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Urban Planning and design ready for 2030

D4.4 - Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 1

WP4 – UP-GRADING: Piloting and demonstrating

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Author(s)	**Majsa Ammouriova (UPV) and Veronika Tsertsvadze (UPV)**				
Reviewer(s)	**Trinidad Fernandez (Fraunhofer), Leon Kapetas (RCN), Nilofer Tajuddin (RCN), Grigoris Kalogiannis (DRAXIS), Anastasios Karakostas (DRAXIS), Catalina Diaz (Fraunhofer), and Constanza Vera (Fraunhofer)**				
Abstract	**The UP2030 project utilises Key Performance Indicators (KPIs) to assess actions in pilot cities, aiming to achieve a shared vision. This involves identifying, measuring, and monitoring these KPIs to gauge progress and impact. The process starts with pilot visions, aligning KPIs with objectives for a meaningful assessment. Data collection and analysis are critical for quantifying KPIs, with 15 Core KPIs identified to reflect the project's ambitions. The deliverable outlines KPI identification, pilot profiling, KPI list, data requirements, and dissemination strategies. KPIs are essential for monitoring project progress, aiding decision-making, and ensuring alignment with objectives. They measure progress, support decisions, promote accountability, and drive improvement, bridging the gap between strategy and operation.**				

Document History

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Contents

List of Figures

List of Tables

Executive Summary

The key performance indicators (KPIs) are quantifiable measures that describe the state of a system. They demonstrate how a system achieves set objectives. Different KPIs are defined to evaluate the success and achievements of a system. In the context of the UP2030 project, several methods will be implemented on the identified pilots. These methods aim to achieve the pre-defined vision by the partner cities in their pilots. KPIs should be determined to measure these achievements and study the impact of these actions within the project's lifetime.

Identifying the KPIs is a process with numerous steps, starting from getting to know the pilots' and project's visions to defining the appropriate KPIs. The initial list of KPIs could be identified based on the determined pilots' vision and targets. It is required to determine those KPIs that are linked with project objectives and vision and be measurable at the same time. The measurability of KPIs should be confirmed for their identification. Each KPI requires one or more data to determine its quantitative value. Thus, the measurability of KPIs depends on the availability and ability to collect the needed data. Therefore, the identification process of the KPIs is not linear; the initial list of KPIs is updated according to feedback and revisions. The feedback includes consideration of other KPIs or removing KPIs from the list.

In the context of the UP2030 project, around 15 KPIs are identified. These KPIs reflect the project's ambition and are called core KPIs. To assess the ability to measure these KPIs, they are broken down based on the required data to be collected. In the workshop carried out at Lisbon's General Assembly, the required data was communicated to the involved partners (Pilot Cities and City Liaisons). Accordingly, initial feedback was received concerning the measurability of the needed data. This feedback serves as the base for the identification of cities capabilities in collecting the needed data for KPI measurement. Because of the pilots' differences and the variety of methods applied to them, pilot-specific KPIs are identified. A preliminary list of KPIs is currently constructed based on the pilots' vision and storyline (D4.1).

After KPI identification, the needed data is collected to assign to each KPI its quantitative value. The data is to be collected at the beginning of the project, during the project lifetime, and at the end of the project. The assigned KPI values at the start of the project demonstrate the "As-Is" state before the implementation of selected methods. KPIs values during the project lifetimes illustrate the evolution of the pilot. The final KPI values are the end state of the pilot after the project's lifetime. The measured KPIs enable the analysis of the pilots' evolution and assess the methods' impact. These further analyses form a rich input to the engagement taskforce as well as the policymakers and decision-makers.

Section 2 of this report describes the process of identifying the KPIs. In Section 3, the pilot profile based on which the KPIs are identified is introduced. Then, Section 4 presents the derivation of the list of KPIs. Section 5 describes the data collection and analysis concerning the KPIs. Finally, Section 6 defines the dissemination in the context of the UP2030 project.

Content alignment with other UP2030 deliverables

The UP2030 project fosters exchange and cooperation among partners and deliverables beyond the work package's structure. Therefore, the content of this document has been developed in alignment with the WP4 and WP2; UIC, RCities, and Benchmarking, Monitoring, KPIs Taskforce, as well as D4.2. 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 D4.1 – UP2030 pilot implementation plan for the pilot cities 1 D4.2: UP2030 implementation plan for the pilot cities 2	D5.1: Analysis and recommendations for transformative governance and policy 1 D4.5: Report on monitoring, evaluation and KPI validation in the 5UP-approach implementation pilots 2 D3.6: Digital planning and design tools for climate neutral cities 1 D3.8: Tools and approaches for promoting inclusive participation and spatial justice 1
M4: Cities have set-up LAAs M5: Cities run first workshop on needs	M10: Cities run third workshop on action M13: All cities have at least one successful prototype M14: 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 (R-Cities, TSPA, BH, DRAXIS). The main beneficiaries of this deliverable will be taskforce leaders related to implementation of methods and their assessment as well as project coordinators. Some parts of this report are based on the contact with Pilot Cities and City Liaisons, and the further versions of this report analyse the impact of implemented methods on the pilot cities. Thus, input from Pilot Cities and City Liaisons is needed during the project's lifetime. The report is to be shared with the project coordinators, WP4, and Pilot Cities and City Liaisons.

Acronyms

Acronym	Full name
BH	Buro Happold GMBH
D	Deliverable
DRAXIS	DRAXIS Environmental S.A.
GenALisbon	General Assembly Lisbon
ICT	Internet and Communication Technology Infrastructure
IoT	Internet of Things
KPIs	Key Performance Indicators
M	Milestone
TSPA	Thomas Stellmach Planning & Architecture
WP	Work package

1 Introduction

Measuring the progress in the UP2030 is crucial to ensure the success of the cities and their pilot evolution. For this purpose, monitoring defined KPIs is one of the vital steps incorporated in project management. These KPIs could then be used as a compass to guide the decision-makers and policymakers (Parmenter, 2015). In the context of UP2030, the KPIs assess the applied methods and show the evolution of pilots achieved during the project period.

KPIs are quantifiable measurements that allow decision-makers and policymakers to assess their progress toward defined goals and objectives. Identifying these KPIs is aligned with objectives to observe whether they are achieved. Based on them, achievable milestones could be identified, and a clearer project vision is articulated.

The KPIs play a significant role in the project. Its importance is found in (i) providing quantifiable means for measuring the progress in the project, (ii) ensuring the alignment with project goals, (iii) supporting the decision-making process, (iv) promoting accountability, and (v) enabling continuous improvement by identifying trends and taking corrective actions. KPIs support decision makers in locating the gap between the pre-defined objectives and the achievement, and KPIs help them to bridge the gap between the strategic and operational levels (Juan et al., 2023; Soriano-Gonzalez et al., 2023).

The work in task T4.3 (Monitoring, Evaluation and KPI validation) extends other tasks in the UP2030 project. For instance, the benchmarking activities influence the definition of KPIs as well as the definition of the cities' storylines and visions. In addition, organized workshops form a valuable input for KPI definition, such as the Lisbon's General Assembly workshop (GenALisbon), in which discussion enrich the knowledge transfer. In addition, D4.1 (UP2030 pilot implementation plan for the pilot cities 1) and D4.2 (UP2030 implementation plan for the pilot cities 2) provide valuable input with respect to pilots' stories and visions.

The definition of KPIs is the starting step in evaluating and monitoring in the UP2030 project. Their definition is essential in setting the monitoring process of the project impact and changes. Monitoring the KPIs serves as an aid for the project by comparing and evaluating the evolution of the pilots in the context of the UP2030 project. The pilot is defined as a city district undergoing changes in the progress of the UP2030 project. These pilots could be an existing district that will be improved and renovated or new districts to be constructed. The size of the pilots differs between the involved cities as well as the cities themselves. Some of these cities could have some experience in one or more selected methods to be implemented during the UP2030 project. Thus, these cities are examples of the method implementation.

The validation of KPIs is an iterative process. This deliverable describes the process of defining a preliminary list of KPIs, the process of their validation, as well as an example of their analysis. In the next deliverable submission, a validated list of KPIs will be presented, as well as initial KPI values associated with these KPIs. These KPIs form a guide for the cities in tracking the evolution and changes in their districts during the project and after it.

2 KPIs Identification and Monitoring Process

The genesis of KPIs is deeply rooted in business management, serving as pivotal tools for translating organizational strategy into measurable action. In the broader spectrum of the project's scope, KPIs are not merely numerical values but pivotal signposts that guide the trajectory towards achieving the smart city objectives. These indicators are the quantifiable companions of the project's strategic intents, ensuring that every stride taken is in concordance with the overarching mission of urban transformation.

In the pursuit of operational excellence and strategic clarity within the smart city initiatives, it is imperative to establish a robust framework for monitoring and evaluation. The methodology is iterative, designed to capture the dynamic nature of urban development projects. This process is not static; it is a living system that adapts, evolves, and responds to the shifts in the project implementation. Figure 1 shows the methodology that is described in the subsequent paragraphs.

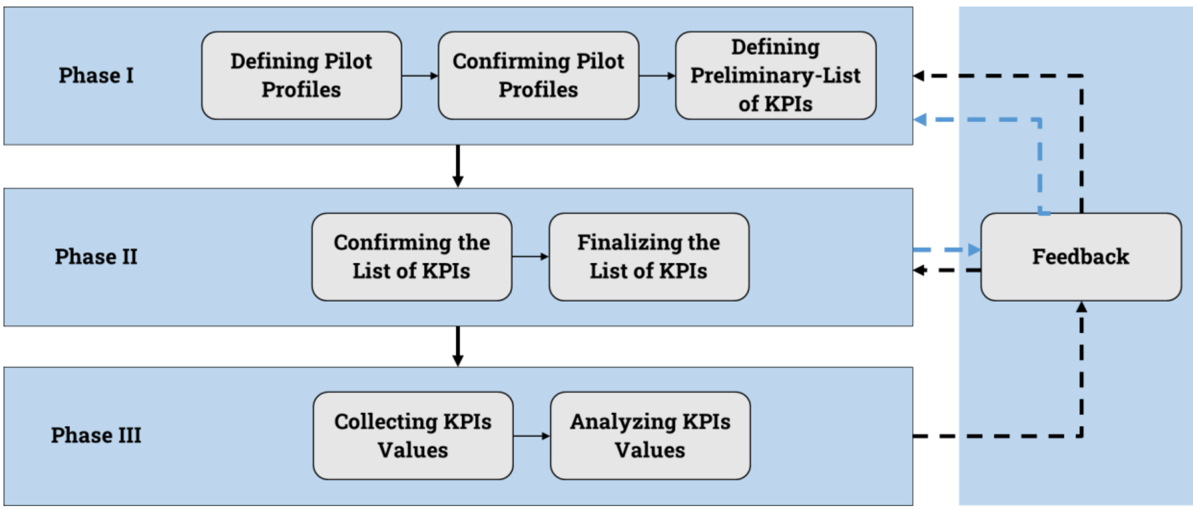

Figure 1: KPI monitoring process

2.1 Phase I: Strategic Alignment and Preliminary Design

Phase I is the initial phase of the process aiming to draft a list of KPIs for the following phases. This phase starts with defining the pilots' vision and storyline, which is considered a valuable input. Thus, this phase is planned to be finished in 2023. Below are the steps involved in this phase:

1. **Strategic Profiling of Pilots**: In Phase I of the monitoring process, the objective is to gain an intimate understanding of each pilot city. This initial stage is critical as it lays the groundwork for the tailored approach, beginning with the crafting of distinct city profiles with the cooperation with TSPA. These profiles are instrumental in defining the categories of KPIs that are pertinent, and of interest, for measurement within each pilot. It is essential that these profiles are not only meticulously developed to reflect the unique urban priorities but also validated in close collaboration with the Pilot Cities and City Liaisons. Such confirmation ensures that the selected KPIs resonate with local needs and strategic aims, establishing a synchronized evaluation that is attuned to the vision and aspirations of each urban landscape.
2. **Validation of Pilot Profiles**: The validation of pilot profiles is a multi-faceted process designed to ensure that the KPIs chosen to reflect the strategic intent of the project and are sensitive to the specific characteristics of each urban environment. The typical process would unfold as follows:

a. **Stakeholder Consultation**: Engage with key stakeholders from each pilot city, including city planners, local government officials, community leaders, and other relevant parties. These consultations aim to gather insights and perspectives that will inform the refinement of each city's profile. This validation process could be facilitated in the visioning workshop arranged by TSPA.

b. **Review of Strategic Documents**: Examine each city's storylines, development strategies, and policy frameworks. This review helps to align the pilot profiles with the city's long-term goals and the project's strategic objectives.

c. **Feedback Integration**: Collate feedback from the initial consultations and document reviews, identifying areas where the pilot profiles may need adjustments to reflect better the city's objectives and the project's goals.

d. **Profile Refinement**: Amend the profiles based on the feedback, ensuring that each KPI category is relevant and that the profiles adapt to each urban area's unique challenges and opportunities.

e. **Quantitative and Qualitative Analysis**: Utilize quantitative data (such as demographic statistics, economic figures, etc.) and qualitative insights (like residents' priorities, cultural significance, etc.) to validate and enrich the profiles.

f. **Iterative Review**: Establish an iterative review process, where profiles are repeatedly assessed and refined in a cycle of feedback and improvement, fostering a dynamic and responsive validation process.

g. **Final Confirmation**: Once the profiles are refined and considered to accurately represent the cities and align with the project's strategic intent, they are presented back to the stakeholders for final confirmation.

h. **Documentation**: The validated profiles are documented with clear justifications for the choice of KPI categories and metrics, providing a transparent account of the validation process and its outcomes.

i. **Approval and Sign-Off**: The final step involves formal approval and sign-off from the lead organizations and city liaisons, affirming that the pilot profiles are ready to be implemented in the monitoring phase.

3. **Preliminary KPI Formulation**: Here, a preliminary list of KPIs is constructed to measure the success of project interventions. These indicators are initially hypothetical and will evolve through successive phases of the project. During this stage, a dual categorization process is employed. This process involves the identification and classification of KPIs into two principal groups (Figure 2):

a. **Core (Common) KPIs**: These indicators are derived directly from the overarching goals of the project that all pilot cities are expected to implement. They represent the foundational metrics that will be consistently monitored across all urban pilots to ensure that the broader objectives of the project are being met. Core KPIs are critical for maintaining a cohesive direction and enabling cross-city comparisons and benchmarking.

b. **Pilot-specific KPIs**: Tailored to the unique context of each pilot city, these KPIs are selected to capture the localized goals specific to an individual city's strategic aims. They reflect the priorities, challenges, and opportunities within each urban environment and are crucial for measuring the success of localized interventions.

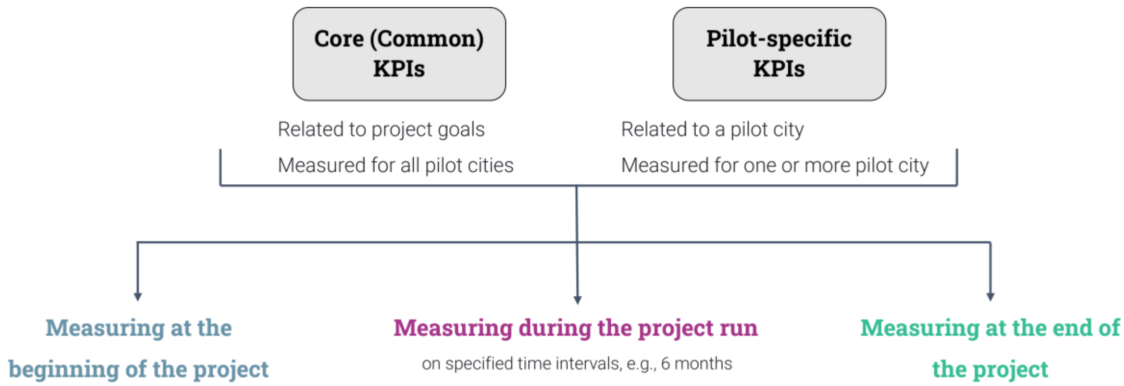

Figure 2: Classification of KPIs in the UP2030

To elucidate the potential temporal monitoring or measurement moments for Core (Common) and Pilot-specific KPIs, it is essential to consider three critical stages:

- **At Project Initiation**: In the initial phase of the project, monitoring focuses on establishing baselines for each KPI.
- **During Project Implementation**: Throughout the project's implementation, KPI monitoring is ongoing and responsive to the project's phases and needs.
- **At Project Completion**: Upon the project's conclusion, a final evaluation of KPIs is conducted to measure the outcomes and overall impact.

