissions in their data. This is surprising given the earlier discussion about industrial zones in central and Eastern Europe contributing to SO_2 emissions. The low numbers might reflect how cities report their data. Some industrial facilities may be located just outside city borders, or cities may only count emissions from facilities they control directly. One key finding is that GHG reports from cities may not capture all pollution sources. Shipping emissions, which were identified as important for port cities, do not appear clearly in the sector breakdown.

This could be because ships in international waters are not counted in city reports, but they affect local air quality. Industrial facilities near cities but outside their borders may also not show up in city data.

Waste contributes a small amount in a few cities. Istanbul and Granollers both report 7% from waste. Lisbon reports 3% and Zagreb 4%. Other cities report zero. Waste emissions come from landfills and waste treatment, which release methane and other gases.

The data suggests that reducing GHG emissions will require different actions than reducing air pollutants. For air quality, the focus has been on cleaner fuels for ships, better vehicle standards, and controlling industrial emissions. For GHG, the data shows that making buildings more efficient is the top priority for most European cities. This includes better insulation, modern heating systems, and clean energy. Transportation is also important but takes second place in most cities.

The match between CO and SO_2 patterns and GHG patterns is partial. Port cities do show higher levels in both datasets, supporting the connection between shipping, traffic, and overall urban emissions. Inland cities like Milan and Budapest show high building emissions, which relates to their geography and climate conditions. However, some cities like Rotterdam show that good air quality and high carbon emissions can exist together, pointing to different policy needs. The data from the Global Covenant of Mayors provides a helpful complement to the air pollution maps but shows that the full picture requires looking at multiple types of measurements.

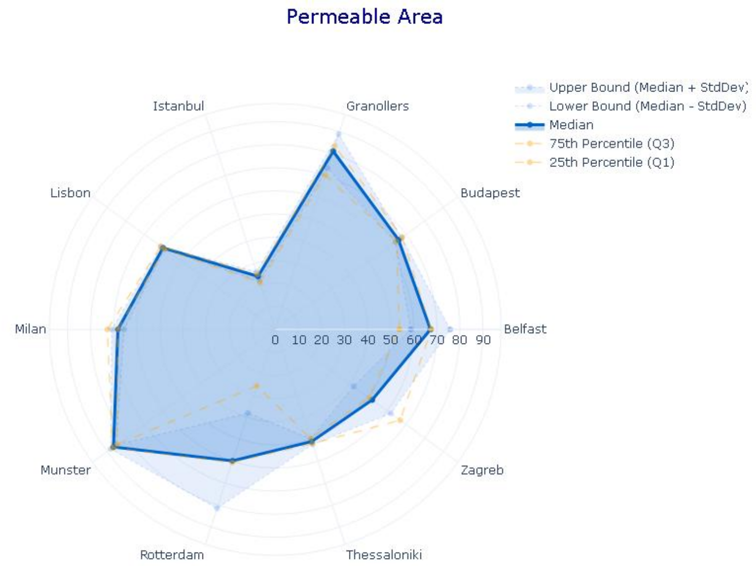

Figure 42 Permeable Area (%) Comparison between cities. Own elaboration. Source: Copernicus.

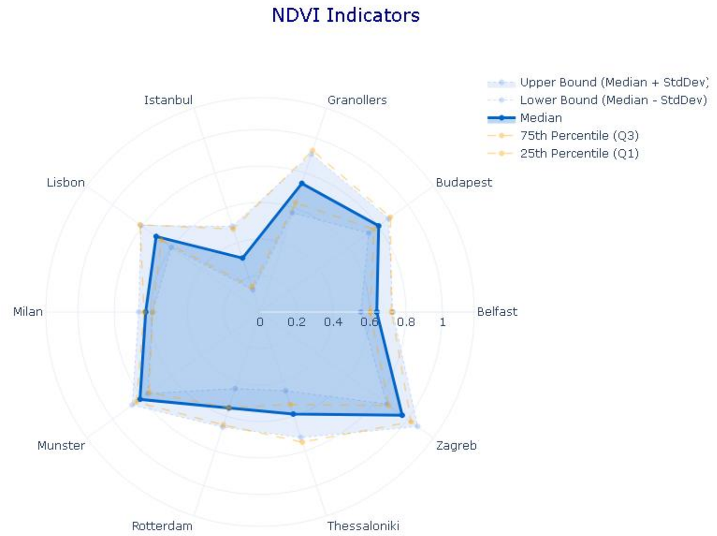

Figure 43 NDVI Comparison between cities. Own elaboration. Source: Copernicus.

The radar charts help identify clear groups of cities based on their overall performance. Figure 42 and Figure 43 show a top-performing group which includes Munster and Granollers. These two cities show both high plant cover and high permeable surface percentages. Munster leads with about 86% permeable area and 0.81 plant cover. Granollers follows closely with roughly 81% permeable area and 0.74 plant cover. These cities offer the best conditions for maintaining green spaces and allowing rainwater to soak into the ground. Granollers also shows a concern for flood resilience aligned with the climate aspect. The city internally reports a stormwater runoff volume of approximately 0.52 m3 per m2 per year. This hard data is the foundation for the internal use of the RESCCUE tool, which is used to model 11 flood risk scenarios and evaluate six resilience options.

A second group forms around Zagreb and Budapest. Both cities achieve high plant cover values. Zagreb reaches the highest plant cover at 0.96, while Budapest scores 0.80. However, their permeable surfaces fall in the moderate range. Zagreb sits at about 52% and Budapest at 66%. This combination means these cities have abundant vegetation but less ground area that can absorb water compared to the top performers.

A middle group contains Belfast, Lisbon, Milan, and Rotterdam. These cities show moderate performance on both measures. Belfast records about 0.64 plant cover and 67% permeable area. Lisbon reaches 0.70 plant cover and 60% permeable area with a reported increase of green areas in the internal KPI set as well. Milan shows 0.63 plant cover with a fairly high 68% permeable area. Rotterdam displays 0.55 plant cover and 60% permeable area. All four cities perform adequately but do not excel on either measure. The stability of Milan's green coverage contrasts with its action of planting trees, though this could be due to the recent implementation of this measure, and it is a step forward in this regard.

This might explain an inconsistency in Lisbon regarding the external KPI of water consumption, which shows a persistent challenge. Although drinking water consumption was 3.2% lower in 2022 compared to the baseline year 2019, the progress report showed that in 2023 consumption increased by 1.3%. This negative change in a key external indicator for water resilience highlights why the city must continue focusing on RAF ICARIA and water efficiency. The internal response extends to social preparedness, with 2,000 volunteers and civil society organisations acting as focal points for citizens after a disaster. The maximum score of 5 in user participation validates that the community actively supports these water resilience measures, as seen in Table 27 KPI values for Granollers. Own elaboration..

Thessaloniki occupies a space between the middle group and the struggling cities. The Greek city has moderate-low plant cover at 0.59 and moderate-low permeable area at 51 percent. Its performance places it below the middle group but well above Istanbul.

Istanbul forms its own category as the only clear struggling city. Istanbul shows the lowest values for both plant cover at 0.31 and permeable area at 24 percent. The combination of limited vegetation and mostly sealed surfaces creates major challenges for the city. Istanbul has much less ability to absorb rainwater and provides far fewer green spaces than any other city in the study.

According to Figure 44, the economic decline due to COVID-19 was not the same everywhere. Some countries saw their Gross Domestic Product (GDP) per capita drop by more than 10%, while others had smaller losses or even small gains.

The countries that suffered the biggest losses appear in the darkest blue on the map. Spain, the United Kingdom, Ireland, Italy, and Greece were among the hardest hit. These places saw their economies shrink by 8% to 10% or more. France, Portugal, and several countries in Central and Eastern Europe also faced serious drops, though not quite as severe.

Why does this matter for economic resilience? When an economy can better withstand a shock like COVID-19, the government has more money to spend on what people need. Countries with stronger economies during the crisis could keep paying for hospitals, schools, and other public services. They could also keep making their own decisions without depending too much on outside help.

The connection to climate change is important too. Countries that lost less money during COVID-19 had more resources left over to invest in green energy, better public transport, and other ways to fight climate change. When your economy crashes, you have to focus on basic survival. You cannot spend money on long-term projects like reducing carbon emissions.

The most vulnerable cities and regions were often those that depended heavily on tourism, like parts of Spain, Greece, and Italy. When travel stopped, these places lost a huge part of their income almost overnight. Cities with more varied economies — with tech companies, manufacturing, and different kinds of businesses — handled the shock better.

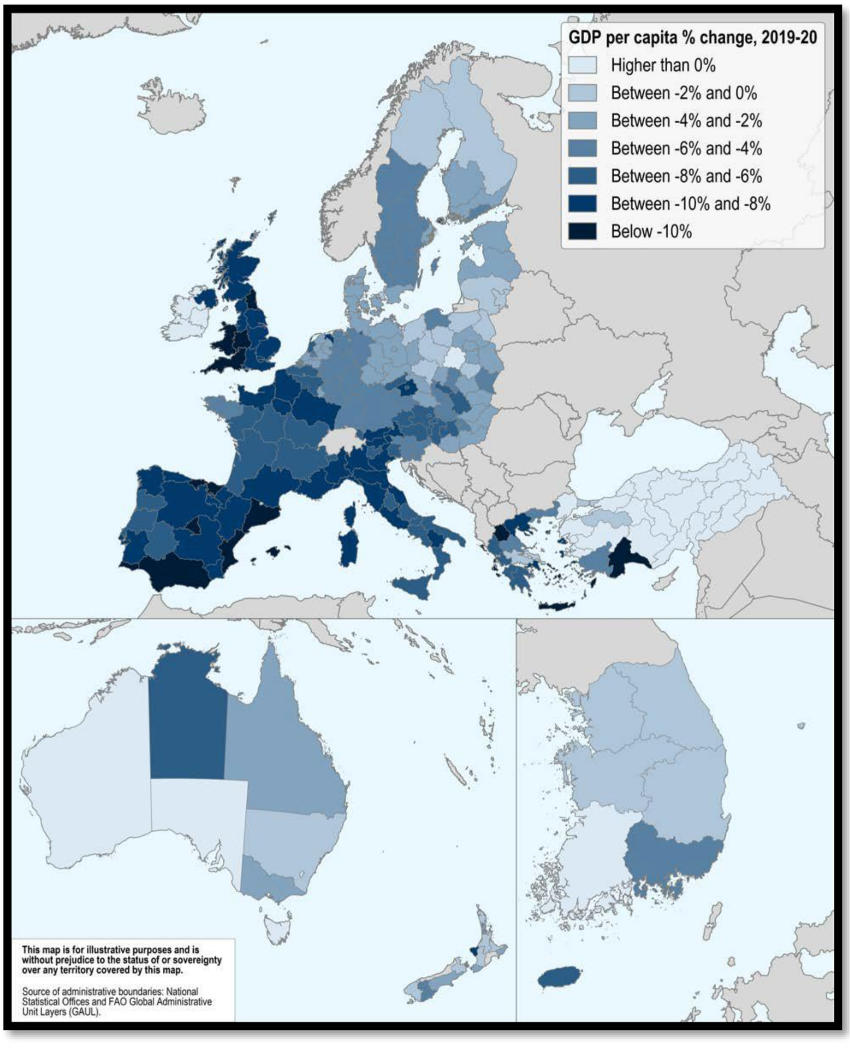

Figure 44 COVID-19 year GFP variation per region. Source: OECD 2022.

Some Northern European countries, shown in lighter blue, had smaller economic drops. Their economies were more stable. They had savings built up and could support their people and businesses through the crisis. This meant they kept more money available for both immediate needs and future investments. Economic resilience is not just about having money in good times. It is about having systems that can bend without breaking when crisis hits.

The map in Figure 36 shows the most steady pattern appears in the moderate performers. Milan and Rotterdam both show similar light blue shading, suggesting they maintained consistent growth slightly above their national rates. Neither city experienced dramatic changes up or down. This stability may reflect mature, diversified economies that avoided major shocks during this period.

The map reveals important differences between these cities' economic paths from 2015 to 2022. While Budapest, Istanbul, and Thessaloniki surged ahead of their countries, other cities like Belfast, Lisbon, and Zagreb fell behind their national averages. Milan and Rotterdam held steady with moderate positive growth. These patterns shaped conditions in each city during the years when the cycling and green space data was collected. Cities with stronger economic growth may have had more resources for infrastructure projects, while cities with slower growth may have faced budget pressures that affected their ability to maintain or expand green spaces and cycling networks.

Figure 45 provides important context on social vulnerability across the participating nations. The 2021 poverty rates show considerable variation. Spain and Turkey show the highest rates, both approaching 14%. Italy and Croatia also have rates above 12%. In contrast, the Netherlands, Portugal, and Hungary report lower rates, with Hungary below 7%. These national-level economic challenges connect directly to the project's goals of spatial justice and social inclusion. Implementing fair climate transitions is more difficult in areas with higher underlying poverty. This data highlights the different social starting points for cities like Granollers (Spain) or Istanbul (Turkey) compared to cities in countries with lower poverty rates.

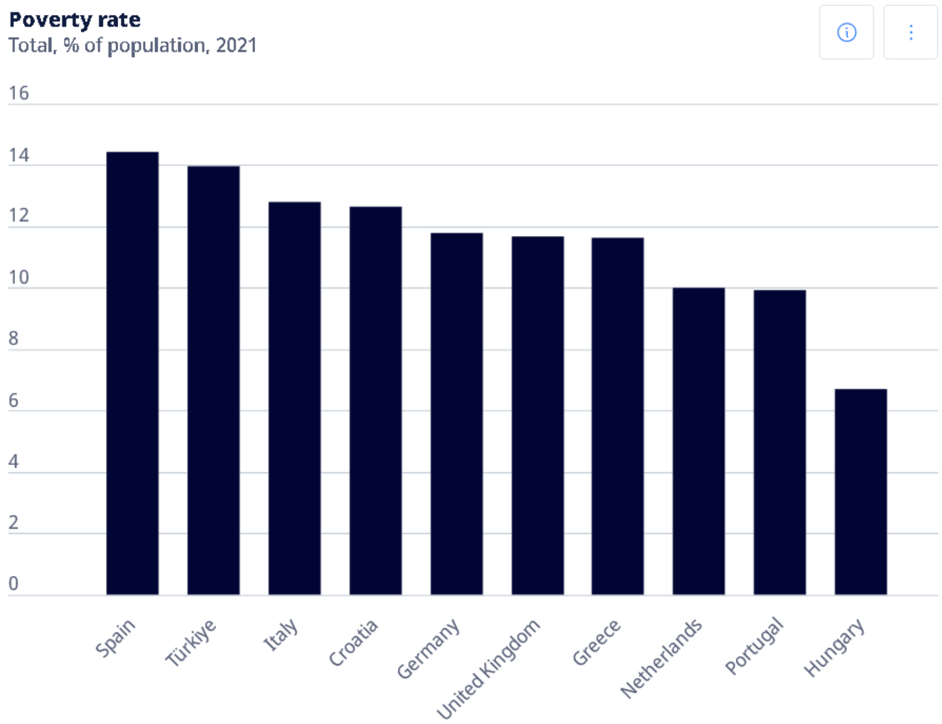

Figure 45 Poverty rate per country, 2021. Source: OECD Indicators.

The use of the Community Maps tool in Belfast to show information related to social deprivation illustrates the need to diagnose external inequality and It is a first step towards solving its social inequalities issues. In Thessaloniki, there is a clear intention to move forward in this direction as well. The project focus evolved from addressing energy poverty toward a neighborhood that deals with social equity. Internal KPIs as shown in Table 35 City Performance Scores for Community Involvement and Local. Own elaboration. reflected a pattern of strong social acceptance, as the measure of Change in Social Norms increased dramatically from 1 to 4, although other indicators have not yet evolved so positively. Münster shares the goal of creating neighborhoods that are "fair for everyone" but It shows an inconsistency in its participatory process, while implementation citizen involvement increased strongly from 1 to 4, their participation in project planning remained at 1.

Citizens involvement is the key in Healthy Streets approach from Budapest, in the country of the best poverty rate data (external KPI). Their approach is based in building "around what people need". Budapest's internal KPIs are consistent with its country poverty rates and COVID 19 crysis resilience (external KPIs), and this confirm this success: Resident Participation in Planning and Implementation jumped from 1 to 4, and Change in Social Norms increased by 2 points. This wave of internal participation relates directly to the participation tools implemented, such as the Community Maps, which received close to 900 responses.

The case of Rotterdam is also especially relevant, as it presents a resilience pattern centered on the social aspect, where the external threat is the socioeconomic vulnerability of the BoTu districts. It is another example of how to achieve this economic resilience aspect according to the broader external KPI analysis and the internal KPI results. The fact that these districts have been subject to the Resilient BoTu 2028 program since 2019 provides the external context that the project seeks to address. According to Table 22, internal success is reflected in the high score of 4 for resident participation in planning and work, an internal KPI that validates the ABCD approach. However, the medium rating of 3 in local authority participation is an inconsistency that suggest that, while social resilience is a priority, internal administrative challenges (such as the lack of a project manager) could slow down organisational resilience efforts in the long term.

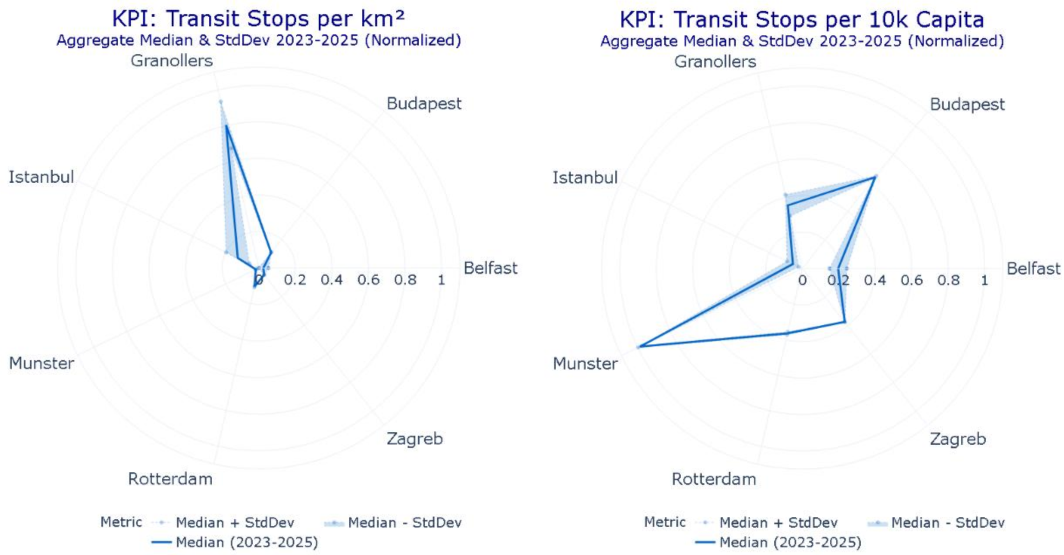

Figure 46 Transit Stops Density. Own elaboration. Source: ITDP Atlas.

Rotterdam shows strong performance in bike infrastructure but moderate performance in rapid transit, which fits its reputation as a bike-friendly city, as displayed in Figure 48 and Figure 49. Figure 47 illustrates Cities like Budapest and Zagreb show strong performance in frequent transit access, suggesting they have well-developed bus and tram networks. Istanbul shows low values for most indicators except rapid transit, where it leads. This pattern suggests Istanbul's transportation system focuses more on metro and rapid transit rather than bikeways (Figure 46 Transit Stops Density. Own elaboration. Source: ITDP Atlas., Figure 48 and Figure 49) or frequent local transit.

The changes between 2023 and 2024 reveal where cities invested during the project period. Zagreb's increase in combined bikeway and transit access suggests targeted efforts to connect these systems. Istanbul's increase in rapid transit access suggests continued expansion of its metro system. Rotterdam's slight increase in combined bikeway and transit access suggests ongoing efforts to improve connections.

However, not all changes are positive. Lisbon shows decreases in both rapid transit and specially frequent transit access. This is shown in Figure 23 and Figure 25. These decreases could reflect service cuts, route changes, or changes in how the data was measured. If these decreases reflect real service reductions, they suggest Lisbon faced challenges in maintaining or expanding transit service.