2.2 Phase II: Refinement and Ratification

1. **Engagement with cities and liaisons and KPI Confirmation**: The preliminary set of KPIs is subjected to a consultative process, engaging with cities and liaisons to confirm each KPI's relevance and practicality. The consultative process for confirming KPIs begins with the identification of key partners and cities, described below, followed by an initial communication that provides an overview of the preliminary KPIs. Detailed documents describing each KPI are distributed, and consultation sessions are scheduled to discuss them in detail, encouraging the exchange of views. Feedback is collected and the team analyzes and evaluates the responses to make necessary adjustments to the KPIs. Updates are communicated to participants, and once consensus is reached, the final list of KPIs is formally confirmed. Final documentation is prepared that includes the final list of KPIs and justifications. This guarantees that every KPI is logically sound and rooted in the operational realities of the project. The subsequent partners are crucial stakeholders who would be involved in verifying the relevance and practicality of each KPI:
   a. Research & Innovation Partners, who bring the technical expertise to ensure the KPIs are aligned with the latest urban planning and climate neutrality research. These partners include: R-Cities, TSPA, BH, UIC, and DRAXIS.
   b. City Representatives, who will ensure that the KPIs are relevant and can be operationalized within the urban context. These are the city councils of the cities involved in the UP2030 project.
2. **KPI Finalization**: Based on the received feedback, the KPIs list is finalized. This results in a calibrated suite of indicators ready to serve as the benchmarks which the project will be measured against.

2.3 Phase III: Execution and Analytical Review

1. **Methodical Data Acquisition**: In this execution phase, data collection for each KPI commences with precision and methodological rigor. Accuracy in data collection involves seeking information with a high degree of accuracy and detail, ensuring that the data representatively reflects the reality of the project's impact. This approach is essential when using open city data sources, where accuracy is linked to the veracity and timeliness of the available information. On the other hand, methodological rigor ensures consistency in data collection over time and across sources, especially during direct interaction with pilot cities and linkages. In these cases, it follows a structured approach to collecting project-specific data that may not be publicly available. This phase involves deploying tailored data gathering tools to accurately reflect the project's impact. The primary sources of data for this phase are:

    a. **Open Data from Cities**: Utilizing open data sets provided by the cities allows access to a wealth of information regarding urban infrastructure, socio-economic parameters, environmental data, and more. These data sets are regularly updated, and freely accessible, providing a baseline for KPI assessment. An example of such data set is found in Appendix 2 for cities in the UP2030 project. While open data from cities is an invaluable resource, it is recognized that the availability and quality of such data can be variable. Open data may not always encapsulate the full spectrum of KPIs required for comprehensive project evaluation, and in some cases, the quality may not meet the high standards necessary for accurate analysis. Consequently, the project must employ a multifaceted approach to data collection.

    b. **Direct Engagement with Pilots and Liaisons**: Since open data sources may not provide the granularity or scope required, direct interactions with pilot cities and liaisons become indispensable. This level of interaction is designed not only to collect project-specific data that may not be publicly accessible, but also to provide an ongoing feedback mechanism. It is envisaged that in case of changes in the KPI selection process or in the determination of the variables needed to measure a KPI, additional interactions will be carried out with the pilot cities and liaisons. These interactions will allow constant feedback, ensuring that the evaluation of the UP2030 project is dynamically and accurately adjusted to evolving requirements and objectives. This approach reaffirms the importance of maintaining active and collaborative communication with stakeholders to ensure the effectiveness and continued relevance of the project evaluation process. Through these interactions, project-specific data, which may not be publicly available, can be collected. These data points are crucial for a nuanced understanding of each pilot's unique context and for filling the gaps left by open data.

    c. **Surveys and Questionnaires**: Custom-designed surveys and questionnaires can yield valuable insights directly from the stakeholders most affected by the smart city initiatives. This primary data is often more targeted and can provide a depth of understanding that secondary data sources cannot.

    d. **Sensor Data and Internet of Things (IoT)**: Utilizing real-time data from IoT devices and sensors can supplement open data with high-quality, actionable insights that are often necessary for responsive project management and KPI monitoring.

2. **Comprehensive Data Analysis**: The data undergoes a comprehensive analytical process. The essence of this analysis is to distill the collected data into actionable insights, examining the extent to which the project meets its established benchmarks. In the data analysis subphase, the project will apply

advanced analytical methods to not only interpret the data, but also to predict and model future scenarios:

a. **Time Series Analysis**: This will involve examining patterns over specified intervals to detect trends and anomalies that may not be apparent in raw data.

b. **Forecasting and Predictive Analytics**: Statistical and machine learning models will be used to predict future trends and outcomes. This is crucial for proactive strategy adjustments and resource allocation.

2.4 Iterative Feedback for Continuous Improvement

1. **Adaptive Feedback Mechanisms**: The process is designed to be cyclical, with feedback loops for continuous improvement. This ensures that the project remains agile and can adapt and refine strategies in response to analytical findings.

Figure 3 illustrates the temporal framework of the project's three phases, strategically aligned over the timeline to maximize the efficacy of the monitoring process. The initial two phases are scheduled within the year 2023, a foundational period dedicated to the identification and confirmation of the KPIs. This crucial groundwork is set to be completed by the end of the project's first year, establishing a robust platform from which the subsequent monitoring activities will extend over the following two years, 2024 and 2025. This structured approach ensures that the KPIs are not only reflective of the project's strategic objectives but also positioned to capture the evolving dynamics of the smart city transformations as they unfold.

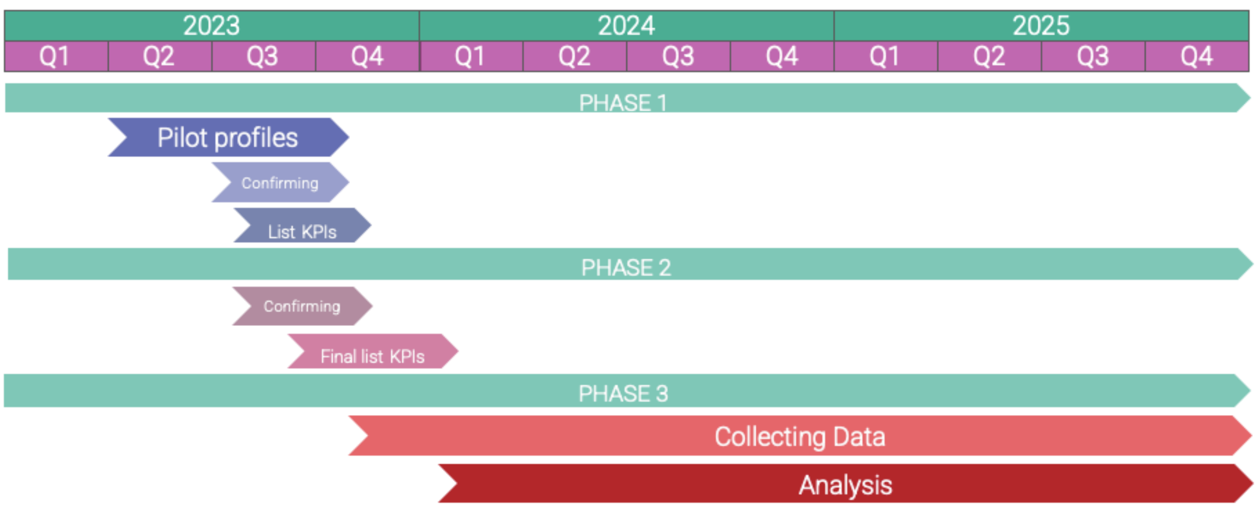

Figure 3: KPI identification, evaluation, and monitoring Gantt chart

3 Defining Pilot Profiles

In accordance with the UP2030 project's aim to instigate a socio-technical transition, the classification of KPIs is undertaken with an emphasis on integrating key thematic domains and cross-cutting expertise areas. The project identifies three primary domains—Connected, Compact, and Net-Zero—as the foundation for this endeavour. Each domain encapsulates distinct, yet interconnected, urban development aspects, reflecting the project's multifaceted approach to urban sustainability.

Each domain encompasses a distinct set of needs and objectives critical for shaping the project's vision of urban sustainability. The Connected City domain focuses on the advancement of urban connectivity and mobility, prioritizing integrated transportation systems, mixed-use development, transit-oriented planning, and the incorporation of smart technologies. In the Compact City domain, the emphasis is on efficient land use and fostering vibrant, cohesive communities, highlighting the importance of service proximity, mixed-use environments, social interaction, and sustainable waste management systems. Lastly, the Net-Zero City domain underscores the commitment to environmental sustainability, concentrating on energy efficiency, renewable energy generation, sustainable urban planning, and emission offsetting. These domains collectively frame the project's approach, with each domain's specific needs serving as the bedrock for defining relevant KPIs that align with the overarching objectives of creating sustainable, efficient, and inclusive urban spaces.

Consequently, pilot profiles are formulated not as mere representations but as dynamic constructs that articulate the project's core needs. Thus, every pilot city is expected to respond substantially to these needs, creating a feedback mechanism that propels the project forward. Given the diversity of the pilots, with their unique scales and specific goals, the endeavor extends beyond core KPIs to select Specific KPIs that align with the individual contexts of each city (Figure 2).

In alignment with Task T2.4 (Co-designing pilot shared visions and adaptive pathways for transformation), specific KPIs are carefully selected according to the foundational pillars of resilience, just transition, and decarbonization. These pillars ensure that the KPIs measure progress and reflect the values that the UP2030 project promotes.

The Carbon Neutral City pillar is centered around the concept of decarbonization, demanding a holistic approach in urban planning. This pillar encompasses efforts towards achieving Net-Zero targets, integrating urban design and management, as well as policies and engagement strategies that advocate a city-wide transition towards sustainability. Its core focus is reducing emissions across various urban aspects, from energy consumption to infrastructure design and operation.

Concurrently, the Resilient City pillar expands upon the traditional notion of resilience. It involves the city's capacity to adapt to various challenges, whether climatic, environmental, or social. This pillar highlights the need for robust urban planning, resilient governance structures, and the empowerment of communities in actively shaping their urban spaces. The goal is to ensure that cities are not just prepared for immediate threats, such as technological failures, but are also adaptable and sustainable over the long term.

The Just and Inclusive City pillar complements the other two by embedding the principles of justice within urban transformation processes. It addresses the socio-economic impacts of urban development, striving to ensure that urban planning and design transitions are equitable and do not exacerbate social vulnerabilities or lead to gentrification. This pillar emphasizes the importance of fair and inclusive urban development, ensuring the participation and consideration of all community members, especially those who are most vulnerable.

Together, these pillars guide the selection of specific KPIs for each pilot city in the UP2030 project. By aligning these KPIs with the varied needs and objectives of each domain, the project ensures that the strategies and actions are not only tailored to the immediate needs of each city but also contribute to the broader goals of sustainability, resilience, and inclusivity. This approach lays the groundwork for creating pilot profiles that accurately reflect the unique context and ambitions of each city, facilitating an effective implementation of the UP2030 project's objectives.

Likewise, the KPIs, meticulously aligned with these pillars, encompass a broad spectrum of areas, including economic, environmental, social, governance, propagation, and society and culture. This expansive approach ensures that the impact and progress of the project are not only measured in terms of environmental sustainability or infrastructural development but also consider economic vitality, social equity, cultural enrichment, and governance effectiveness. The inclusion of propagation as a dimension underscores the project's commitment to sharing knowledge and practices, thereby amplifying the impact of the initiatives undertaken. This holistic framework of KPIs, spanning across diverse yet interconnected domains, fortifies the project's ability to create sustainable, resilient, and inclusive urban environments, while fostering a balanced integration of various aspects of urban life.

To compile a comprehensive set of KPIs, a broad array of standards and frameworks has been reviewed. Resources such as United for Smart Sustainable Cities (U4SSC)[1], CITYKEYS[2], the City Resilience Index[3], and the World Benchmarking Alliance's Just Transition Methodology[4] have been consulted. These resources offer a rich perspective on the quantification of sustainability and are instrumental in guiding the measurement and management of urban community transitions towards low carbon footprints.

Figure 4 is presented as a central diagram in the context of the UP2030 project, systematically outlining the process of classifying and selecting KPIs. In its design, the central core highlights the three main domains of the project: Connected, Compact and Net-Zero, which form the basis of the initiative. Around this core, in an inner circle, the specific needs of each domain are detailed, from which the Core KPIs are derived. These indicators are evaluated in various scenarios, such as economic, social, governmental, environmental, etc. Wrapped in an outer circle are the core pillars of Resilience, Just Transition and Decarbonization. Each pillar represents a distinctive approach, from emission reductions in various urban aspects to the city's adaptive capacity in the face of climate and social challenges, as well as the integration of justice principles in urban transformation. Figure 4 therefore provides a key insight into the holistic approach of the UP2030 project, from the identification of specific needs to the assessment of KPIs in line with the key pillars of sustainability, resilience and inclusiveness.

[1] https://unece.org/DAM/hlm/documents/Publications/U4SSC-CollectionMethodologyforKPIfoSSC-2017.pdf
[2] https://cordis.europa.eu/project/id/646440
[3] https://www.arup.com/perspectives/publications/research/section/city-resilience-index
[4] https://assets.worldbenchmarkingalliance.org/app/uploads/2021/07/Just-Transition-Methodology.pdf

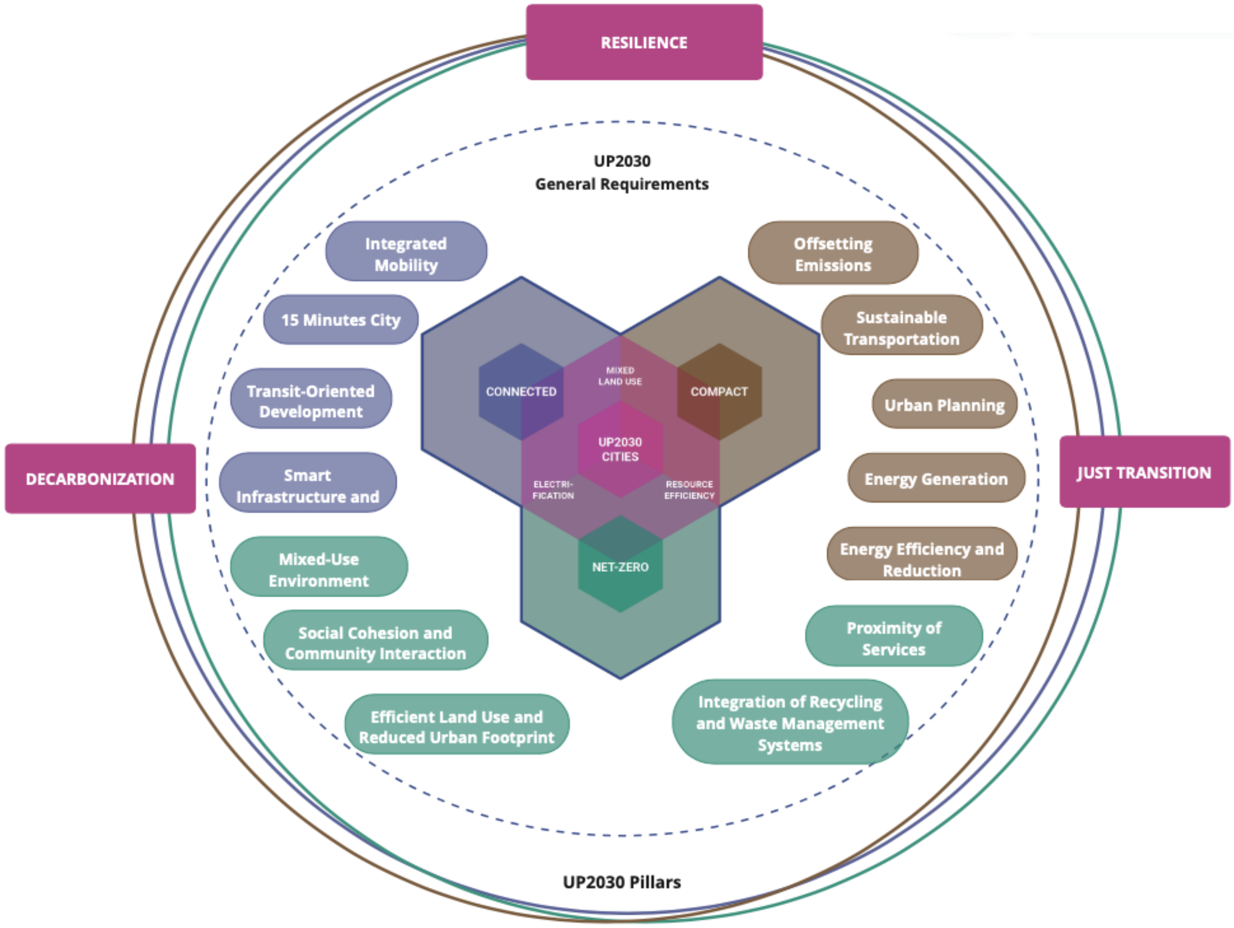

Figure 4: UP2030 project foundational pillars and domains

4 Identified List of KPIs

The process of defining the list of KPIs in the UP2030 project, categorized into core and specific KPIs, is governed by a set of meticulously selected criteria designed to ensure the effectiveness and relevance of the monitoring and evaluation process. Each of these criteria plays a crucial role in shaping a robust, comprehensive, and practical framework for KPI selection and assessment:

1. **Relevance:** This criterion underscores the importance of each KPI's alignment with the project's broader objectives and subthemes. A relevant KPI directly correlates with the project's goals, ensuring that the indicators accurately reflect the progress and impact of the project's initiatives. The relevance of a KPI is gauged not only by its alignment with the project's thematic goals, but also by its potential to drive meaningful insights and decision-making processes throughout the project lifetime.
2. **Completeness:** The indicator set must encompass all dimensions of smart city project implementation. Completeness ensures that no critical aspect of the project—environmental, social, economic, or technological—is overlooked. This holistic approach guarantees a comprehensive evaluation of the project, considering the multifaceted nature of smart city developments and the diverse objectives of the involved stakeholders.
3. **Accessibility:** This criterion focuses on the practicality of data collection. KPIs should be based on data that are readily available or can be collected with reasonable effort and resources. This ensures the sustainability and feasibility of the monitoring process over the project's duration. Accessibility also implies that the data sources are reliable and can be consistently tapped into for the duration of the project.
4. **Objective Measurability:** KPIs should be quantifiable in an objective manner. For qualitative aspects, which are often challenging to measure, methodologies from the social sciences should be employed to ensure that these aspects are captured in a semi-quantitative or quantifiable way. Objective measurability is crucial for maintaining the integrity of the evaluation process and for providing clear, unbiased insights into the project's outcomes. An example of a methodology from the social sciences that could be employed for the objective measurability criterion in the UP2030 project is qualitative content analysis. When dealing with qualitative aspects that are challenging to measure in a quantitative manner, such as public perception or social inclusivity, qualitative content analysis allows for a systematic and structured approach. This methodology involves systematically categorizing and interpreting textual or visual data to identify patterns, themes, and meanings. For instance, in the assessment of a smart city initiative's social impact, qualitative content analysis can be applied to analyze public feedback, social media sentiments, or qualitative survey responses. By employing this social science methodology, the project ensures that qualitative dimensions are captured in a semi-quantitative or quantifiable manner, aligning with the objective measurability criterion. This approach enhances the robustness of the evaluation process, providing a more comprehensive understanding of the social aspects of the project's outcomes.
5. **Clarity and Consistency:** Clear definitions and consistent methodologies for calculating the KPIs are essential. This clarity is vital to avoid ambiguities and misunderstandings in data interpretation. Consistency in calculation methods across different metrics ensures comparability and reliability of the data, which is crucial for accurately assessing progress and making informed decisions.
6. **Intelligibility:** The KPIs must be easily understandable to a wide range of stakeholders, including project team members, city officials, and the general public. This involves using familiar

terminologies or providing clear explanations for new concepts. Intelligible KPIs facilitate effective communication and engagement with all project stakeholders.

7. **Distinctiveness:** Each KPI should measure a unique aspect of the project's impact, avoiding redundancy. Distinctiveness ensures that the KPIs provide a diverse range of insights, covering different facets of the project without overlapping in their scope or focus. This diversity in measurement helps in painting a complete picture of the project's progress and impact.
8. **Autonomy:** The sensitivity of each indicator should be carefully calibrated so that changes in one do not disproportionately affect the evaluation of others. This independence among KPIs is crucial to ensure that each indicator provides specific, targeted insights without being unduly influenced by the performance of other metrics. This separation allows for a more nuanced and accurate assessment of different areas of the project.

Collectively, these criteria form a comprehensive and balanced framework for KPI selection, ensuring that the chosen metrics are not only reflective of the project's goals but also practical, reliable, and meaningful in their application and interpretation.

As previously mentioned, various resources have been utilized to compile a preliminary list of 128 KPIs, detailed in Appendix 1, which serves as a foundational pool for extracting the necessary information for each class of KPI—core and specific. From this extensive list, KPIs are selected. Those KPIs best align with, and most accurately quantify, the needs identified within the UP2030 project domains and the pillars of a connected, compact, and Net-Zero city. This methodical selection process guarantees that the final suite of KPIs is precisely curated to address the unique challenges and opportunities presented in each city, providing a critical tool for monitoring, analysis, and decision-making. This focused approach allows for a tailored set of KPIs that cater specifically to the nuanced requirements and strategic objectives of the project, ensuring that each selected KPI has the potential to provide significant insights into the project's performance and its impact on the urban environment.

2.1. List of Core KPIs

The derivation of Core KPIs has been methodically conducted with respect to the urban transformation domains, as delineated by the UP2030 project initiative: Connectivity, Compact City, and Net-Zero City. These domains encapsulate a spectrum of indicators that assess the urban milieu's baseline and facilitate the measurement of progressive transformations induced by the project's interventions. A deliberate translation of the intrinsic needs inherent to each domain has resulted in a curated selection of KPIs, crafted to reflect the essential attributes and projected advancements of the respective domains.

The interconnectivity among the designated pillars necessitates a multi-dimensional approach to KPI allocation. Consequently, certain KPIs demonstrate relevance across multiple domains, embodying the synergetic essence of the project's framework. This multidisciplinary relevance is illustrated in Figure 5, which maps the interrelations of the assorted KPIs to their corresponding UP2030 project domains. Such a configuration underscores the validity of the chosen KPIs, affirming that a broader array of KPIs delineating a domain equates to a richer, more granular understanding of the city's status and trajectory. This strategic approach ensures that the evaluation matrix aligns with and rigorously quantifies the dynamic scope of urban transformation envisaged by the UP2030 project.

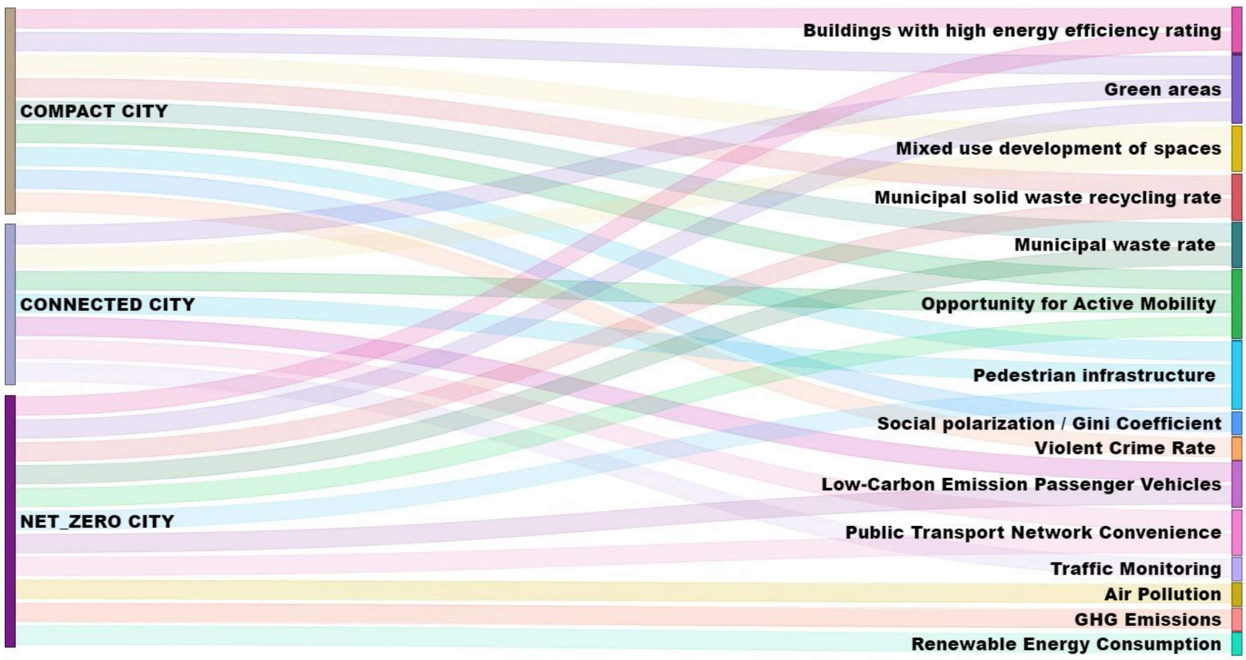

Figure 5: Relation between UP2030 domains and core KPIs

To ensure the measurability of the core KPIs, the necessary data required to be collected are broken down, as illustrated in Figure 6. These data are measured for a pilot or a city in a pre-specified period, depending on the available capability measurement.

1. Population (inhabitants)
2. Length travelled by public transportation (km)
3. Pedestrian areas (m^2)
4. Total green areas (m^2)
5. Total length of streets (km)
6. Total area of the pilot or city (m^2)
7. Total length of streets of active mobility (km)
8. Total length of streets controlled by Internet and Communication Technology Infrastructure (ICT)(km)
9. Total number of low-emission vehicles
10. Total number of vehicles
11. Total mixed-use area (m2), i.e., an area that combines various functions in the same space, such as housing, retail, offices and recreation. These areas promote the integration of activities, reducing the need for commuting and fostering more dynamic and sustainable urban communities.
12. Total number of buildings
13. Total energy efficient buildings

14. Total electricity consumption per period (kW/period)
15. Total energy consumption from renewable sources per period (kW/period)
16. Total emissions of tons of CO2 (tCO_2)
17. Average concentration (μg)/m3) of pollutants: N02, CO, NOx, SP2, PMIO, PM2.5
18. Percentage of total solid waste recycled
19. Kilos of total waste in the city per unit time (Kg/period)
20. Number of violent crimes
21. Social Polarization (%)

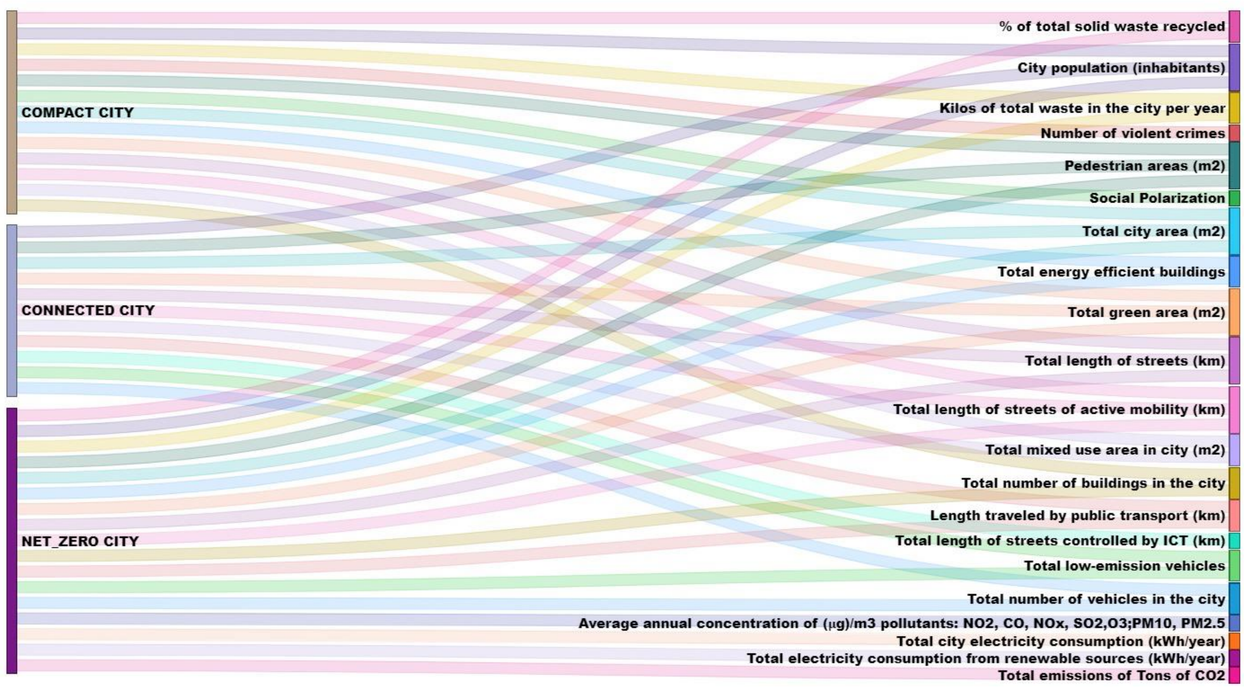

Figure 6: Relationship between domains and data needed for core KPI

In the context of the UP2030 project, the GenALisbon held in Lisbon (13 – 15 November 2023) marked a significant milestone in the evolution and refinement of the core KPIs. During this meeting, participating cities were urged to provide their critical and constructive perspective on the core KPIs. The specific request for feedback covered essential aspects such as the availability and quality of data, the frequency with which data could be collected and the level at which collection would be most relevant, either on a pilot scale or on a broader, city-wide basis.

This collaborative feedback and direct dialogue with the cities involved has resulted in a rich harvest of detailed information, which has been meticulously incorporated into Appendix 1 of the document. The annex, therefore, serves not only as a repository of data but also as a source of insights to better understand the context and capabilities of each participating city in the management and interpretation of the KPIs.

The information gathered from city feedback provides an invaluable basis for informed decision-making and guides the final selection of core KPIs. In addition, it helps to anticipate and plan for potential challenges in data collection. It also ensures that the selected KPIs are aligned with the operational and strategic realities of each urban environment.

The integration of this valuable feedback underscores the UP2030 project's commitment to a participatory and adaptive approach. Recognizing the diversity of circumstances and resources among cities, the project strives to establish a KPI framework that is both robust and flexible and that can be adjusted and refined over time, thus ensuring that project monitoring and evaluation are as relevant and effective as possible.

In the culminating section of the Core KPIs, the focus narrows to the granular specifics as provided in the tables of Appendix 1, which embody the collective intelligence of the urban survey. Each row stands as a testament to the approach adopted for each KPI:

- **Description including justification**: This row provides a narrative that describes the KPI and articulates the rationale behind its inclusion, ensuring its alignment with the project's objectives.
- **Definition**: Here, the precise contours of each KPI are delineated, establishing the parameters and boundaries within which it operates.
- **Normalization**: This segment addresses how the raw data will be standardized to allow for cross-comparison and contextual analysis, ensuring that the KPIs are universally applicable and interpretable.
- **Rating on a Scale**: This row proposes a scaling system to rate the performance or status of each KPI, transforming qualitative judgments into quantifiable metrics.
- **Relevance**: The relevance row underlines the significance of each KPI in relation to the project's broader aims and the specific domain it seeks to measure.
- **Limitations**: Acknowledging that no measure is without its constraints, this row candidly charts out any anticipated limitations or challenges inherent in each KPI.
- **Expected data source**: Identifies where the data for each KPI will be sourced, laying the groundwork for data procurement strategies.
- **Expected availability**: Addresses the expected ease or difficulty in obtaining the data, factoring in geographical, logistical, and policy-related variables.
- **Collection interval**: This outlines the frequency with which data will be gathered, ensuring timely and relevant insights into the project's progression.
- **Expected reliability**: Considers the dependability of the data sources, which is pivotal for the integrity of the KPI analysis.
- **Expected accessibility**: Discusses how the data can be accessed, including considerations around data sharing protocols and privacy concerns.
- **Expected data models**: Envisions the analytical frameworks or models that will be utilized to process and interpret the data, ensuring that the KPIs can be transformed into actionable insights.

Together, these rows construct a comprehensive schema that underpins the Core KPIs, ensuring that each indicator is robust, relevant, and reflective of both the project's ambitions and the practicalities of urban data ecosystems.

In short, the following table (Table 1) provides a summary of the feedback collected in Lisbon, more detailed in Appendix 1 as mentioned above. This feedback shows the cities' responses, Budapest, Lisbon, Belfast, Granollers, Istanbul and Zagreb, to whether they can collect data at the pilot area level or at the city-wide level, and the data collection frequency, i.e., once, annually, every half year or quarterly. Their feedback shows which data and, accordingly, KPIs that can be measured. For example, 'social polarization' cannot be measured by most of the responses and cannot be included in the final list of KPIs. Further investigation of its measurement is required before adding it to the final list of KPIs. This investigation involves the possibility of starting data collection related to the missing variables. Only the first two options are represented in the table. The notes provided by each city that participated in the feedback are also detailed. The summary will be updated after receiving the feedback from the rest of the cities.

Table 1: Summary of feedback collected in GenALisbon workshop.