The relatively small changes in most connectivity indicators between 2023 and 2024 reflect the reality that transportation infrastructure changes slowly. Building new bike lanes, expanding transit networks, and improving service frequency require time, funding, and planning. One year is a short period for major infrastructure changes.

Regarding the rest of indicators the advanced infrastructure group includes Rotterdam and Munster. These cities show high values across nearly all measures. They have extensive cycleway networks (Figure 48), high connectivity between bikes and destinations (Figure 49), and dense public transit. Values typically exceed 0.7 for connectivity measures and they lead in absolute infrastructure measures. Both cities show stability rather than growth, suggesting they reached high development levels before this period.

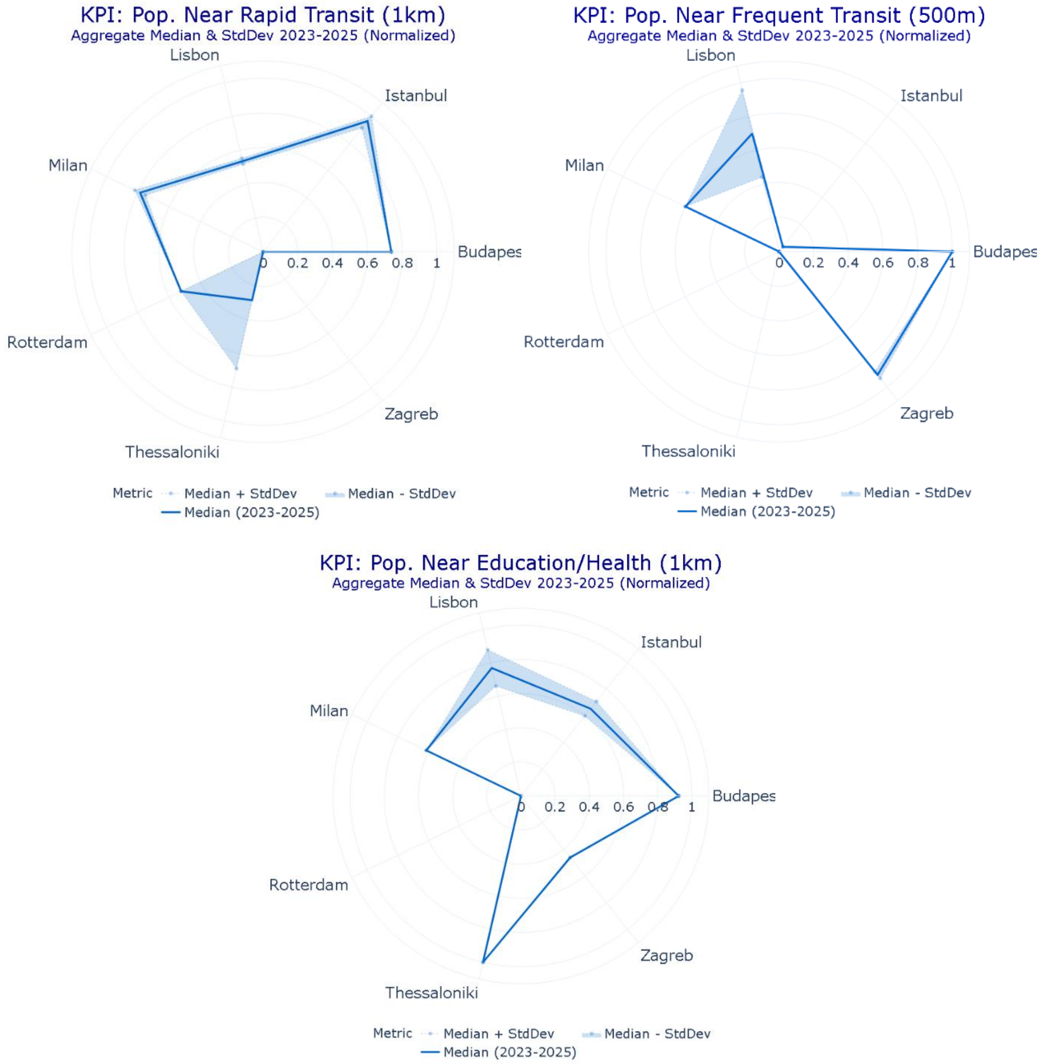

Figure 47 Connectivity KPIs. Own elaboration. Source: ITDP Atlas.

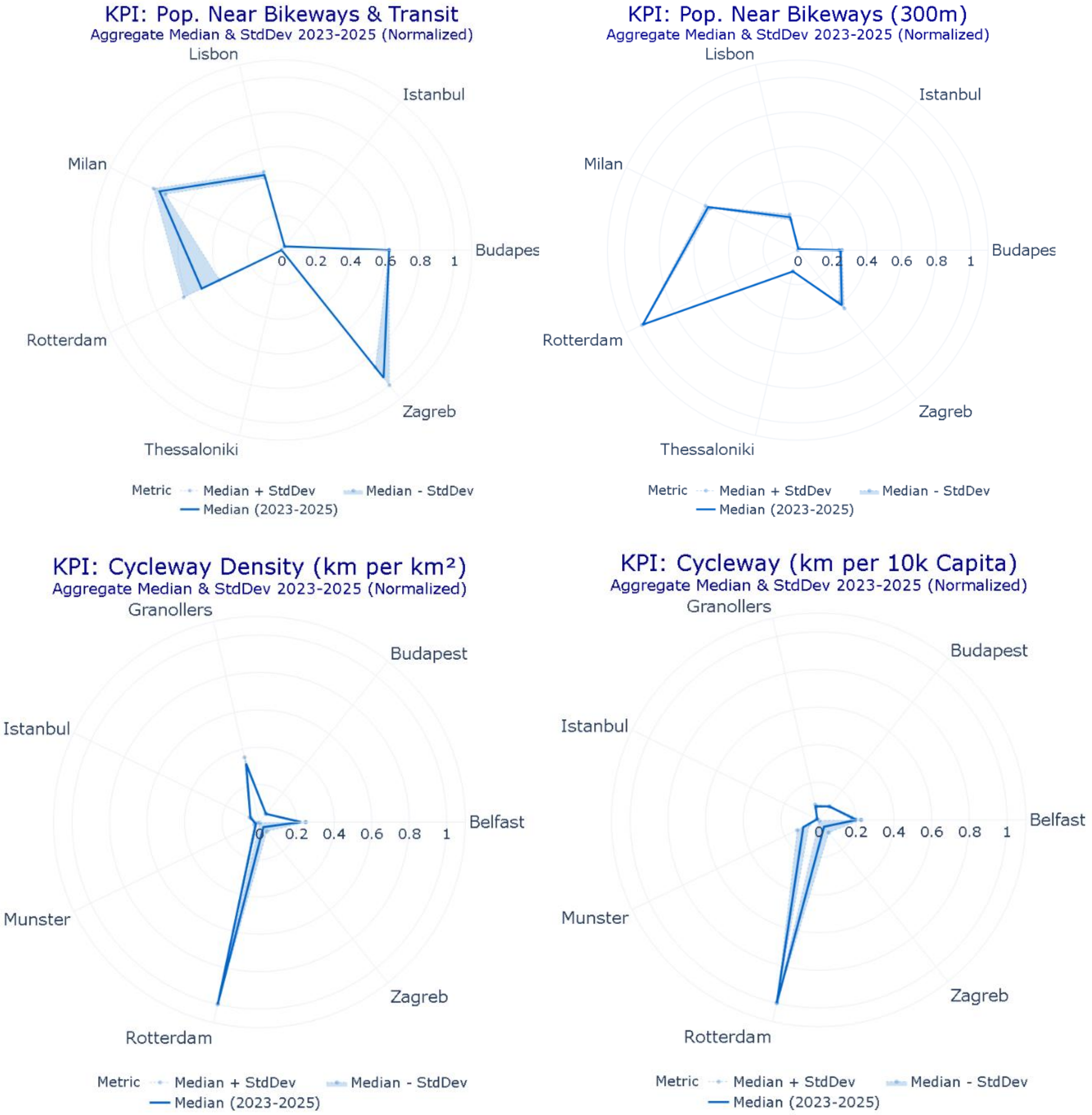

Figure 48 Population near cycleways and cycleway density. Own elaboration. Source: ITDP Atlas.

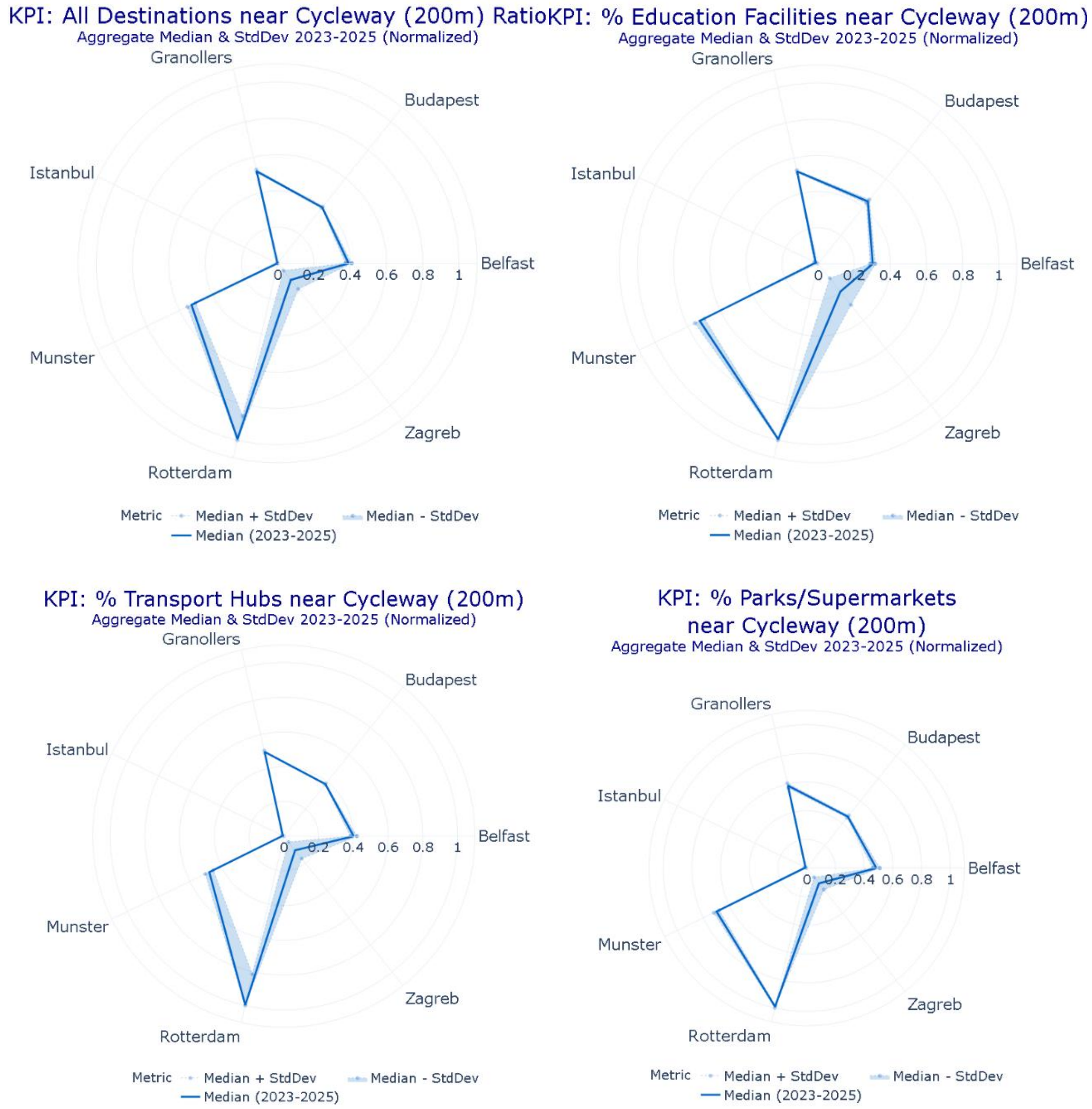

Figure 49 Percentage of facilities near cycleways. Own elaboration. Source: MIT Overpass.

The established infrastructure group includes Budapest, Milan, and Belfast. These cities show moderate to good values across most indicators, typically between 0.4 and 0.6 for connectivity and moderate transit density as shown in Figure 47. They show general stability with slight improvements in some areas. This group has working transportation systems that serve residents but have room for improvement.

Taking this external KPI data as a reference, a first step to begin implementing improvements in an informed way could be Belfast's URCAM tool to calculate the possible carbon reduction that could be achieved with increased bicycle use, in addition to using the Safe Routes, Healthy Places Belfast toolkit to support activities such as the Walking Bus. Despite this clear internal focus on promoting active travel, the internal KPI of contribution to changes in rules and regulations was zero, and the internal KPIs do not yet show an evolution that matches the effort likely due to the recent implementation.

In Budapest, the pilot is based on the HSKC, which promotes an urban planning method focused on making public spaces healthier and more people-centered. This approach, which implicitly requires changes in transport infrastructure to prioritise health, is strongly supported by the internal KPIs of social acceptance, where the Change in Social Norms experienced a strong increase of 2 points, as seen in Table 15 Budapest Performance Scores for Community Involvement and Local. Own elaboration..

The developing infrastructure group includes Istanbul, Zagreb, and Thessaloniki as shown in Figure 21, Figure 22, Figure 23, Figure 25 and Figure 30. These cities generally start with lower values but show growth patterns. Istanbul is expanding its cycleway network rapidly. Zagreb is improving transit density and bike connectivity. Thessaloniki shows growth in some measures. This group is actively building infrastructure during the project period.

Granollers stands apart as a special case. It starts with very high values in some connectivity measures (Figure 46 Transit Stops Density. Own elaboration. Source: ITDP Atlas. and Figure 47 Connectivity KPIs. Own elaboration. Source: ITDP Atlas.), similar to Rotterdam and Munster, but shows significant declines over the period. The reasons for these declines are unclear but may relate to data collection changes, boundary changes, or actual infrastructure reorganisation. As displayed in Figure 46 Transit Stops Density. Own elaboration. Source: ITDP Atlas., Granollers stands alone with extremely high density of about 35-45 stops per square kilometer, likely reflecting its compact urban form. Most other cities cluster between 5-10 stops per square kilometer, showing similar spatial organisation of transit networks.

Lessons

The implementation of the UP2030 project's Monitoring and Evaluation framework, which uses validation of City-led KPIs (Track 1) and external analysis of open data (Track 2), has revealed persistent challenges related to the operational capacity of cities and data management. A recurring limitation is the difficulty in collecting specific and high-resolution data needed for the KPIs, especially those that measure impact at the pilot scale, since cities often can only collect data at the city-wide level for most variables. This data shortage, together with the absence of advanced digital resources such as BIM models or digital twins, blocks the completion of accurate simulations and informed decision-making. In addition, a general gap was identified where cities did not report the publication of new open data sets, despite all of them having open data portals. In terms of commitment and institutional capacity, it was observed that city participation is unequal, probably due to the early stage of climate actions and barriers were noted such as limited internal capacity, long bureaucratic processes, local electoral agendas, the need for specialised technical staff, and stakeholder fatigue, which affects the sustainability of long-term commitment.

Given the absence of direct prototype data for Zagreb, satellite image analysis of the prototype area is recommended for future monitoring. This approach could track physical changes in green areas, distinguishing between institutional interventions and private investments in green strategies like urban farming. Comparing green area changes in institutional prototype zones versus citywide patterns might reveal individual participation in urban agriculture and climate-friendly practices. This method could be combined with simple probabilistic approaches similar to those used by Kemeling et al., offering quantitative assessment when questionnaire data proves insufficient or difficult to collect. Such satellite monitoring would provide at least the physical information needed to evaluate whether the circular food system is creating visible environmental changes at the neighbourhood scale.

External data for Zagreb shows positive trends. Between 2023 and 2024, sustainable transport accessibility improved, with 76% to 78% of residents now living near frequent transit. This matters because transport produces 27% of city emissions. Zagreb leads all studied cities with a plant cover index (NDVI) of 0.96, though permeable surfaces cover only 52% of urban area. The broader context creates both challenges and opportunities. Public concern about climate change in Croatia fell 9% between 2023 and 2025, potentially weakening policy support. However, with Croatia's poverty rate exceeding 12%, Zagreb's food system prototype could create important connections between climate action and poverty relief. If the project succeeds in improving food security and reducing costs through local food production and circular methods, it addresses environmental and economic problems simultaneously. This dual benefit becomes especially valuable where public climate concern is declining but economic pressures remain high.

Looking ahead to future actions, it is important to take a dual approach focused on improving data collection and strengthening governance to ensure replicability and sustainable impact. To overcome data challenges, moving toward the integration of diverse data sources and using analysis to optimise services is recommended. This includes the need to provide specific guides, such as the CBA Guide, which should include links to data sources to address the data gaps reported by users. Furthermore, training and capacity-building activities must be implemented to allow urban actors to introduce advanced solutions in resilient planning and improve data governance, for example, through the development of methodological guides to understand the flow of carbon data within municipal administrations. Regarding stakeholder participation, it is essential to consider LAA stakeholders as "active actors" rather than "passive" ones, since their genuine participation helps capture local knowledge and promotes the replication of solutions at different scales. The formalisation of "Partnership Commitments" can help to build collaborations and generate a sense of ownership, which is vital for continuing the work after project completion. Cities benefit from monitoring by transforming KPIs into a tool for accountability, efficient resource allocation, and project prioritisation, while driving innovation and continuous improvement of residents' quality of life. Finally, continuous tracking of KPIs beyond the project duration should be done to evaluate the long-term evolution of the impact of implemented initiatives, which provides a solid foundation for future evaluation.

6 Conclusions

The monitoring results for key performance measures show a mixed picture. There is a major gap in how cities report their data. Cities like Budapest, Munster, Thessaloniki, Milan, and Lisbon gave both starting point data and progress updates. Others, including Belfast, Zagreb and Rotterdam, only gave starting point information. These incomplete reports make it hard to compare progress across all cities. One problem found in all cities was the failure to report new open datasets, even though all cities have open data systems. The surveys also show that the project is still in its early stages. So far, there have been few changes in official laws or rules.

Even with these gaps in reporting, the data from cities shows positive growth in local climate work. Budapest, for example, saw large increases in how many residents and local government offices got involved. Munster saw a strong rise in resident participation during the project. Thessaloniki greatly expanded its public outreach, growing from 12 to 700 people. However, this local progress does not match what is happening at the national level. In these same countries—Hungary, Germany, and Greece—national public concern about climate change actually went down between 2023 and 2025. This means that local project wins are not yet creating a broader national shift in awareness.

The external analysis confirms that cities start from very different places. For transportation, Rotterdam is the clear leader in bicycle infrastructure. Istanbul's system is built around rapid transit. For environmental quality, cities fall into clear groups. Munster and Granollers perform very well. They have high levels of both green plants and ground that absorbs water. In sharp contrast, Istanbul has the lowest scores for both. This points to serious environmental stress and problems with rainwater absorption. Air quality data also shows that eastern and port cities like Istanbul and Thessaloniki face greater pollution from sources like shipping.

Three main findings come from the data on plant cover and surfaces that absorb water. First, clear groups of cities exist based on how they perform across all measures. Second, most cities show remarkable stability over three years. Their values change very little from year to year. Third, climate zone plays a role in explaining differences between cities. But local planning and development choices matter more for outcomes.

Economic factors are clearly connected to these environmental goals. The 2019-2020 economic shock from the pandemic hit southern European countries like Spain, Italy, and Greece hard. This event likely reduced the money available for climate projects in cities such as Granollers, Milan, and Thessaloniki. Long-term economic growth from 2015 to 2022 was also uneven. Budapest, Thessaloniki, and Istanbul grew faster than their national averages. Belfast, Lisbon, and Zagreb grew slower. These economic realities are tied to social inclusion. Nations with high poverty rates, such as Spain and Turkey, face extra difficulty in achieving a fair and just climate transition.

The monitoring framework provides a complete model for checking city prototypes. It combines direct city-level checks with objective external data. This dual approach measures the success of the projects. It also offers a clear way to estimate their potential future impact if they were used on a wider scale. The project's monitoring system is built on a two-track approach to ensure a complete and reliable review.