	Place											Time											
Variable	**Pilot**					**City**						**Once**						**Yearly**					
Population		Lisbon	Belfast	Istanbul		Budapest	Lisbon	Belfast	Granollers	Istanbul	Zagreb		Lisbon	Belfast				Budapest			Granollers	Istanbul	Zagreb
Length travelled by public transportation	Budapest		Belfast	Istanbul		Budapest	Lisbon	Belfast	Granollers		Zagreb		Lisbon				Zagreb				Granollers	Istanbul	
Pedestrian areas	Budapest	Lisbon	Belfast			Budapest	Lisbon		Granollers		Zagreb		Lisbon	Belfast				Budapest			Granollers		Zagreb
Total green areas	Budapest	Lisbon	Belfast			Budapest	Lisbon	Belfast	Granollers		Zagreb	Budapest	Lisbon	Belfast							Granollers		Zagreb
Total length of streets	Budapest	Lisbon	Belfast			Budapest	Lisbon		Granollers			Budapest	Lisbon	Belfast							Granollers		
Total area of the pilot or city	Budapest	Lisbon	Belfast	Istanbul	Zagreb	Budapest	Lisbon	Belfast	Granollers	Istanbul		Budapest	Lisbon	Belfast		Istanbul					Granollers		
Total length of streets of active mobility	Budapest	Lisbon	Belfast	Istanbul		Budapest	Lisbon		Granollers	Istanbul		Budapest	Lisbon								Granollers	Istanbul	
Total length of streets controlled by ICT						Budapest			Granollers			Budapest			Granollers								
Total number of low-emission vehicles						Budapest		Belfast	Granollers					Belfast				Budapest			Granollers		
Total number of vehicles	Budapest		Belfast			Budapest	Lisbon		Granollers				Lisbon	Belfast				Budapest			Granollers		
Total mixed-use area	Budapest	Lisbon	Belfast			Budapest	Lisbon		Granollers			Budapest	Lisbon	Belfast	Granollers								
Total number of buildings	Budapest	Lisbon	Belfast	Istanbul		Budapest	Lisbon		Granollers	Istanbul		Budapest	Lisbon	Belfast	Granollers							Istanbul	
Total energy efficient buildings	Budapest					Budapest			Granollers			Budapest			Granollers								
Total electricity consumption		Lisbon		Istanbul	Zagreb	Budapest	Lisbon		Granollers	Istanbul								Budapest	Lisbon		Granollers	Istanbul	Zagreb
Total energy consumption from renewable sources		Lisbon				Budapest			Granollers									Budapest	Lisbon		Granollers		
Total emissions of tons of CO2					Zagreb	Budapest	Lisbon	Belfast	Granollers	Istanbul					Granollers			Budapest				Istanbul	Zagreb
Average concentration of pollutants		Lisbon				Budapest	Lisbon	Belfast	Granollers						Granollers				Lisbon	Belfast			
Percentage of total solid waste recycled		Lisbon				Budapest	Lisbon	Belfast	Granollers									Budapest	Lisbon		Granollers		
Kilos of total waste						Budapest	Lisbon	Belfast	Granollers									Budapest	Lisbon		Granollers		
Number of violent crimes		Lisbon				Budapest	Lisbon	Belfast	Granollers									Budapest	Lisbon	Belfast	Granollers		
Social Polarization						Budapest						Budapest											

Budapest Lisbon Belfast Granollers Istanbul Zagreb

2.2. List of Specific KPIs

Drawing from the foundational work outlined in the earlier sections of the proposal or Grant Agreement document, the construction of Specific KPIs is tailored to the distinctive needs and characteristics of each pilot city participating in the UP2030 project. This customization is essential due to the varied barriers and unique urban fabrics that each pilot presents. The Specific KPIs are not generic metrics; rather, they are the result of a careful extraction and adaptation process from the established base of KPIs, ensuring that each indicator resonates with the individual context of the pilot it is meant to serve.

The selection process for these Specific KPIs is inherently dynamic, engaging deeply with the specific challenges and aspirations of each city. This process considers the diversity in economic, social, environmental, and technological domains that typify each pilot. It is a rigorous exercise that considers not only the present state of the city but also its strategic trajectory towards the goals of connectedness, compactness, and carbon neutrality.

The methodology for developing these Specific KPIs involves an iterative consultation with each pilot city, delving into the granular aspects of their urban ecosystem. It includes an assessment of urban morphology, infrastructure maturity, policy landscapes, and the socio-economic fabric that underpins the city's operation. The barriers identified during these consultations—ranging from regulatory hurdles to infrastructural constraints—are critical in shaping the Specific KPIs, ensuring they are both ambitious and achievable.

By tailoring the KPIs in this manner, the project aspires to forge a set of indicators that not only benchmark progress but also illuminate the pathways to overcoming obstacles and unlocking the potential of each city. These Specific KPIs serve as a compass for targeted interventions, informed policymaking, and strategic city planning, ultimately facilitating the transformation into resilient, sustainable, and inclusive urban spaces. Each KPI thus becomes a building block in the comprehensive evaluation framework of the UP2030 project, reflecting an in-depth understanding of the interplay between a city's present conditions and its pursuit of a smarter, more sustainable future.

In this scenario, exchanging perspectives and feedback between the pilots' needs and capabilities with the dedicated task team is a cornerstone. This reciprocal dialogue is not merely supplementary; it is the lifeblood that ensures the analysis remains attuned to the evolving landscapes of the cities. Such an iterative feedback process is indispensable for calibrating the Specific KPIs, aligning them not just with the envisioned future but also with the pragmatic realities of present capabilities.

The relationship fostered through this exchange is essential in refining the defined approach. It enables the task team to adjust the analytical lens, ensuring that the KPIs reflect a balance between objectives and actionable insights. This ongoing conversation facilitates a mutual shaping of expectations and strategies.

Figure 7 serves as a strategic map for the UP2030 project, illustrating the intricate interplay between various urban elements and the three foundational domains that constitute the project's vision: Net-Zero (green), Compact (brown), and Connected (purple). This visual representation aids in understanding how different sectors (categories) of urban development—ranging from infrastructure and environment to society and governance—align with the overarching objectives of decarbonization, resilience, and just transition. Color-coded markers differentiate the contributions of each element to the corresponding domains, offering a comprehensive overview of the project's integrated approach to transforming urban landscapes. This map is not only a tool for analysis but also a blueprint guiding the prioritization and implementation of the project's initiatives, ensuring that each action taken resonates with the core mission of creating cities that are resilient, equitable, and attuned to the demands of the future.

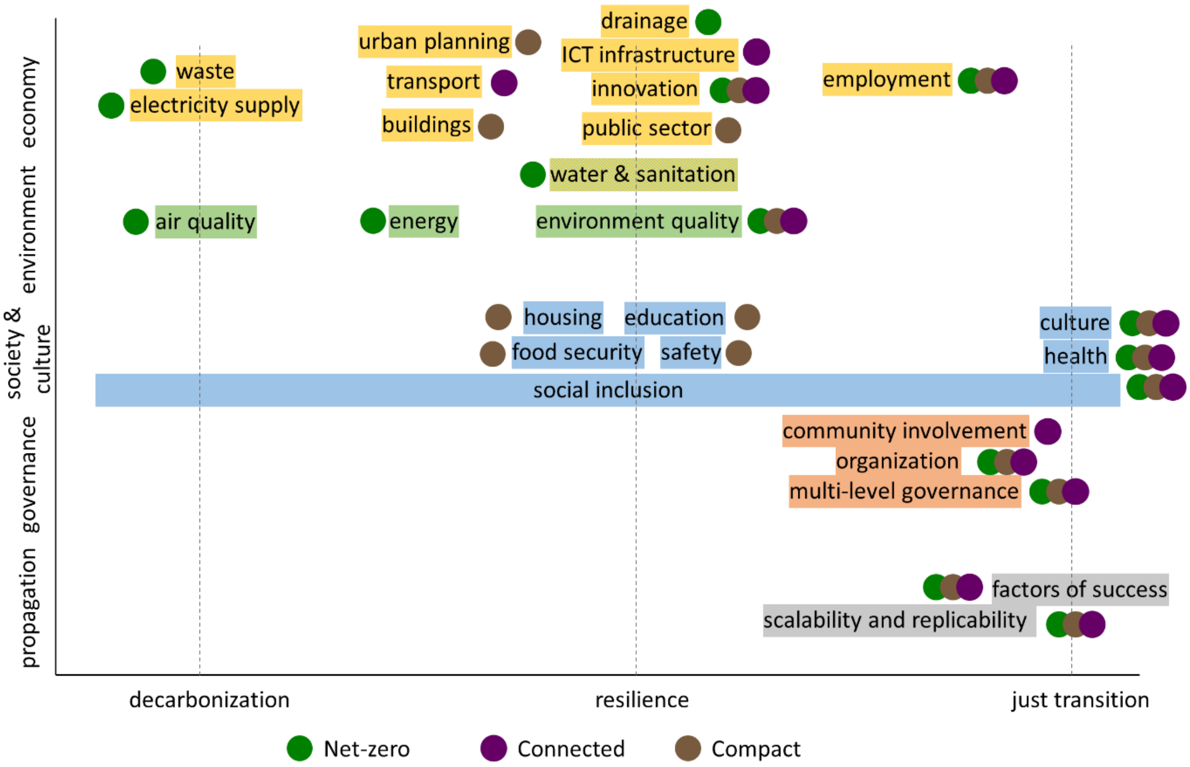

Figure 7: The distribution of categories with respect to defined domains and project pillars

5 Data Collection and Analysis

In the context of the UP2030 project, it is critical to understand why the collection and analysis of KPIs for cities play a crucial role in urban planning and development. Collecting measurable KPIs provides a solid basis for assessing the city's performance in various aspects, from resource management to residents' quality of life. Likewise, collecting historical data that assesses the evolution of the city's performance on various KPIs allows for an in-depth understanding of how it has changed over time. This is critical for assessing the impact of urban policies and methods implemented in the past. By understanding how KPIs have evolved, decision makers can identify areas for improvement and success. This provides an invaluable tool for cities in forecasting future trends. Time series models allow the future values of these indicators to be projected based on trends observed in past data. This predictive capability is not only valuable in itself, but also lays the foundation for informed decision-making and proactive strategies in various urban areas.

Standardizing the measurement of KPIs allows cities to compare their performance with other European cities in a more accurate and meaningful way. This provides a solid basis for benchmarking, meaning a city can assess its performance relative to other cities with similar characteristics and contexts. These comparisons provide valuable insights into the areas in which a city excels and those in which it can improve. Moreover, standardization facilitates collaboration between cities. Cities can share their experiences and best practices to address common challenges, leading to knowledge exchange that benefits all parties involved and contributes to the sustainable development of European cities.

The ability to measure and benchmark KPIs effectively supports improving the quality of life in the pilots. Cities will strive to outperform their peers in areas such as sustainability, air quality, mobility and more. This not only leads to improved performance in terms of quality of life for citizens, but also fosters innovation as cities seek to implement more effective and sustainable solutions. Additionally, policymakers and decision makers can use this data to assess the impact of urban policies and adjust them as needed. In addition, the monitoring of KPIs supports the efficient allocation of resources and prioritization of projects that have the greatest impact on the city.

Accountability is prompted when measuring and monitoring KPIs transparently. Citizens, organizations, and stakeholders can access this data and evaluate the performance of local authorities. This creates a system in which policymakers and decision-makers are accountable for their actions and results.

For illustration purposes, sample data analysis is presented in this section, shown in the figures below. Several KPIs were identified, and required data were looked for in the open-access dataset for Münster, Lisbon, Thessaloniki, and Zagreb. The collected sequential KPI measurements were used to forecast future values for the KPI using time series analysis. Time series models are based on well-known statistical techniques designed to analyze and predict data points that evolve over time. These models consider the temporal sequence of data, aiming to identify underlying patterns, trends, and seasonal variations. Among these models, Holt's double exponential smoothing is used when the time series shows a trend with no seasonality. This method expands upon simple exponential smoothing by introducing a trend component alongside the basic level component. This augmentation facilitates the capture of linear trends within the data. The approach incorporates two smoothing parameters, one for the level and another for the trend. This technique generates smoothed values that effectively combine information about the trend and the basic level by iteratively updating both the level and trend. The source for the open data is found in Appendix 2.

Examples of these plots are shown in the following figures. In Figure 8, the municipal waste is predicted for three years for Münster and Lisbon. The municipal waste includes commercial and household waste in the magnitude of 1000t. These two cities are similar in their population density. Despite this similarity, it is observed that the trend of tons of waste collected in Lisbon is almost seven times higher than in Munster.

Figure 8: Forecasted Municipal Waste in Munster and Lisbon

Another example is presented in Figure 9, referring to the unemployment rate (%) in Thessaloniki and Zagreb. This rate reflects the economic growth in the respective cities.

Additionally, Radar Plots are used as a powerful visualization aid. Radar Plots, also known as spider charts or network charts, are a graphical representation that allows multiple variables to be displayed on a single pie chart. Each variable is represented as an axis starting from the center of the graph and extending outward. The length of each axis corresponds to the value of the variable in question, and the area of the polygon that is formed reveals information about the set of variables. These graphs are used to facilitate detailed and direct comparisons between cities, allowing various key performance indicators to be assessed, such as the radar graphs shown in Figure 10.

In the radar chart, each city is represented by a polygon on the graph, and the shape and size of that polygon allows for quick interpretation of its performance on various key performance indicators. As an example, several radar charts are included to show data collected on a short list of KPIs from some of the most important European cities. These charts represent what kind of analysis can be carried out once the required and necessary data has been obtained. In addition, these charts illustrate how cities differ in terms of sustainability and performance in various key areas.

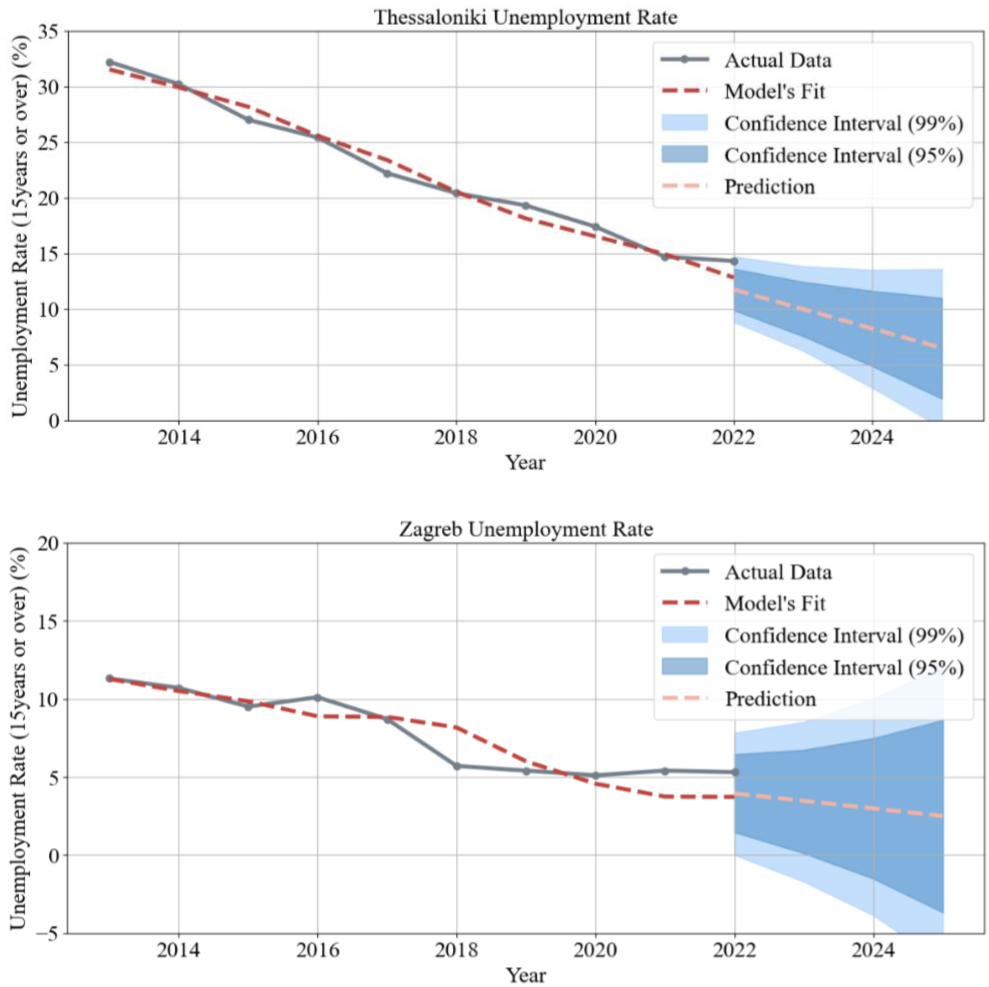

Figure 9: Predicted unemployment rate in Thessaloniki and Zagreb (Juan et al., 2023)

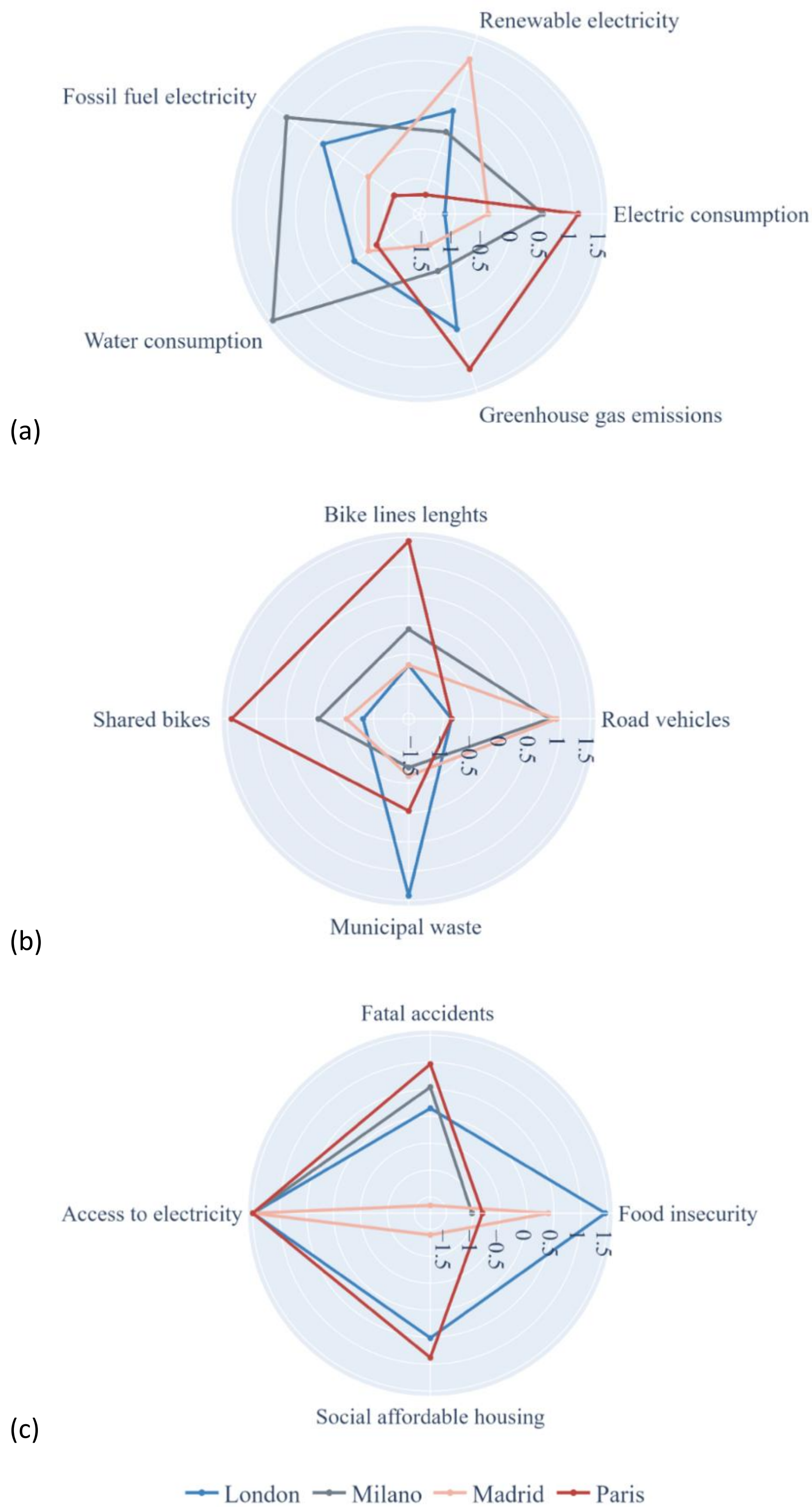

Figure 10: Radar plots for selected (a) environmental, (b) economic, and (c) social KPIs (Juan et al., 2023)

6 Dissemination Process

The analysis including the study of KPIs evolution during the progress of the project and the comparisons will be arranged in a format to be published. In the first step, two articles were published in Logistics[5] and Energies[6], as shown in Figures 11 to 14, respectively.

The first article, entitled "*Analyzing Key Performance Indicators for Mobility Logistics in Smart and Sustainable Cities: A Case Study Centered on Barcelona*", identified and examined key performance indicators (KPIs) related to citizen mobility logistics in smart and sustainable urban environments. The study, focused on Barcelona, used open data from the city council from 2017 and compared KPIs with other European cities, highlighting the importance of data quality and highlighting the need for attention to environmental data in sustainable mobility logistics.

The second article, "*Promoting Energy Efficiency and Emissions Reduction in Urban Areas with Key Performance Indicators and Data Analytics*", presents a comprehensive conceptual framework that proposes a series of KPIs as essential metrics to guide, monitor and evaluate energy efficiency and emissions reduction in smart cities. Some of the KPIs included are ‘annual energy consumption per person’, ‘greenhouse gas emissions reduction’, ‘public transport use’ and ‘renewable energy adoption’. The article highlights how the integration of KPIs with data analytics can be used to assess overall city performance and presents visualization tools and forecasting methods for informed decision making and efficient resource allocation. In addition, case studies of smart city projects and comparisons of KPIs between various European cities are included, providing models for forecasting the evolution of KPIs related to energy use and emission reductions in different European cities. These findings provide valuable resources for policy makers, urban planners and mobility experts.

Future publications include the evolution of KPIs in different categories/ dimensions and the impact of the applied methods on the measured KPIs. The change in KPI values depends on the adapted methodology, culture and society, available infrastructure, and other factors. Each one of them has its influence to be investigated.

[5] https://www.mdpi.com/2305-6290/7/4/75
[6] https://www.mdpi.com/1996-1073/16/20/7195

logistics

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Article

Analyzing Key Performance Indicators for Mobility Logistics in Smart and Sustainable Cities: A Case Study Centered on Barcelona

Raquel Soriano-Gonzalez [1], Elena Perez-Bernabeu [1], Yusef Ahsini [1], Patricia Carracedo [1], Andres Camacho [2] and Angel A. Juan [1,*]

[1] Research Center on Production Management and Engineering, Universitat Politècnica de València, Ferrandiz-Carbonell, 03802 Alcoy, Spain; pcarracedo@eio.upv.es (P.C.)

[2] Department of Communications, Universitat Politècnica de València, Ferrandiz-Carbonell, 03802 Alcoy, Spain; acamacho@dcom.upv.es

* Correspondence: ajuanp@upv.es

Abstract: *Background*: This article identifies and examines key performance indicators (KPIs) related to citizen mobility logistics in smart and sustainable urban areas. It begins with a comprehensive literature review to identify essential KPIs, offering valuable insights for both public and private stakeholders, including policymakers and mobility service providers. Drawing from various mobility projects in smart cities, the study extracts common KPIs and best practices. The focus of the paper then turns to Barcelona, Spain, where KPIs that matter most are analyzed. *Methods*: Using open data from the city council spanning from 2017 onwards, the study provides insights into the evolving mobility logistics landscape. KPIs from other European cities are also considered by utilizing similar open data sources. This comparative analysis provides valuable benchmarks and reveals disparities in mobility logistics. Throughout this investigation, the paper emphasizes the role of data quality in KPI selection. *Results*: Reliable open data significantly influence indicator choices and present challenges when comparing cities. Remarkably, the findings consistently highlight environmental data as an area requiring attention in sustainable mobility logistics. *Conclusions*: This paper makes contributions by identifying and examining KPIs relevant to citizen mobility logistics in smart and sustainable urban areas. It offers insights by applying these KPIs to Barcelona and conducting comparative analyses with other European cities. These findings serve as a valuable resource for policymakers, city planners, and mobility experts.

Keywords: logistics and transportation; smart city mobility; key performance indicators; data analytics

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1. Introduction

Mobility and transportation logistics are vital elements in developing smart and sustainable cities worldwide [1,2]. The growth of on-demand economies and e-commerce [3] has led to an increase in transportation and mobility activities in urban and metropolitan areas [4,5] and in last-mile logistics [6–8]. Consequently, the use of zero-emission vehicles such as electric vehicles [9,10], unmanned aerial vehicles [11], and autonomous vehicles [12,13] has been steadily rising in cities. This trend has increased the popularity of new transportation services, carsharing and ridesharing [14–16], or bike sharing services [17]. As these changes reshape urban transportation, it becomes increasingly crucial to identify KPIs capable of effectively measuring the current state of mobility logistics in smart and sustainable urban areas worldwide. European cities, in particular, have made this a primary objective [18]. Governments are implementing numerous programs for smart cities and intelligent infrastructure aimed at enhancing people's quality of life and assisting city administrators in improving the efficiency and management of public infrastructures [19,20].

Logistics **2023**, *7*, 75. https://doi.org/10.3390/logistics7040075 https://www.mdpi.com/journal/logistics

Figure 11: Cover of the published article in Logistics

framework provides a means to assess the interdependencies among various indicators, enabling a comprehensive comprehension of the implications and trade-offs associated with policy decisions. In addition to the foremost outcomes, which hold significant value for public and private policymakers in urban areas worldwide, the study highlights aspects that require careful consideration to enhance the capacity for building smarter and more sustainable cities. These include (i) the necessity of collecting a common dataset across diverse cities for KPI computation; (ii) the need for including the KPI timestamp in order to reflect urban realities accurately; and (iii) the relevant role of municipal councils in increasing data collection frequency and making it available in an open-access format through their respective websites.

This study has also some inherent limitations. Firstly, the gathered results rely on data available from publicly accessible sources. Therefore, the precision of results is contingent upon data quality and availability, and direct control over this process was not exercised. Furthermore, variations in KPIs' update frequencies could miss short-term changes in urban mobility. Another limitation pertains to data availability in other cities for meaningful comparisons. Disparities in the quality and quantity of data provided by different municipalities may pose challenges for accurate cross-city comparisons, emphasizing the need for collaborative efforts to standardize data collection and access across European cities.

In future endeavors, the plan is to expand this study to encompass non-European cities. Regarding Barcelona, there is an intention to explore potential correlations between measured values of specific environmental KPIs and recorded transportation data in the urban area. This research will facilitate the development of machine-learning models capable of predicting how changes in transportation habits and modes could impact environmental KPIs. It is essential to underscore that the NO_2 indicator consistently yielded subpar results across all analyzed cities, emphasizing the urgent need for a comprehensive study and a more precise definition of this indicator at a European scale. This concern is based on the low ratings received and the lack of sufficiently detailed definition, particularly when considering daily fluctuations in NO_2 emissions, which can exceed the maximum allowed limit by a factor up to three in certain city areas. These future research directions can make a significant contribution to the understanding of citizen mobility logistics in urban environments.

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Data Availability Statement: See Tables 5 and 6.

Conflicts of Interest: The authors declare no conflict of interest.

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Figure 12: Acknowledgment in the published article in Logistics

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Article

Promoting Energy Efficiency and Emissions Reduction in Urban Areas with Key Performance Indicators and Data Analytics

Angel A. Juan [1,*], Majsa Ammouriova [2], Veronika Tsertsvadze [1], Celia Osorio [1], Noelia Fuster [1] and Yusef Ahsini [1]

[1] Research Center on Production Management and Engineering, Universitat Politècnica de València, 03801 Alcoy, Spain
[2] Computer Science Department, Universitat Oberta de Catalunya, 08018 Barcelona, Spain
* Correspondence: ajuanp@upv.es

Abstract: With the increasing demand for sustainable urban development, smart cities have emerged as a promising solution for optimizing energy usage, reducing emissions, and enhancing the quality of life for citizens. In this context, the combined use of key performance indicators (KPIs) and data analytics has gained significant attention as a powerful tool for promoting energy efficiency and emissions reduction in urban areas. This paper presents a comprehensive conceptual framework in which a series of KPIs are proposed to serve as essential metrics for guiding, monitoring, and assessing energy efficiency and emissions reduction levels in smart cities. Some of the included KPIs in the analysis are 'annual energy consumption per person', 'reduction in greenhouse gas emissions', 'public transport use', and 'adoption of renewable energy'. By incorporating these KPIs, city planners and policymakers can gain valuable insights into the effectiveness of sustainability initiatives. Furthermore, the paper explores how the integration of KPIs with data analytics can be used for monitoring and assessing the overall performance of the city in terms of energy efficiency, emissions reduction, and the enhancement of urban living conditions. Visualization tools, such as radar plots, and time series analysis forecasting methods allow data to be processed and patterns to be identified, enabling informed decision-making and efficient resource allocation. Real-life case studies of ongoing smart city projects are presented in the paper, which also provides a KPI comparison among different European cities, as well as models to forecast the evolution of KPIs related to energy usage and emissions reduction in different European cities.

Keywords: urban areas; energy efficiency; emissions reduction; key performance indicators; data analytics

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1. Introduction

The intersection of rapid urbanization and climate change has sparked a surge of interest in smart cities. These urban environments leverage cutting-edge information and communication technologies, empowering data-driven solutions [1]. By addressing local sustainability challenges, the concept of smart cities strives to facilitate the urban transition. Central to this transition is the strategic and efficient utilization of resources, promoting sustainable development and a reduced ecological footprint. In this context, energy and sustainability emerge as pivotal focal points, as cities endeavor to create resilient environments [2]. To effectively monitor and assess policies aimed at urban transformation, it becomes essential to establish performance indicators that drive energy-saving and zero-emissions initiatives across transportation, mobility, and urban design domains. This research centers on identifying the diverse dimensions of sustainability critical to the development of smart cities. Through well-defined strategies and initiatives, these cities can achieve environmental friendliness, social inclusivity, and economic viability. These interconnected dimensions constitute the foundation for effective policy evaluation in

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Figure 13: Cover of the published articles in Energies

become smarter and more sustainable. Still, the following limitations of this study can be highlighted: (i) it relies on the availability and quality of data, which has been shown to be limited for specific KPIs in some cases; (ii) it primarily focuses on individual KPIs, potentially not capturing the full complexity of urban systems with interdependencies among various factors; and (iii) its scope is limited to a specific time period and geographical context, while urban environments are dynamic, and factors influencing energy consumption, emissions, and other KPIs can change over time.

Other key contributions of this research work are described next: (i) the paper introduces the application of time series analysis, particularly exponential smoothing and ARIMA models, to forecast KPIs related to urban sustainability, focusing on electric consumption per capita; (ii) the paper discusses how the use of relatively simple and computationally efficient time series models makes the forecasting methodology accessible to a wide audience, including policymakers and city planners; (iii) the paper offers city-specific insights by applying time series forecasting to multiple European cities, such as London, Amsterdam, Helsinki, Vienna, Madrid, and Cologne; and (iv) the paper conducts a validation of the forecasting models, comparing the results of exponential smoothing with those of ARIMA models.

In addition to the presented results, this work has laid the foundation for future research in several directions: (i) further investigation into urban planning and design strategies that prioritize energy efficiency and sustainability, such as building orientation, green spaces, and sustainable transportation networks; (ii) development of multi-objective optimization techniques that balance energy efficiency with social equity, economic viability, and environmental preservation in urban development; (iii) exploration of dynamic mobility management systems that adapt to real-time traffic conditions and weather patterns to optimize transportation routes and reduce energy consumption; (iv) use of IoT technologies to gather real-time data for energy optimization and implement automated energy-saving measures.

Author Contributions: Conceptualization, A.A.J. and M.A.; methodology, C.O., Y.A. and V.T.; investigation, V.T., C.O., Y.A. and N.F.; writing—original draft preparation, all authors; writing—review and editing, A.A.J. and M.A. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: See links in the main text.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Sources of Data for Cities

Table A1 displays the sources from which data utilized in Table 7 was collected. Notice that most of these sources are public repositories, while others refer to scientific publications.

Figure 14: Acknowledgment section in the published article in Energies

7 Conclusions

In this deliverable, the process of identification of KPIs is illustrated. This process aims to define a list of measurable KPIs that are related to the UP2030 project ambitions and cities visions. These KPIs are used in later stages for the monitoring of the project progress and its evolution.

The focus is on validating the preliminary list of KPIs in the next steps. The validation is in collaboration with pilot cities and liaisons as well as the representatives of the involved work packages. This approach guarantees that the KPIs are relevant, achievable, and aligned with UP2030 project ambitions. In this step, the KPIs are revised, and the list is updated accordingly.

The data collection could start for conformed KPIs (Phase III). Data collection, analysis, and reporting facilitate the monitoring of the KPIs. The reports provide insights to guide decision-making in cities with respect to the adapted methods to achieve the cities' vision; monitoring these KPIs will play a pivotal role in assessing the impact of proposed initiatives or methods and driving positive urban transformation. Additionally, these KPIs could be further tracked by cities after the project duration to study their evolution after the UP2030 project.