- Track 1 is a collaborative process. Each city, along with project partners, creates and checks a specific list of performance measures. These measures fit its unique prototype, goals, and local context. This method measures the direct, ground-level success of the prototypes. Progress is tracked by comparing starting data (the state before implementation) against reporting period data (the status after the actions have been put in place). This track often includes qualitative and perception-based measures, such as resident involvement, local government cooperation, and changes in societal norms. These are measured using scales.

- Track 2 runs at the same time. It provides an objective, external view by monitoring a set of measurable indicators from publicly available open data. This data-driven analysis allows for a broader, number-based assessment of a city's performance and impact. It works independently of the direct feedback from participants.

The results show how these prototypes can directly influence key areas. For example, the Budapest prototype, focused on a "Healthy Streets" approach, led to a measured increase in resident involvement from a score of 1 to 4. Local government involvement rose from 2 to 5 departments. This shows the prototype's power to change governance and public participation. Similarly, Thessaloniki's prototype, focused on a DCAP, expanded its public outreach from 12 to 700 people. This shows its success in spreading information.

By monitoring the external measures at the same time, the project can see if these local prototype wins translate into city-wide, number-based changes. For instance, if a city puts in place multiple prototypes focused on greening and water-absorbing drainage (like those in Granollers or Milan), a successful city-wide rollout would show up in the external analysis. This would appear as an increase in the city's overall plant cover and percentage of water-absorbing ground over the coming years.

This dual system also aligns directly with the project's 5UP approach. The city-led KPI validation (Track 1) is primarily concerned with the immediate results of the prototypes, reflecting the **Updating** of plans, the **Upgrading** of tools, and the **Upskilling** of staff and stakeholders. In contrast, the external KPI monitoring (Track 2) is designed to measure the long-term, city-wide impact. This track is therefore more related to the **Upscaling** of proven solutions and the **Uptaking** of these new methods into standard city policy and societal norms.

To ensure lasting impact, cities should focus on specific pathways for action and collaboration. To address existing challenges and ensure lasting impact, cities must take specific steps in data management and stakeholder engagement. The persistent difficulty in collecting high-resolution data at the pilot scale requires immediate attention. Cities often can only collect data at the city-wide level, which blocks accurate simulations and informed decisions. The absence of advanced digital resources such as BIM models or digital twins further limits technical capacity. Moving forward, cities should integrate diverse data sources and use analysis to optimize services.

Strengthening governance and stakeholder participation will determine whether progress continues beyond the project. The experience shows that city participation is unequal, limited by internal capacity, long bureaucratic processes, local electoral agendas, the need for specialised technical staff, and stakeholder fatigue. To address these barriers, local actors must be treated as "active participants" rather than "passive recipients". We pointed out social inclusion initiatives from Budapest and Rotterdam as examples of initiatives with successful results at broader level. Their genuine involvement captures local knowledge and promotes the replication of solutions at different scales. The formalisation of "Partnership Commitments" can build collaborations and generate a sense of ownership, which is vital for continuing work after project completion.

Cities benefit from continuous monitoring by transforming performance measures into tools for accountability, efficient resource allocation, and project prioritisation. This drives innovation and continuous improvement of residents' quality of life. The project commits to Open Science practices and open data following FAIR principles. Making data and validated tools openly available through the

UP2030 Services Platform ensures that results become standard practice in urban planning and support other EU Mission cities. This commitment to open sharing creates opportunities for cities beyond the current project to learn from these experiences.

The gap between local technical progress and national public concern reveals a key challenge. While Budapest, Munster, and Thessaloniki achieved measurable improvements in resident involvement, tool implementation, and public reach, their countries experienced drops in climate concern between 2023 and 2025. This could be due to new European challenges that have emerged recently and changed people's sense of what matters most. This disconnect shows that technical action alone does not drive broader social and political change. Cities must go beyond technical designs and overcome social barriers, including understanding what people see as priorities, to achieve city-wide impact.

Looking forward, continuous tracking of performance measures beyond the project duration is essential. This long-term monitoring will evaluate how implemented initiatives perform over time and provide a solid foundation for future assessment. Cities that commit to this ongoing work position themselves to demonstrate real impact, attract additional resources, and influence policy at higher levels. The success of UP2030 depends not only on what cities achieve during the project period but on building systems and partnerships that sustain progress toward climate neutrality by 2030 and beyond.

Granollers was the first city to start its participation workshops, and its design and execution methods will be used as a test to be copied in other cities. Zagreb's approach focuses on the circular economy to support the city's food system and seeks to optimise resources and improve logistics with a multi-objective interest. The two-track performance measure framework is expected to allow enough alternatives to request information from ongoing initiatives that can be shared between different cities, check if they have conforming results, and copy or scale projects that help build according to common objectives.

Cities are taking action with their prototypes to address challenges identified by the external KPI track measures, which validates this approach. For example, according to external data, Istanbul experiences high GHG emissions. Istanbul could tackle this challenge using tools like those Munster has implemented, instead of implementing its own alternatives, and by raising investment in bikeways, green areas, clean industry, and transportation. These areas have stayed at low levels in Istanbul for an extended period and require more focus. Similarly, Lisbon and Milan are working to increase green areas, responding to needs shown in their external measurements. Both Munster and Rotterdam seems to be ahead in many aspects and they are strongly oriented toward spatial justice and inclusive participation to involve residents directly to the broader goal of making climate action fair for all social groups.

The use of open data and satellite sources offers significant potential for improving monitoring in future project phases. These sources provide objective, consistent measurements that work independently of local reporting capacity. Satellite imagery can track physical changes like green area growth, building construction, and surface permeability over time without requiring cities to collect and submit data. While cities provide detailed information about governance, participation, and project-specific outcomes, satellite and open data sources verify physical implementation and broader urban trends. This dual approach reduces the monitoring burden on cities while maintaining accountability and making it possible to assess whether local projects translate into measurable citywide changes.

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8 Annex I: MIT Overpass Script Queries

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***CITYNAME EXAMPLE**: :"Rotterdam"

CYCLEWAY QGIS EXTRACTION

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(
  way["highway"="cycleway"](area.searchArea);
);
out body;
>;
out skel qt;
```

AMENITIES NEAR CYCLING WAYS

```
[out:json][timeout:300][date:*DATE];
area[name=*CITYNAME]->.searchArea;
(
 nwr["railway"~"station|halt|tram_stop"](area.searchArea);
 nwr["public_transport"~"station|platform"](area.searchArea);
 nwr["highway"="bus_stop"](area.searchArea);
);
out count;
(
  nwr["amenity"~"university|college|school"](area.searchArea);
);
out count;
(
 nwr["leisure"="park"](area.searchArea);
 nwr["shop"="supermarket"](area.searchArea);
);
out count;
```

```
(
 way["highway"="cycleway"](area.searchArea);
 way["cycleway"~"lane|track|opposite_track|shared_lane"](area.searchArea);
)->.all_cycleways;