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APPENDIX A: Description of the project Indicators

A.1: Integrated List of KPIs

Table 2: KPIs related to the Economy dimension

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
ICT	Household Internet Access	Percentage of households with Internet access.	Calculate as: [Number of households with internet access / Total number of households] *100
	Fixed Broadband Subscriptions	Percentage of households with fixed broadband.	Calculate as: [Number of fixed broadband subscriptions / Total number of households] *100
	Wireless Broadband Subscriptions	Wireless broadband subscriptions per 100,000 inhabitants.	Calculate as: Number of wireless broadband subscriptions / one 100,000th of the city's population.
	Wireless Broadband Coverage	Percentage of the city served by wireless broadband (by technology).	Calculate as: Area of city covered by mobile services (km2) / Total area of the city (km2). Each service should be reported on separately.
	Availability of Wi-Fi in Public Areas	Number of public Wi-Fi hotspots in the city.	Calculate as: Total number of Wi-Fi hotspots provided by the city administration (excluding commercial entities).
Water Sanitation	Smart Water Meters	Percentage implementation of smart water meters.	Calculate as: [Number of smart water meters installed / Total number of water meters installed] *100
	Water Supply ICT Monitoring	Percentage of the water distribution system monitored by ICT.	Calculate as: [Length of system monitored by ICT (km) / Total length of total system (km)] *100
	Basic Water Supply	Percentage of city households with access to a basic water supply.	Calculate as: [Number of city households with access to basic water sources / Total number of city households] *100
	Potable Water Supply	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
	Water Supply Loss	Percentage of water loss in the water distribution system.	Calculate as: [(Volume of water supplied minus the volume of utilized water (l/year)) / Total volume of water supplied (l/year)] *100
	Wastewater Collection	Percentage of households served by wastewater collection.	Calculate as: [Number of households served by wastewater collection / Total number of households] *100

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	Household Sanitation	Percentage of the city households with access to basic sanitation facilities.	Calculate as: [Total number of city households with access to basic sanitation and facilities / Total number of city households] *100
Drainage	Drainage / Storm Water System ICT Monitoring	Percentage of drainage / storm water system monitored by ICT.	Calculate as: [Length of system monitored by ICT (km) / Total length of total system (km)] *100
	Inclusive access to safe drinking water	Access to an adequate supply of safe drinking water.	Calculate as: [Number of people with access to safe drinking water / Total city population] *100
Waste	Municipal waste rate	Kilos/ person. period.	Calculate as: Kilos per person/ period.
	Municipal solid waste recycling rate	Percentage of municipal waste that is recycled with respect to the total in a period.	Calculate as: % of municipal solid waste recycled with respect to the total collected waste in a period.
	Solid Waste Collection	Percentage of city households with regular solid waste collection.	Calculate as: [Number of city households that are served by solid waste collection / Total number of city households] *100
Electricity Supply	Local renewable electricity production	Percentage of local renewable electricity production as a percentage of total final electricity consumption in a period.	Calculate as: [Local renewable electricity production (MWh) / Total electricity consumption (MWh)] *100
	Electricity supply quality	The quality of supply is measured in terms of outages/number and duration.	Calculate as: Total number of customer interruptions in a period/ Total number of customers served in a period.
	Smart Electricity Meters	Percentage implementation of smart electricity meters.	Calculate as: [Number of smart electricity meters installed / Total number of electricity meters installed] *100
	Electricity Supply ICT Monitoring	Percentage of electricity supply system monitored by ICT.	Calculate as: [Length of system monitored by ICT (km) / Total length of total system (km)] *100
	Demand Response Penetration	Percentage of electricity customers with demand response capabilities.	Calculate as: [Number of demand response enabled electricity customers / Total number of electricity customers] *100
	Electricity System Outage Frequency	Average number of electrical interruptions per customer per year.	Calculate as: Sum of customers interrupted / Total number of customers served.
	Electricity System Outage Time	Average length of electrical interruptions.	Calculate as: Sum of all customers' interruption durations (mins) / Total number of interruptions.

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	Access to Electricity	Percentage of households with authorized access to electricity.	Calculate as: [Number of city households with an authorized connection to the electrical system / Total number of households] *100
Transport	Diverse and affordable transport networks	Diverse and integrated transport networks, providing flexible and affordable travel around the city for all.	Calculate as: Number of different modes of public transportation available (buses, trams, metro, etc.).
	Dynamic Public Transport Information	Percentage of urban public transport stops for which traveller information is dynamically available to the public in real time.	Calculate as: [Number of stops and stations with dynamic information available / Total number of stops and stations] *100
	Traffic Monitoring	Percentage of major streets monitored by ICT.	Calculate as: [Length of major streets monitored by ICT (km) / Total length of major streets (km)] *100
	Intersection Control	Percentage of road intersections using adaptive traffic control or prioritization measures.	Calculate as: [Number of intersections with adaptive traffic control / Total number of signal-controlled intersections] * 100
	Public Transport Network	Length of public transport network per 100,000 inhabitants.	Calculate as: Length of public transport lines within city boundaries (km) (one way length) / One 100,000th of the city's population.
	Public Transport Network Convenience	Percentage of the city population that has convenient access (within 0.5 km) to public transport.	Calculate as: [Total number of city inhabitants living within 0.5 km of a public transport stop / Total city inhabitants] *100
	Bicycle Network	Length of bicycle paths and lanes per 100,000 population.	Calculate as: km of bicycle paths or lanes / One 100,000th of the city's population.
	Transportation Mode Share	The percentage of people using various forms of transportation to travel to work.	Calculate as: [Number of travelers using a specific transportation mode / Total number of travelers] *100 Report on modes: public transportation, personal vehicles, bicycles, walking, paratransit.
	Shared Bicycles	Number of shared bicycles per 100,000 inhabitants.	Calculate as: Number of shared bicycles available / One 100,000th of the city's population.
	Shared Vehicles	Number of shared vehicles per 100,000 inhabitants.	Calculate as: Number of shared vehicles / One 100,000th of the city's population.

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	Low-Carbon Emission Passenger Vehicles	Percentage of low-carbon emission passenger vehicles.	Calculate as: [Number of low emission vehicles registered (PHEV & EV) / Number of total vehicles] *100
	Non-polluting vehicles	Non-polluting vehicles are those that do not emit any type of pollutant, such as electric vehicles. Hybrids are not taken into account.	Calculate as: % of non-polluting vehicles with respect to the total volume of vehicles in the considered area.
Public Sector	Comprehensive hazard and exposure mapping	Robust systems in place to map the city's exposure and vulnerability to hazards based on current data.	Calculate as: The number of hazards included in the mapping (e.g., flooding, earthquakes, chemical spills).
	Open Data	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
	e-Government	Number of public services delivered through electronic means.	Calculate as: Number of public services available through online services.
Innovation	R & D Expenditure	Research and Development expenditure as a percentage of city GDP.	Calculate as: [R&D expenditure (Euro) / City GDP (Euro)] *100
	Patents / start-ups	Number of new patents/ start-ups granted per 100,000 inhabitants per year.	Calculate as: Total number of new patents issued to residents and organizations of the city / One 100,000th of the city's population.
	Small and Medium-Sized Enterprises	Percentage of small and medium-sized enterprises (SMEs).	Calculate as: [Number of SMEs / Total number of enterprises] *100
	Diverse economic base	Robust, flexible, and diverse local economy.	Calculate as: Inverse of the Herfindahl-Hirschman Index (HHI) of industrial concentration, where lower values indicate greater diversification.
Employment	Creating and providing or supporting access to green and decent jobs for an inclusive and balanced workforce in companies and organizations	The companies and organizations assess and disclose risks of employment dislocation where relevant and are committed to and take appropriate action to create and provide or support access to green and decent jobs in a way which ensures gender	Yes / No.

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
		balance and inclusion of vulnerable groups.	
	Retaining and re-and/or up-skilling workers for an inclusive and balanced workforce	Companies and organizations are committed to and take appropriate action to re-and/or up-skill workers displaced by the transition to a low-carbon economy in a way which ensures gender balance and inclusion of vulnerable groups.	Yes / No.
	Unemployment Rate	Percentage of the total city labor force that is unemployed.	Calculate as: [Total number of city-related unemployed / Total city-related labor force] *100
	Youth Unemployment Rate	Percentage of the city youth labor force that is unemployed.	Calculate as: [Total number of city-related unemployed youth/ Total city-related youth labor force] *100
	Tourist Industry Employment	Percentage of the city-related labor force working in the tourism industry.	Calculate as: [Total number of city-related employees-Tourism Sector / Total city-related labor force] *100
	ICT Sector Employment	Percentage of employees involved with ICT.	Calculate as: [Number of employees ICT sector / Number of total city labor force] *100
Buildings	Public Building Sustainability	Percentage area of public buildings with recognized sustainability certifications for ongoing operations.	Calculate as: [Area of public buildings with certification to a recognized standard for ongoing building operations (m2) / Total area of public buildings (m2)] * 100. Report by Certification Scheme or percentage of the numbers of buildings
	Integrated Building Management Systems in Public Buildings	Percentage of public buildings using integrated ICT systems to automate building management and create a flexible, effective, comfortable, and secure environment.	Calculate as: [Floor Area of public buildings using ICT-based systems for integrated management in the city (m2) / Total floor number of public buildings in the cities (m2)] * 100 or percentage of the numbers
	Buildings with high energy efficiency rating	Percentage of buildings/properties with the highest energy efficiency rating	Calculate as: [Number of buildings with the highest energy efficiency

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
		compared to the total evaluated.	rating / Total number of buildings evaluated] *100
Urban Planning	Pedestrian infrastructure	Percentage of the city designated as a pedestrian/car free zone.	Calculate as: [Total area of pedestrian/car free zones / Total city area] *100
	Green areas	Green area per-100,000 inhabitants.	Calculate as: [Total green area/ Total city area] *100 or total green area / one 100,000th inhabitants
	Green Area Accessibility	Percentage of inhabitants with accessibility to green areas.	Calculate as: [Number of inhabitants living with 300m of a publicly accessible green space of at least 0.5ha / Number of city inhabitants] *100
	Urban Development and Spatial Planning	Existence of urban development and spatial planning strategies or documents at the city level.	To collect the data for the measurement: Step 1: Identify city (in scope) Step 2: Deduce whether there is an urban plan for the city Step 3: Examine if urban plans contain all 5 sustainability principles/elements (if the plans are digitalized and on the web then consider using automated web queries with semantics to examine these elements). --> number: 0, 1, 2, 3, 4, 5

Table 3: KPIs related to the Environment dimension

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
Air Quality	Air Pollution	Air quality index based on reported value for: Particulate matter (PM10 and PM2.5), nitrogen dioxide, sulphur dioxide, ozone.	Calculate as: Mass of pollutant collected (μg) / volume of air sampled (m3). Report as annual mean concentration for each pollutant.
	GHG Emissions	Greenhouse gas emissions per capita.	Calculate as: Total Greenhouse gas emissions (Tons eCO2) / Total number of city inhabitants.
Water Sanitation	Drinking Water Quality	Percentage of households covered by an audited Water Safety Plan	Calculate as: [Number of compliant samples to WHO Guidelines / Total number of samples] *100

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	Water Consumption	Total water consumption per capita.	Calculate as: Total amount of water consumption in cities (l/day) / Total number of city inhabitants.
	Freshwater Consumption	Percentage of water consumed from freshwater sources.	Calculate as: [Volume of fresh water consumed / Total volume of water supply] *100
	EMF Exposure	Percentage of wastewater receiving treatment (Primary, Secondary, Tertiary).	Calculate as: [Total amount of wastewater that has undergone (primary /secondary / tertiary) treatment (l) / Total amount of wastewater collected (l)] *100
Environmental Quality	EMF Exposure	Percentage of mobile network antenna sites in compliance with WHO endorsed Electromagnetic Fields (EMF) exposure guidelines.	Calculate as: [Number of sites complying with WHO guidelines / Total number of sites] *100
	Noise Exposure	Percentage of city inhabitants exposed to excessive noise levels.	Calculate as: [Number of city inhabitants exposed to noise levels [LDEN (day-evening- night)] over 55 dB(A) / Total city inhabitants] *100
Energy	Renewable Energy Consumption	Percentage of renewable energy consumed in the city.	Calculate as: [Total consumption of electricity from renewable sources (kWh/yr) / Total city electricity consumption (kWh/yr)] *100
	Electricity Consumption	Electricity consumption per capita.	Calculate as: Total consumption of electricity (kWh / year) / Total number of city inhabitants.
	Fossil fuel	Percentage of the city's energy coming from fossil fuels.	Calculate as: [Total energy consumption from fossil fuels / Total energy consumption] * 100
	Residential Thermal Energy Consumption	Residential thermal energy consumption per capita.	Calculate as: Total consumption of thermal energy (Gj/year) / Total number of city inhabitants.
	Public Building Energy Consumption	Annual energy consumption of public buildings.	Calculate as: Total energy consumption by public buildings (ekWh/yr) / Total floor space of public buildings (m2).

Table 4: KPIs related to the Social and Culture dimension.

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
Education	Student ICT Access	Percentage of students with classroom access to ICT facilities.	Calculate as: [Students with classroom access to ICT facilities / Total number of students enrolled in schools] *100

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	School Enrolment	Percentage of school-aged population enrolled in schools.	Calculate as: [Number of students in primary and secondary levels in public and private schools / Total number of the school aged population] *100
	Higher Education Degrees	Higher level education degrees per 100,000 inhabitants.	Calculate as: Number of city inhabitants holding at least one higher level education degree / One 100,000th of the city's population.
	Adult Literacy	Adult literacy rate.	Calculate as: [Number of adult city inhabitants who are deemed to be literate / Total number of city inhabitants'] *100
Health	Electronic Health Records	The percentage of city inhabitants with complete health records electronically accessible to all health providers.	Calculate as: [Number of city inhabitants with electronic health records / Total number of city inhabitants] *100
	Life Expectancy	Average life expectancy.	Calculate as: Average number of years that a newborn is expected to live if current mortality rates continue to apply.
	Maternal Mortality Rate	Maternal deaths per 100,000 live births.	Calculate as: Number of maternal deaths per year / One 100,000th of live births per year.
	Physicians	Number of physicians per 100,000 inhabitants.	Calculate as: Number of general or specialized physicians working in the city (FTE) / One 100,000th of the city's population.
	In-Patient Hospital Beds	Number of in-patient public hospital beds per 100,000 inhabitants.	Calculate as: Total number of in-patient hospital beds (public and private) / One 100,000th of the city's population.
	Health Insurance /Public Health Coverage	Percentage of city inhabitants covered by basic health insurance program or a public health system.	Calculate as: [Number of inhabitants covered by health insurance or a public health system / Total city inhabitant] *100
Culture	Cultural Expenditure	Percentage expenditure on city cultural heritage.	Calculate as: Municipal expenditure on preservation, protection, and conservation of all cultural and natural heritage (USD) / Total city operating budget (USD).
	Cultural Infrastructure	Number of the cultural institutions per 100,000 inhabitants.	Calculate as: Number of cultural institutions / One 100,000th of the city's population.
Housing	Informal Settlements	Percentage of city inhabitants living in slums,	Calculate as: [Number of people living in slums, informal settlements, or

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
		informal settlements, or inadequate housing.	inadequate housing / Total city inhabitants] *100
	Expenditure on Housing	Percentage share of income expenditure for housing.	Calculate as: [Expenditure on Housing (USD) / Total household income (USD)] *100
Social Inclusion	Gender Income Equality	Ratio of average hourly earnings of female to male workers.	Calculate as: Average hourly earnings of female employees (USD) / Average hourly earnings of male employees (USD)
	Gini Coefficient	Income distribution in accordance with Gini coefficient.	Calculate as: Area between the 45-degree line and Lorenz curve / Entire area below the 45 degree line.
	Poverty Share	Percentage of city inhabitants living in income poverty.	Calculate as: [Number of city inhabitants living below the poverty line /Total number of city inhabitants] *100
	Childcare Availability	Percentage of pre-school age children (0-3) covered by (public and private) day-care centres.	Calculate as: [Number of day-care spots available for pre-school children / Total number of pre-school age children] *100
	Access to electricity	Percentage of the population with access to electricity	Calculate as: [Number of people with access to electricity / Total population] *100
Safety	Natural Disaster Related Deaths	Number of natural disaster-related deaths per 100,000 inhabitants.	Calculate as: Number of annual natural disaster related deaths / One 100,00th of the city's population.
	Disaster Related Economic Losses	Economic losses (related to natural disasters) as a percentage of the city's gross domestic product (GDP).	Calculate as: [Total economic losses (last annual reporting period) related to disasters / GDP of the city] *100
	Resilience Plans	This involves the implementation of risk and vulnerability assessments, financial (capital and operating) plans and technical systems for disaster mitigation addressing natural and human-induced disasters and hazards.	The indicator would involve a summation of qualitative data from various sources of risk and vulnerability assessments, financial (capital and operating) plans and technical systems for disaster mitigation addressing natural and human-induced disasters and risks in the cities. Possible categorization may be plans present and adequate; plans present and inadequate; or plans do not exist. The second option could even be expanded further to provide a level of inadequacy.

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	Population Living in Disaster Prone Areas	Percentage of inhabitants living in natural hazards prone areas.	Calculate as: Number of city inhabitants living in natural hazard prone areas / Total number of city inhabitants.
	Emergency Service Response Time	Average response time for Emergency Services.	Calculate as: Sum of all the minutes from an initial call to the on-site arrival of the emergency service in the year (minutes) / Number of emergency responses in the same year.
	Police Service	Number of police officers per 100,000 inhabitants.	Calculate as: Number of full-time police officers (expressed as FTE) / One 100,000th of the city’s population.
	Fire Service	Number of firefighters per 100,000 inhabitants.	Calculate as: Number of full-time firefighters (expressed as FTE) / One 100,000th of the city’s population.
	Violent Crime Rate	Violent crime rate per 100,000 inhabitants.	Calculate as: Number of violent crimes committed /One 100,000th of the city's population.
	Traffic Fatalities	Traffic fatalities per-100,000 inhabitants.	Calculate as: Number of traffic fatalities / One 100,000th of the city’s population.
Food Security	Local Food Production	Percentage of local food supplied from within 100 km of the urban area.	Calculate as: [Amount of local food supplied (within 100 km) (tons) / Amount of total food supplied in tons] *100
	Sufficient affordable food supply	Sufficient and affordable food supplies for all.	Calculate as: [Average food expenditure per household / Average household income] * 100

Table 5: KPIs related to the Governance dimension

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
Organization	Leadership	The extent to which the leadership of the project is successful in creating support for the project.	Likert scale.
	Balanced project team	The extent to which the project team included all relevant experts and stakeholders from the start.	Likert scale.
	Involvement of the city administration	The extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing.	Likert scale.

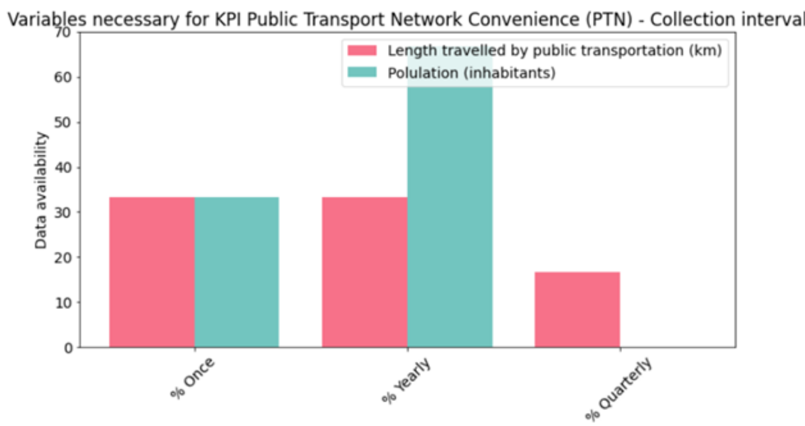
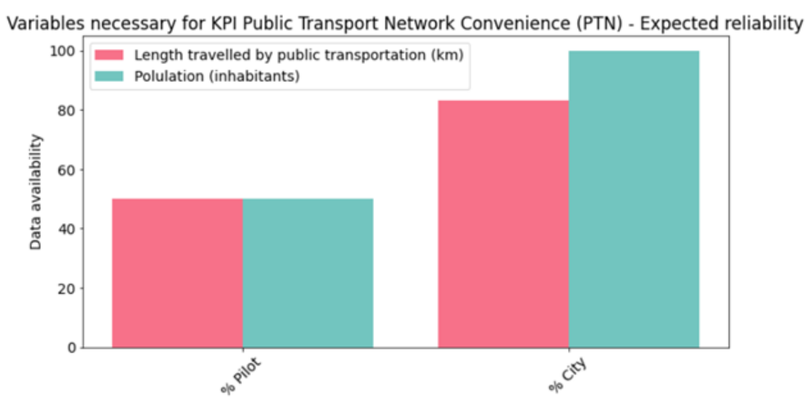
CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
	Clear division of responsibility	Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project?	Likert scale.
	Continued monitoring and reporting	The extent to which the progress towards project goals and compliance with requirements is being monitored and reported.	Likert scale.
	Proactive corruption prevention	Fair and transparent systems to fight corruption and promote justice.	Likert scale.
	Just transition planning	Companies and organizations demonstrate low carbon transition planning which will mitigate the social impacts of the just transition on workers, affected stakeholders and their business relationships, and demonstrate social dialogue and stakeholder engagement in developing its just transition planning.	Likert scale.
Community Involvement	Bottom-up or top-down initiative	Has the project idea originated from the local community?	Yes / No.
	Local community involvement in the planning phase	The extent to which residents/users have been involved in the planning process.	Sum of Likert scale / number of participants.
	Local community involvement in the implementation phase	The extent to which residents/users have been involved in the implementation process.	Sum of Likert scale / number of participants.
	Participatory governance	Share of the population participating in online platforms.	Number of shares / number of participants.
	Social dialogue and stakeholder engagement in a just transition	Companies and organizations commit to social dialogue, disclose the categories of stakeholders they engage with on a just transition and demonstrate ongoing social dialogue and meaningful engagement with affected stakeholders.	Yes / No.
Multi-level Governance	Municipal involvement-Financial support	The extent to which the local authority provides financial support to the project.	Likert scale.
	Smart city policy	The extent to which the project has benefitted from a governmental smart city policy.	Likert scale.
	Supportive financing mechanisms	Inclusive and resourceful finance mechanisms to enable companies and organizations to address a just transition.	Yes / No.

Table 6: KPIs related to the Propagation dimension

CATEGORY	SPECIFIC KPI	DESCRIPTION	METHODOLOGY
Scalability and Replicability	Social compatibility	The extent to which the project's solution fits with people's 'frame of mind' and does not negatively challenge people's values or the ways they use to do things.	Likert scale.
	Technical compatibility	The extent to which the smart city solution fits with the current existing technological standards/infrastructures.	Likert scale.
	Ease of use for end users of the solution	The extent to which the solution is perceived as difficult to understand and use for potential end-users.	Likert scale.
	Ease of use for professional stakeholders	The extent to which the innovation is perceived as difficult to understand, implement and use for professional users of the solution.	Likert scale.
	Trialability	The extent to which the solution can be experimented with on a limited basis in the local context before full implementation.	Likert scale.
	Advantages for end users	The extent to which the project offers clear advantages for end users.	Likert scale.
	Advantages for stakeholders	The extent to which the project offers clear advantages for stakeholders.	Likert scale.
	Visibility of Results	The extent to which the results of the project are visible to external actors.	Likert scale.
	Solution(s) to development issues	The extent to which the project offers a solution to problems which are common to European cities.	Likert scale.
	Effective co-ordination with other government bodies	Integrated and flexible communication and collaboration between city, state, and national government.	Likert scale.
Factor of Success	Changing societal norms	The extent to which the project changes the norms and values of the society	Likert scale.
	Diffusion to other sectors	The extent to which the project is copied by other commercial parties.	Likert scale.
	Change in rules and regulations	The extent to which the project has contributed to, or inspired, changes in rules and regulations.	Likert scale.
	Change in public procurement	The extent to which the project has contributed to, or inspired, new forms of public procurement procedures.	Likert scale.

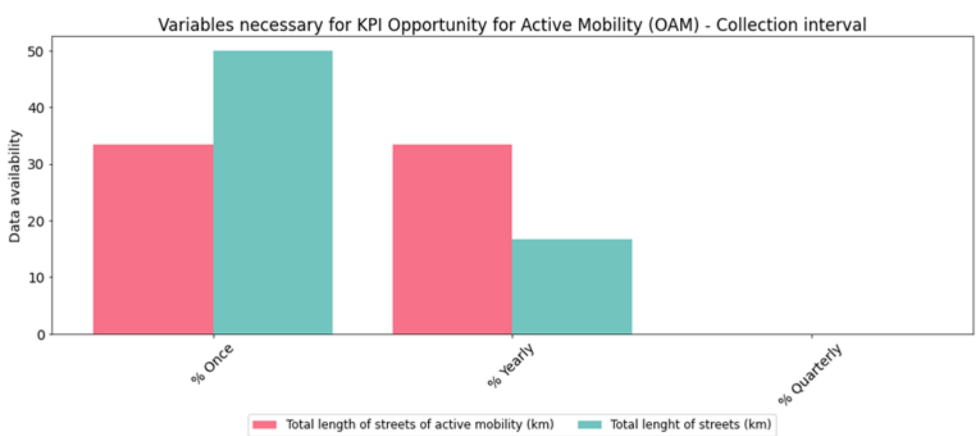
A.2: Core KPI Identifications

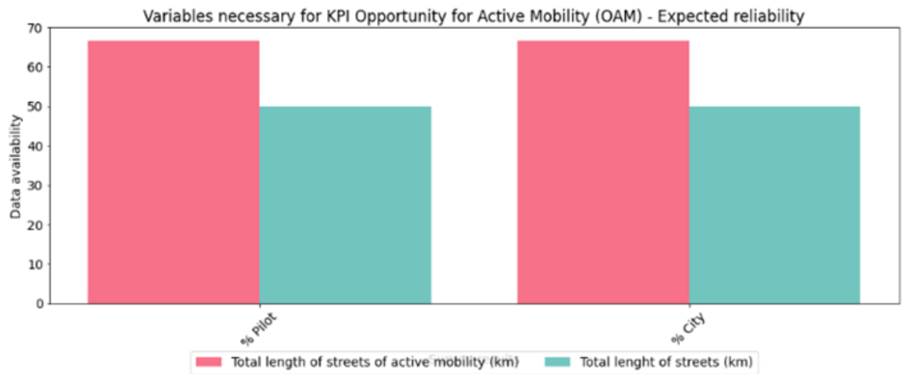
Indicator	**Core KPI-1**
Name of the indicator	**Public Transport Network Convenience**
Description incl. justification	The Public Transport Network Convenience indicator seeks to evaluate the accessibility and convenience of the public transport network within a city. It assesses the length of the public transport network per 100,000 inhabitants, aiming to provide insights into the convenience and efficiency of public transportation services. This includes the evaluation of the spatial coverage and accessibility of public transport lines within the city boundaries.
Rating on a Scale	The classification of KPI values is done on a scale from 0 to 1, where 0 represents the worst-case scenario, indicating that the project does not meet the specifications and objectives defined. On the other hand, 1 represents the best-case scenario, indicating that the project fulfils all proposed objectives and aligns completely with the established definitions. The intermediate scale is proportionally distributed, reflecting different levels of compliance and consideration in relation to the specific KPI criteria. 0: The worst possible outcome, indicating that the project did not take specifications into account and did not achieve the proposed objectives. 0.25: Represents a low level of compliance, where the project has minor importance, and decisions are made without a solid foundation, relying on gut feelings. 0.5: Indicates partial consideration of the KPI in the project. It has been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the KPI has been considered importantly in project decisions. 1: The best possible outcome, indicating that the project has thoroughly considered the KPI, using extensive information, calculations, integral planning, and specifically aims to meet all definitions and proposed objectives.
Data requirements	
Expected data source	Project documentation, including public transport network maps, city population data, and reports.

Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained: 
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of public transport network convenience, incorporating factors such as network length and city population one.

Indicator	**Core KPI-2**
Name of the indicator	**Opportunity for Active Mobility**
Description incl. justification	The Opportunity for Active Mobility indicator aims to assess the percentage of the city's infrastructure that promotes active mobility. Active mobility infrastructure includes facilities such as walking paths, bike lanes, and other elements that encourage physically active transportation. This KPI contributes to evaluating the city's commitment to promoting sustainable and healthy modes of transportation.
Definition	The indicator measures the percentage of the city's infrastructure dedicated to promoting active mobility. This is calculated as the total length of active mobility infrastructure divided by the total length of urban infrastructure, multiplied by 100.
Normalization	Normalization involves comparing the performance of the Opportunity for Active Mobility against a set standard or benchmark, providing a standardized evaluation across different urban areas.
Rating on a Scale	The classification of KPI values is done on a scale from 0 to 1, where 0 represents the worst-case scenario, indicating that the project does not meet the specifications and objectives defined. On the other hand, 1 represents the best-case scenario, indicating that the project fulfils all proposed objectives and aligns completely with the established definitions. The intermediate scale is proportionally distributed, reflecting different levels of compliance and consideration in relation to the specific KPI criteria. 0: The worst possible outcome, indicating that the project did not take specifications into account and did not achieve the proposed objectives. 0.25: Represents a low level of compliance, where the project has minor importance, and decisions are made without a solid foundation, relying on gut feelings. 0.5: Indicates partial consideration of the KPI in the project. It has been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the KPI has been considered importantly in project decisions.

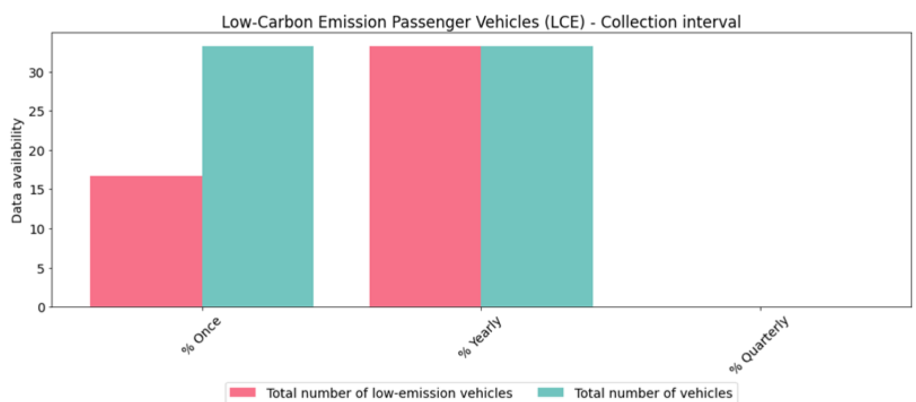
	1: The best possible outcome, indicating that the project has thoroughly considered the KPI, using extensive information, calculations, integral planning, and specifically aims to meet all definitions and proposed objectives.
Relevance	- Aligns with the increasing policy focus on promoting sustainable and healthy modes of transportation. - Encourages the integration of active mobility infrastructure into urban planning.
Limitations	- Lack of a standardized method for evaluating the overall impact of active mobility infrastructure. - Difficulty in assessing the effectiveness of measures in a generalizable manner.

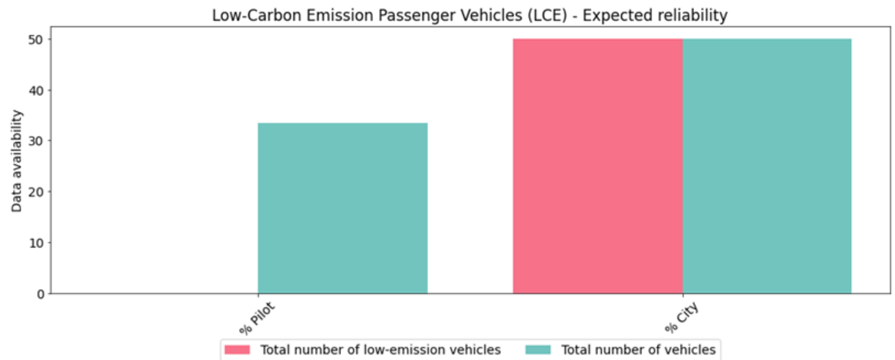
Data requirements	
Expected data source	Project documentation, including maps of active mobility infrastructure, city infrastructure data, and reports.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of the Opportunity for Active Mobility, incorporating factors such as the length of active mobility infrastructure and total urban infrastructure.