(
 nwr["railway"~"station|halt|tram_stop"](area.searchArea)(around.all_cycleways:200);
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);
out count;
(
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);
out count;
(
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 way["cycleway"~"lane|track|opposite_track|shared_lane"](area.searchArea);
)->.all_cycleways;
(
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);
out count;
```

NUMBER OF PUBLIC TRANSPORT STOPS

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```
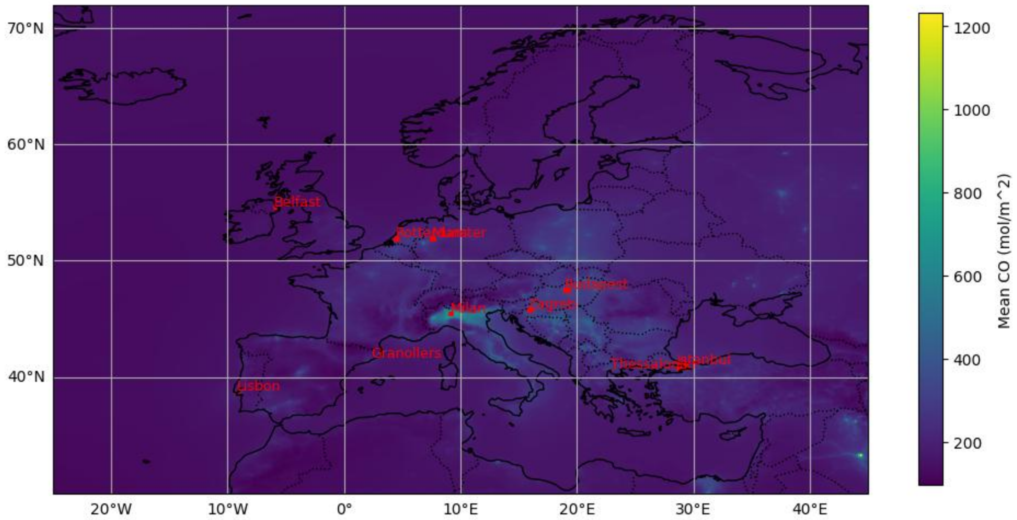
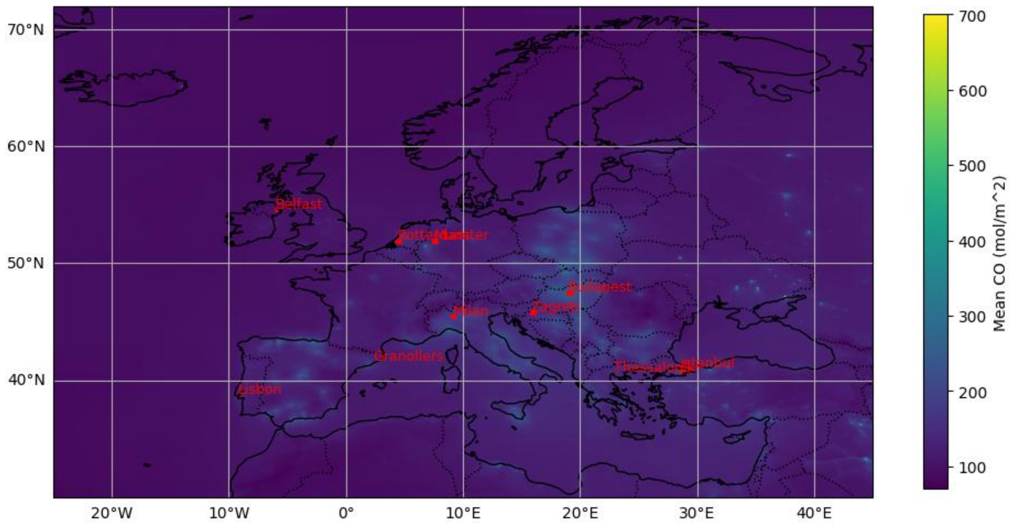

9 Annex II: Mean CO Concentration History

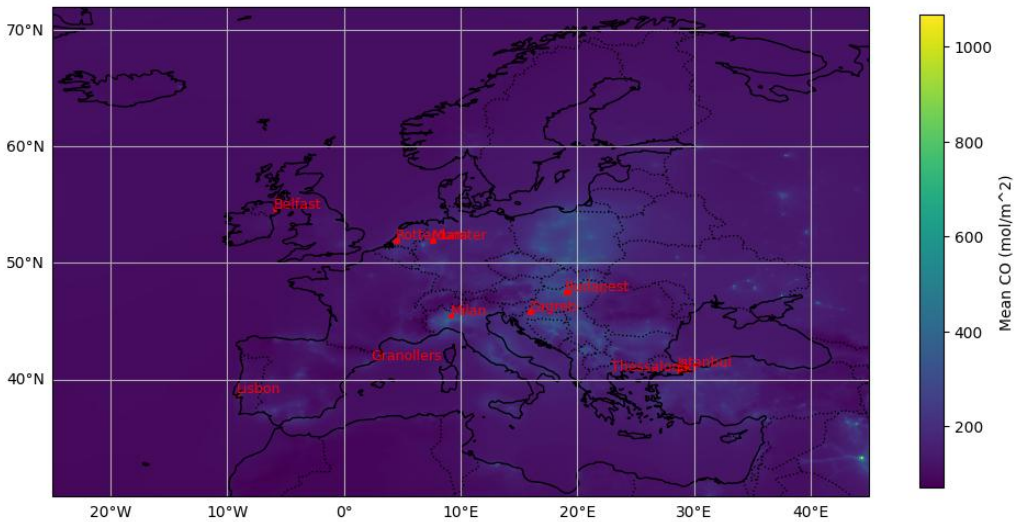
Mean CO Concentration - 2022-01

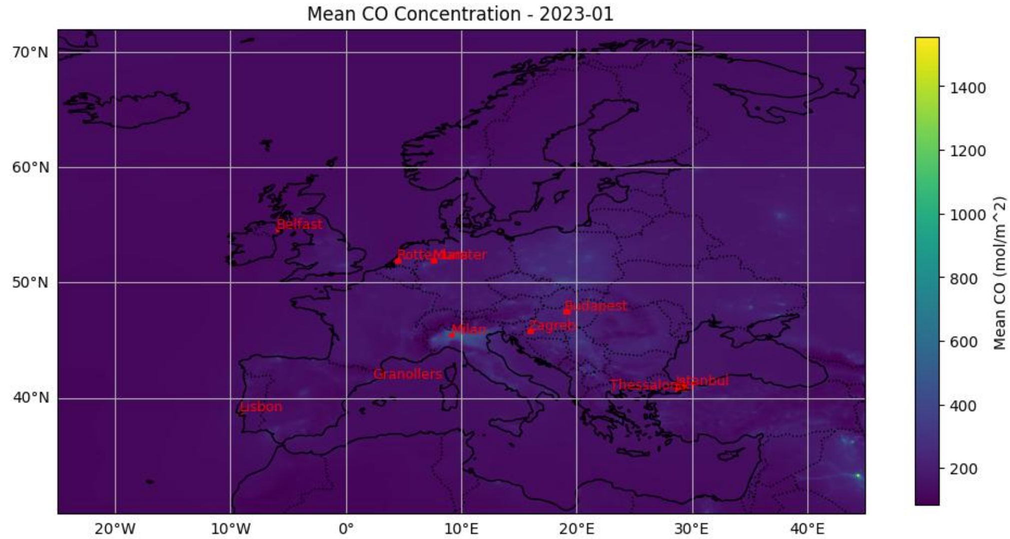


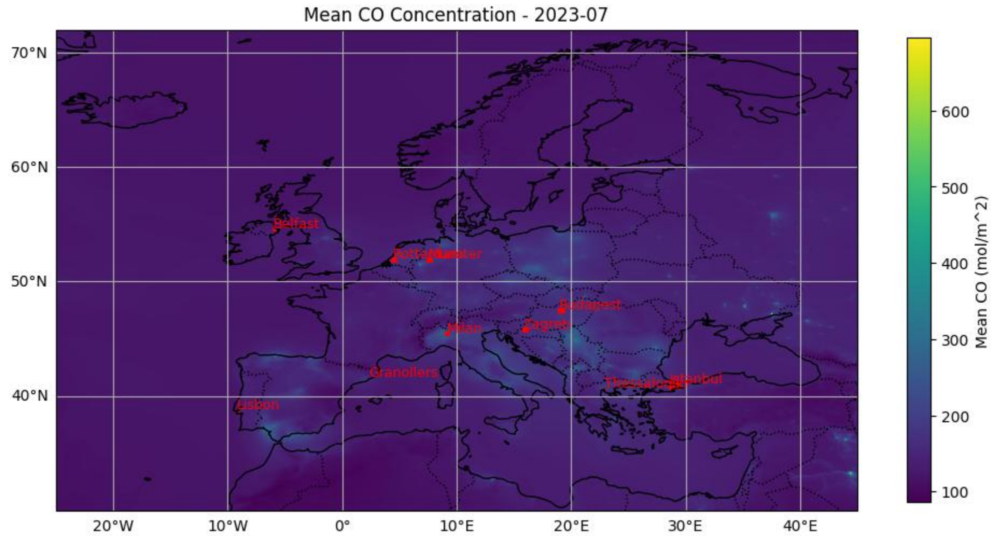
Mean CO Concentration - 2022-07

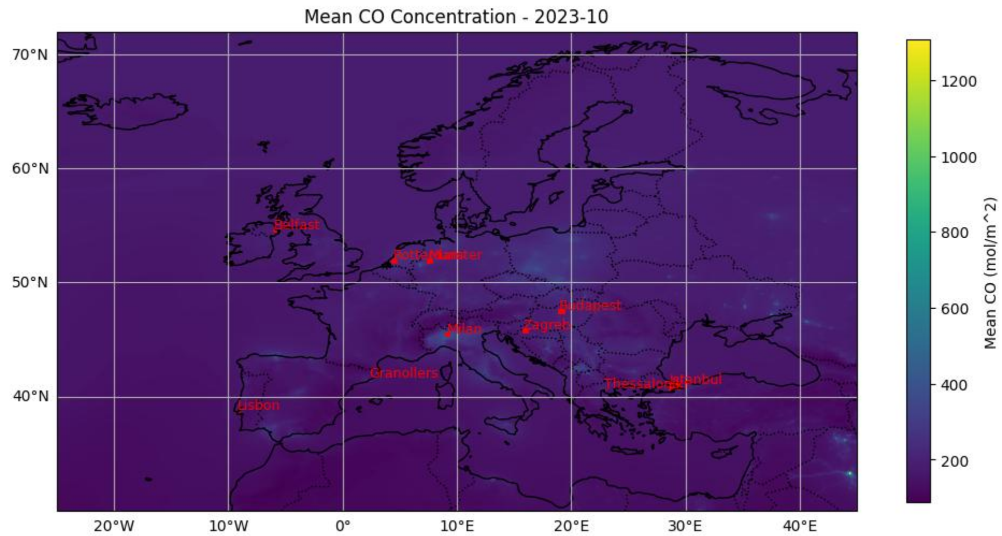


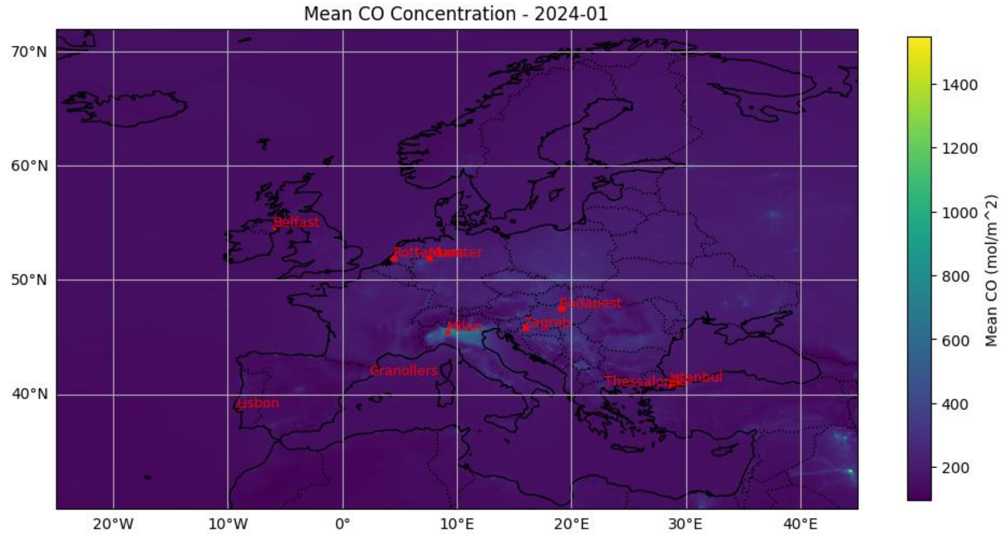
Mean CO Concentration - 2022-10

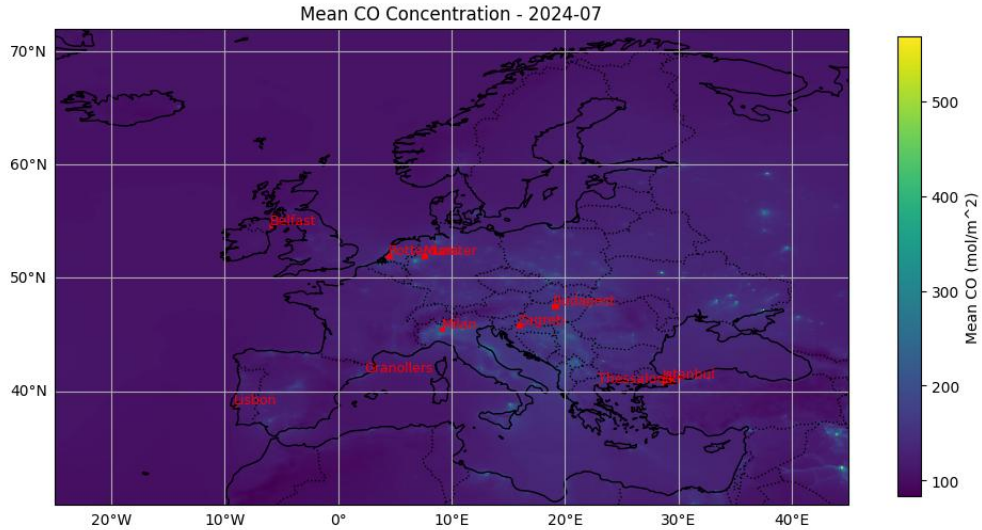


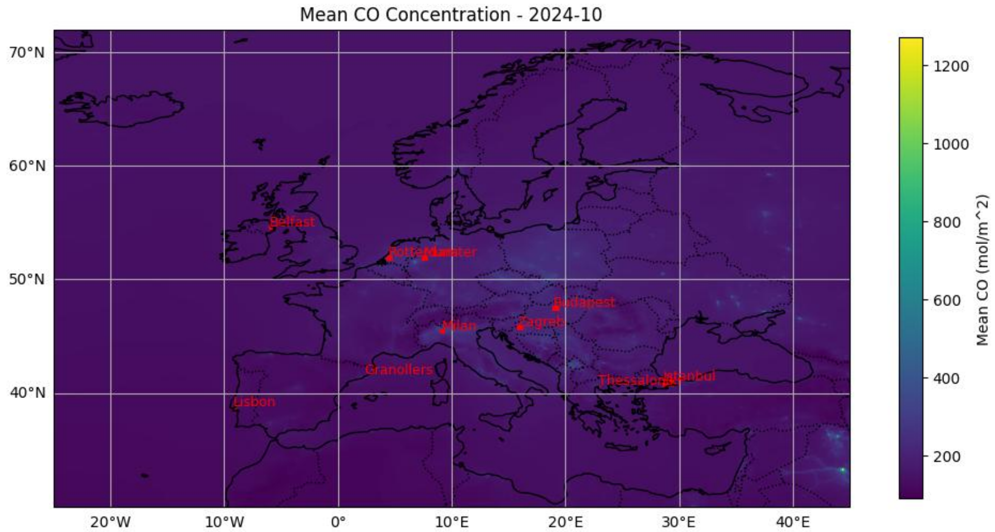

Mean CO Concentration - 2023-01
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Budapest
Zagreb
Milan
Granollers
Lisbon
Istanbul
1400
1200
1000
800
600
400
200
Mean CO (mol/m^2)


Mean CO Concentration - 2023-07
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Budapest
Milan
Granollers
Lisbon
Istanbul
600
500
400
300
200
100
Mean CO (mol/m^2)

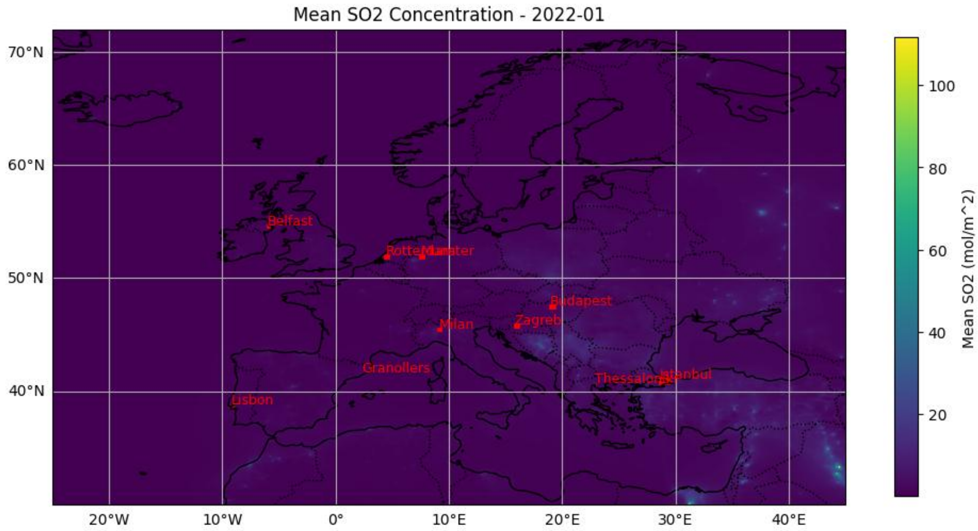

Mean CO Concentration - 2023-10
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Budapest
Zagreb
Milan
Granollers
Lisbon
Istanbul
1200
1000
800
600
400
200
Mean CO (mol/m^2)

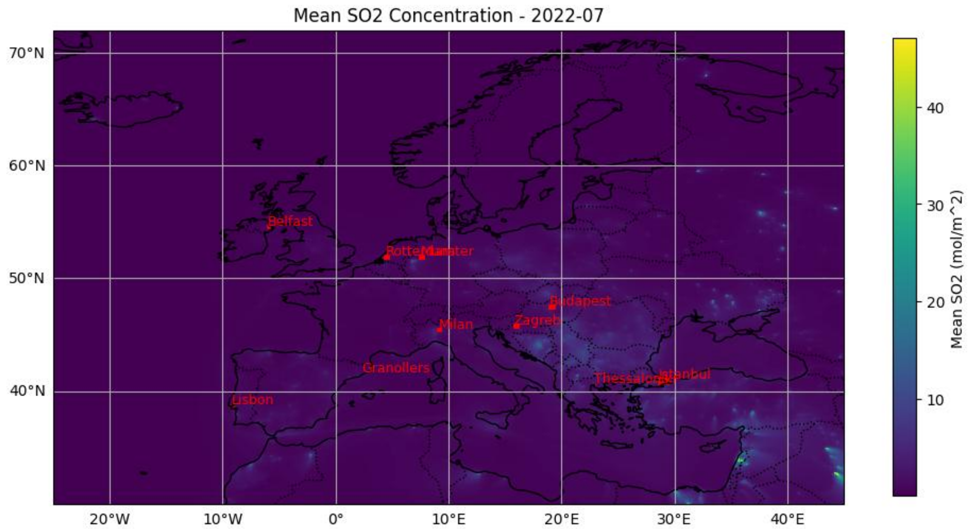

Mean CO Concentration - 2024-01
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Budapest
Zagreb
Milan
Granollers
Lisbon
1400
1200
1000
800
600
400
200
Mean CO (mol/m^2)

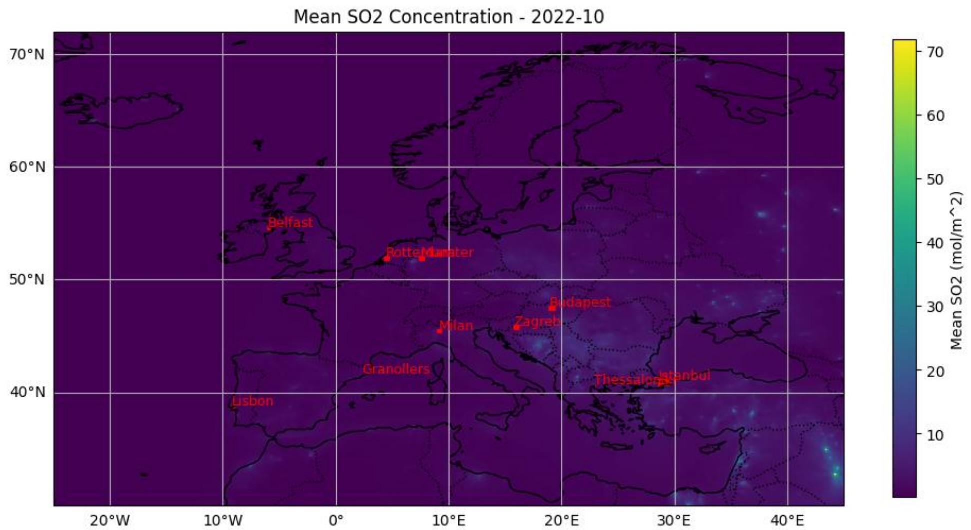

Mean CO Concentration - 2024-07
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Budapest
Zagreb
Milan
Granollers
Lisbon
500
400
300
200
100
Mean CO (mol/m^2)

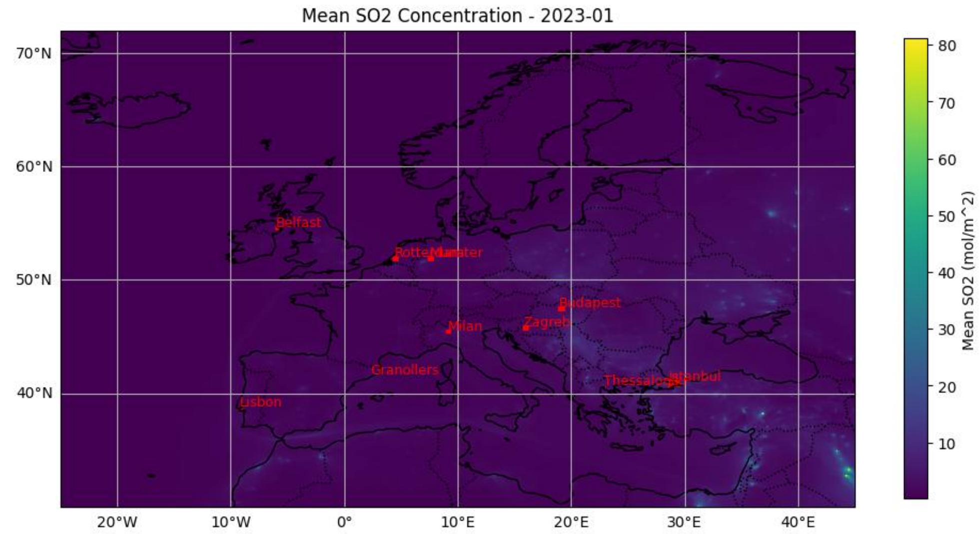

Mean CO Concentration - 2024-10
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Budapest
Zagreb
Milan
Granollers
Lisbon
1200
1000
800
600
400
200
Mean CO (mol/m^2)

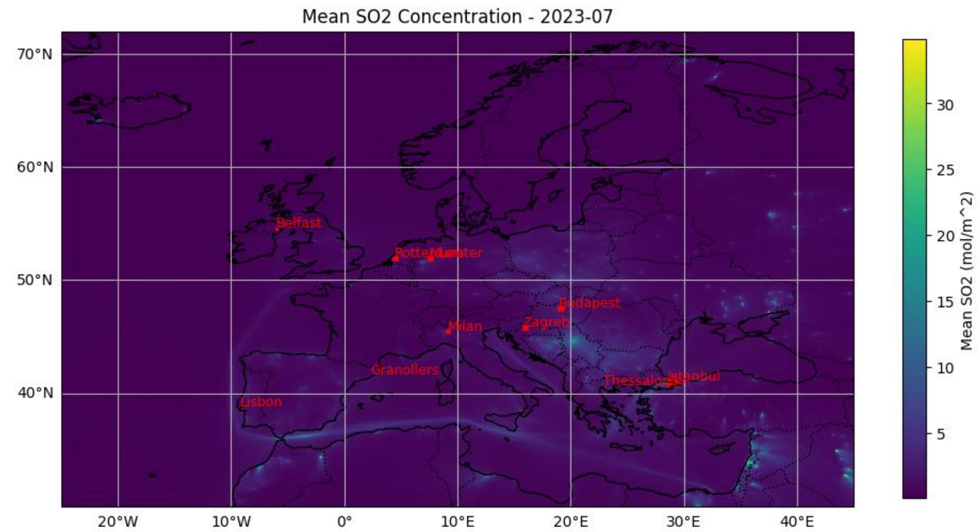
10 Annex III: Mean SO_2 Concentration History

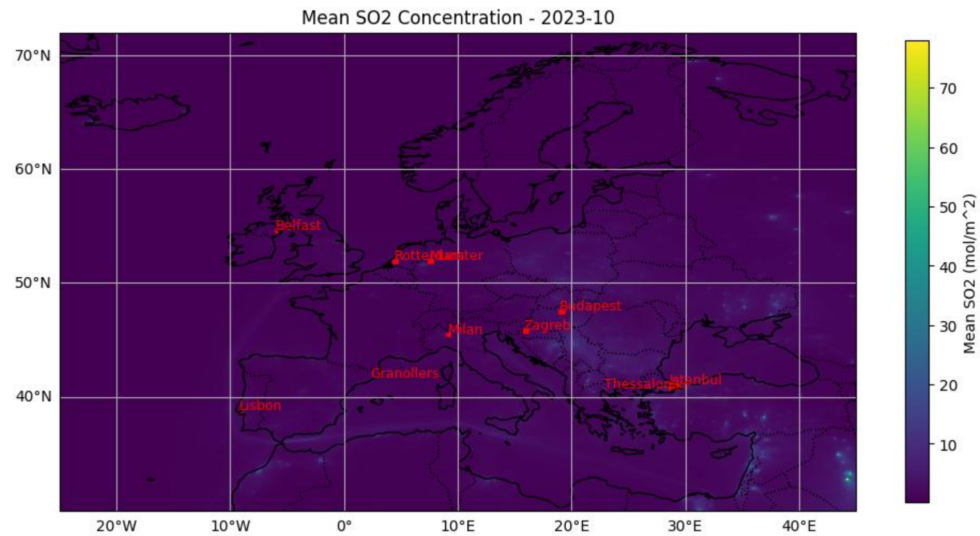


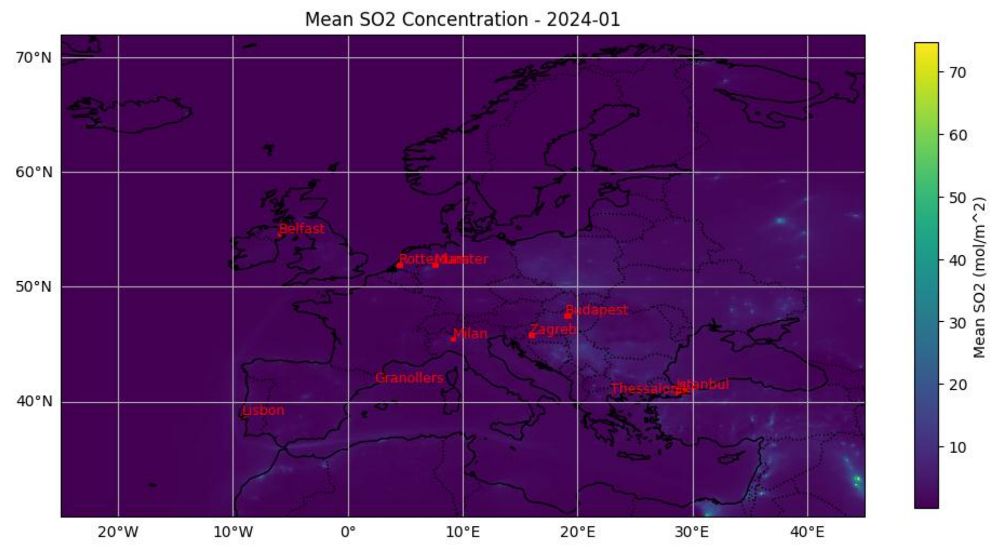


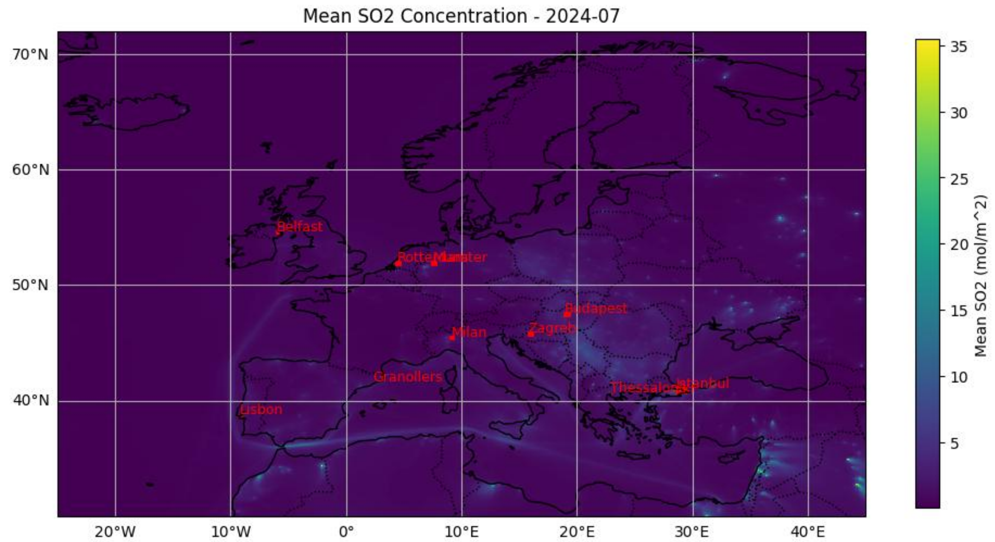


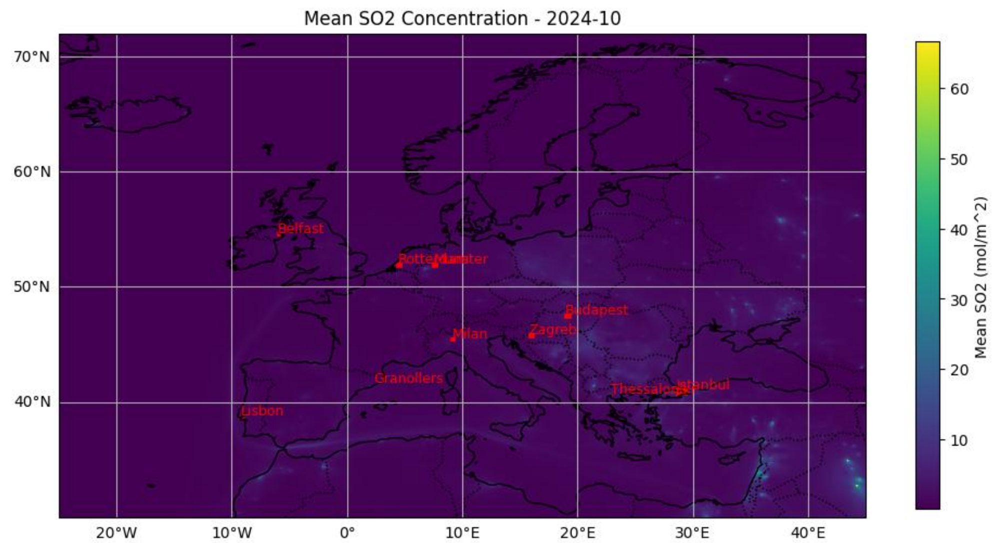

Mean SO2 Concentration - 2023-01
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Granollers
Lisbon
Milan
Zagreb
Budapest
Mean SO2 (mol/m^2)
80
70
60
50
40
30
20
10


Mean SO2 Concentration - 2023-07
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Granollers
Lisbon
Milan
Zagreb
Budapest
Mean SO2 (mol/m^2)
30
25
20
15
10
5


Mean SO2 Concentration - 2023-10
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
Belfast
Granollers
Lisbon
Milan
Zagreb
Budapest
Mean SO2 (mol/m^2)
70
60
50
40
30
20
10


Mean SO2 Concentration - 2024-01
Mean SO2 (mol/m^2)
Belfast
Budapest
Milan
Zagreb
Granollers
Lisbon
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E


Mean SO2 Concentration - 2024-07
Mean SO2 (mol/m^2)
Belfast
Budapest
Milan
Zagreb
Granollers
Lisbon
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E


Mean SO2 Concentration - 2024-10
Mean SO2 (mol/m^2)
Belfast
Budapest
Milan
Zagreb
Granollers
Lisbon
70°N
60°N
50°N
40°N
20°W
10°W
0°
10°E
20°E
30°E
40°E