Indicator	Core KPI-3
Name of the indicator	**Low-Carbon Emission Passenger Vehicles**
Description incl. justification	The Low-Carbon Emission Passenger Vehicles indicator is designed to evaluate the percentage of low-carbon emission passenger vehicles within a given context. This KPI specifically assesses the adoption and prevalence of vehicles with low carbon emissions, contributing to the reduction of environmental impact in the transportation sector. The goal is to gauge the city's commitment to promoting sustainable and eco-friendly transportation options.
Definition	The indicator measures the percentage of low-carbon emission passenger vehicles in the city. This is calculated as the number of low-emission vehicles registered (Plug-in Hybrid Electric Vehicles (PHEV) & Electric Vehicles (EV)) divided by the total number of vehicles, multiplied by 100.
Normalization	Normalization involves comparing the performance of the Low-Carbon Emission Passenger Vehicles against a set standard or benchmark, providing a standardized evaluation across different urban areas.
Rating on a Scale	The classification of KPI values is done on a scale from 0 to 1, where 0 represents the worst-case scenario, indicating that the project does not meet the specifications and objectives defined. On the other hand, 1 represents the best-case scenario, indicating that the project fulfils all proposed objectives and aligns completely with the established definitions. The intermediate scale is proportionally distributed, reflecting different levels of compliance and consideration in relation to the specific KPI criteria. 0: The worst possible outcome, indicating that the project did not take specifications into account and did not achieve the proposed objectives. 0.25: Represents a low level of compliance, where the project has minor importance, and decisions are made without a solid foundation, relying on gut feelings. 0.5: Indicates partial consideration of the KPI in the project. It has been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the KPI has been considered importantly in project decisions.

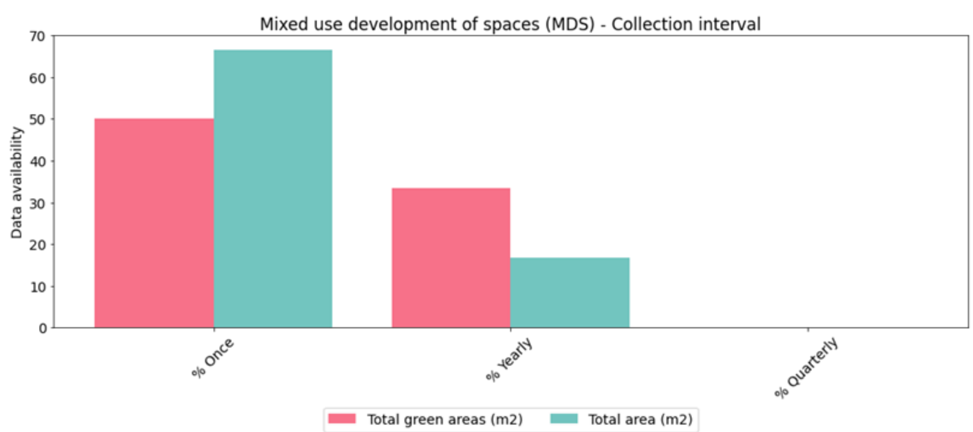
	1: The best possible outcome, indicating that the project has thoroughly considered the KPI, using extensive information, calculations, integral planning, and specifically aims to meet all definitions and proposed objectives.
Relevance	- Aligns with the increasing policy focus on reducing carbon emissions in the transportation sector. - Encourages the integration of low-carbon emission vehicles to enhance environmental sustainability.
Limitations	- Lack of a standardized method for evaluating the overall impact of low-carbon emission vehicles. - Difficulty in assessing the effectiveness of measures in a generalizable manner.

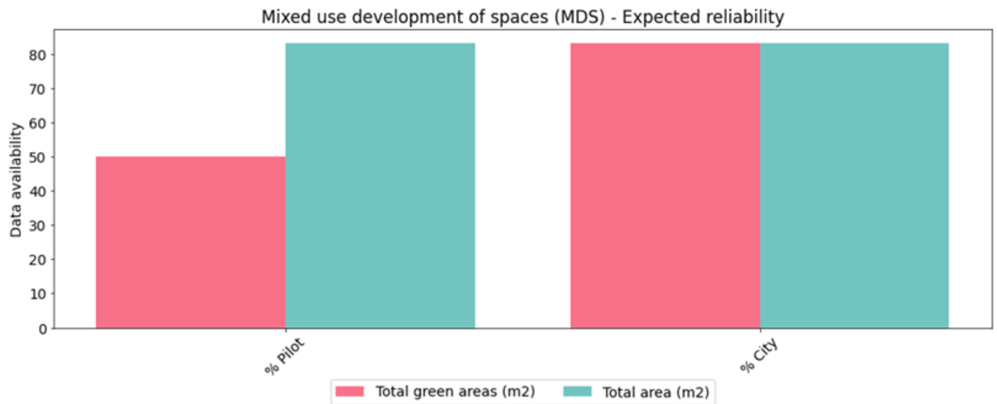
Data requirements	
Expected data source	Vehicle registration data, including the number of low-emission vehicles, and total vehicle counts.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Low-Carbon Emission Passenger Vehicles, incorporating factors such as the number of low-emission vehicles and the total number of vehicles.

Indicator	**Core KPI-4**
Name of the indicator	**Mixed use development of spaces**
Description incl. justification	The Mixed-use Development of Spaces indicator is crafted to evaluate the combination of residential, commercial, and recreational spaces within neighbourhoods. This KPI assesses the degree of mixed-use development, emphasizing the integration of diverse functions to create vibrant and sustainable urban environments. The objective is to measure the city's commitment to fostering neighbourhoods that are well-rounded and cater to multiple needs.
Definition	The indicator measures the proportion of mixed-use development within neighbourhoods. This is calculated as the total mixed-use area, which is the sum of the area of all parcels or areas intended for mixed uses (including housing, commercial, and recreational areas), divided by the total neighbourhood area, multiplied by 100.
Normalization	Normalization involves comparing the performance of Mixed-use development of spaces against a set standard or benchmark, providing a standardized evaluation across different urban areas.
Rating on a Scale	The classification of KPI values is done on a scale from 0 to 1, where 0 represents the worst-case scenario, indicating that the project does not meet the specifications and objectives defined. On the other hand, 1 represents the best-case scenario, indicating that the project fulfils all proposed objectives and aligns completely with the established definitions. The intermediate scale is proportionally distributed, reflecting different levels of compliance and consideration in relation to the specific KPI criteria. 0: The worst possible outcome, indicating that the project did not take specifications into account and did not achieve the proposed objectives. 0.25: Represents a low level of compliance, where the project has minor importance, and decisions are made without a solid foundation, relying on gut feelings. 0.5: Indicates partial consideration of the KPI in the project. It has been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the KPI has been considered importantly in project decisions.

	1: The best possible outcome, indicating that the project has thoroughly considered the KPI, using extensive information, calculations, integral planning, and specifically aims to meet all definitions and proposed objectives.
Relevance	- Aligns with the urban planning focus on creating diverse and sustainable neighbourhoods. - Encourages the integration of mixed-use development to enhance the liveability of urban spaces.
Limitations	- Lack of a standardized method for evaluating the overall impact of mixed-use development. - Difficulty in assessing the effectiveness of measures in a generalizable manner.

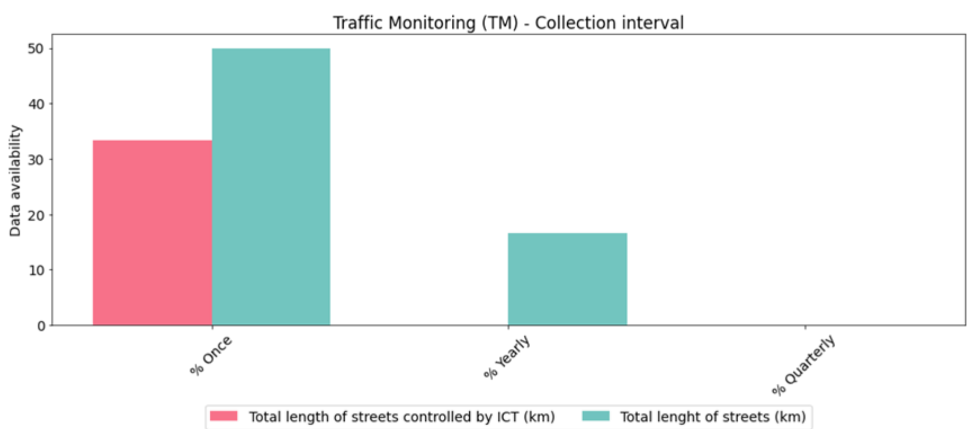
Data requirements	
Expected data source	Urban planning documents, including zoning maps and land-use plans, indicating the mixed-use areas within neighbourhoods.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

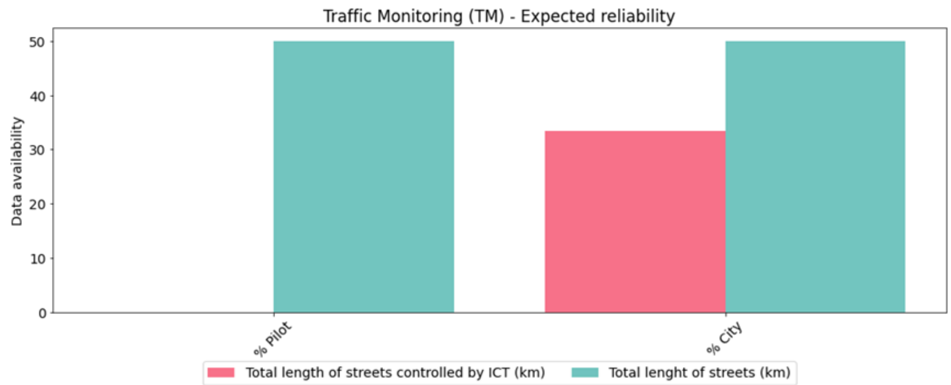
	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Mixed-use Development of Spaces, incorporating factors such as the total mixed-use area and total neighbourhood area.

Indicator	**Core KPI-5**
Name of the indicator	**Traffic Monitoring**
Description incl. justification	The Traffic Monitoring indicator is designed to evaluate the percentage of major streets monitored by ICT. This KPI focuses on assessing the extent to which modern technology is utilized for traffic monitoring on key roadways. The objective is to gauge the city's commitment to efficient traffic management and the utilization of ICT for real-time monitoring and analysis.
Definition	The indicator measures the percentage of major streets monitored by ICT. This is calculated as the length of major streets monitored by ICT (in kilometres) divided by the total length of major streets (in kilometres), multiplied by 100.
Normalization	Normalization involves comparing the performance of Traffic Monitoring against a set standard or benchmark, providing a standardized evaluation across different urban areas.
Rating on a Scale	The classification of KPI values is done on a scale from 0 to 1, where 0 represents the worst-case scenario, indicating that the project does not meet the specifications and objectives defined. On the other hand, 1 represents the best-case scenario, indicating that the project fulfils all proposed objectives and aligns completely with the established definitions. The intermediate scale is proportionally distributed, reflecting different levels of compliance and consideration in relation to the specific KPI criteria. 0: The worst possible outcome, indicating that the project did not take specifications into account and did not achieve the proposed objectives. 0.25: Represents a low level of compliance, where the project has minor importance, and decisions are made without a solid foundation, relying on gut feelings. 0.5: Indicates partial consideration of the KPI in the project. It has been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the KPI has been considered importantly in project decisions. 1: The best possible outcome, indicating that the project has thoroughly considered the KPI, using extensive information, calculations, integral planning, and specifically aims to meet all definitions and proposed objectives.

Relevance	- Aligns with the contemporary approach to traffic management through technology. - Encourages the adoption of ICT for real-time traffic monitoring and analysis.
Limitations	- Lack of a standardized method for evaluating the overall impact of traffic monitoring through ICT. - Difficulty in assessing the effectiveness of measures in a generalizable manner.

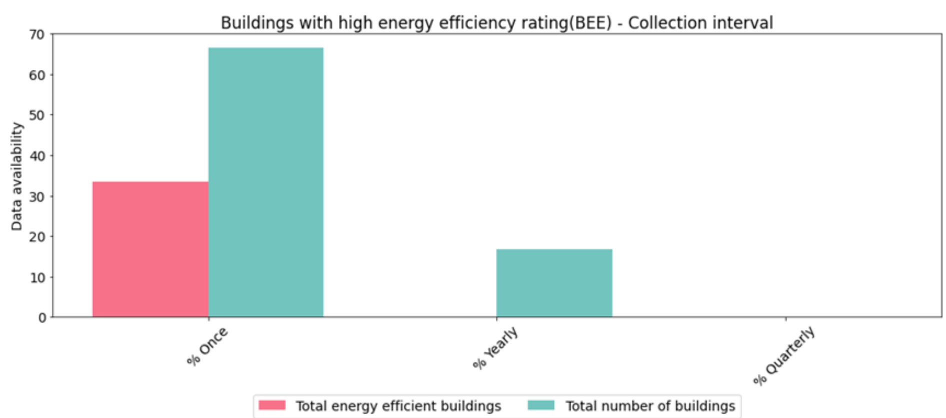
Data requirements

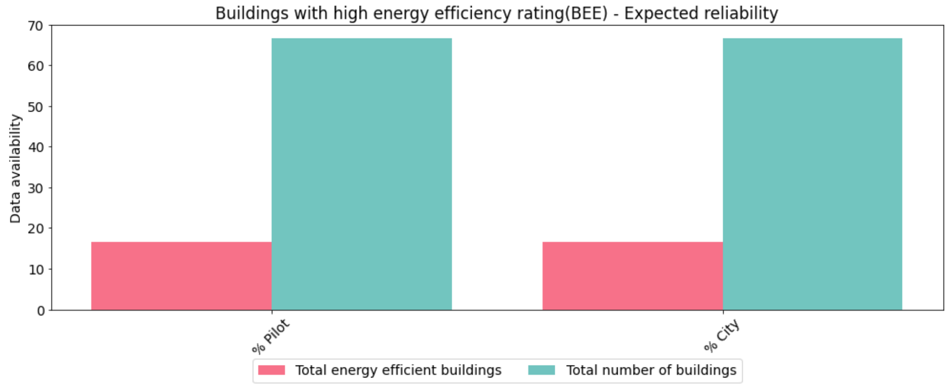
Expected data source	Traffic management systems and ICT infrastructure documentation, indicating the length of major streets monitored by ICT.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Traffic Monitoring, incorporating factors such as the length of major streets monitored by ICT and the total length of major streets.

Indicator	Core KPI-6
Name of the indicator	**Buildings with high energy efficiency rating**
Description incl. justification	The Buildings with High Energy Efficiency Rating indicator aims to assess the percentage of buildings or properties that have achieved the highest energy efficiency rating compared to the total evaluated. This indicator provides insights into the sustainability practices in construction by highlighting the proportion of buildings that attain the maximum energy efficiency. It includes the evaluation of energy labelling of buildings, ranging from letter A to letter G and from dark green to red, corresponding to each dwelling in the same building.
Definition	The indicator measures the percentage of buildings with the highest energy efficiency rating compared to the total evaluated buildings. It is calculated as the number of buildings with the highest energy efficiency rating divided by the total evaluated buildings, multiplied by 100.
Normalization	Normalization involves comparing the performance of buildings with high energy efficiency rating against a set standard or benchmark. This process provides a standardized evaluation of energy efficiency measures across different urban areas.
Rating on a Scale	The classification of KPI values is done on a scale from 0 to 1, where 0 represents the worst-case scenario, indicating that the project does not meet the specifications and objectives defined. On the other hand, 1 represents the best-case scenario, indicating that the project fulfils all proposed objectives and aligns completely with the established definitions. The intermediate scale is proportionally distributed, reflecting different levels of compliance and consideration in relation to the specific KPI criteria. 0: The worst possible outcome, indicating that the project did not take specifications into account and did not achieve the proposed objectives. 0.25: Represents a low level of compliance, where the project has minor importance, and decisions are made without a solid foundation, relying on gut feelings. 0.5: Indicates partial consideration of the KPI in the project. It has been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the KPI has been considered importantly in project decisions.

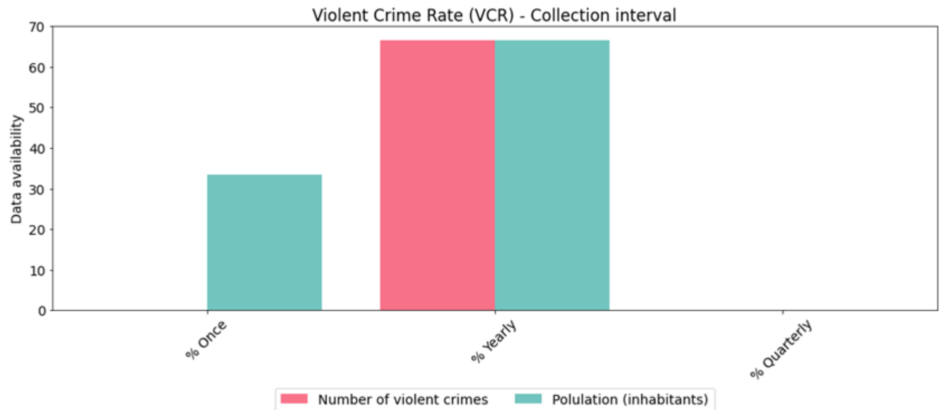
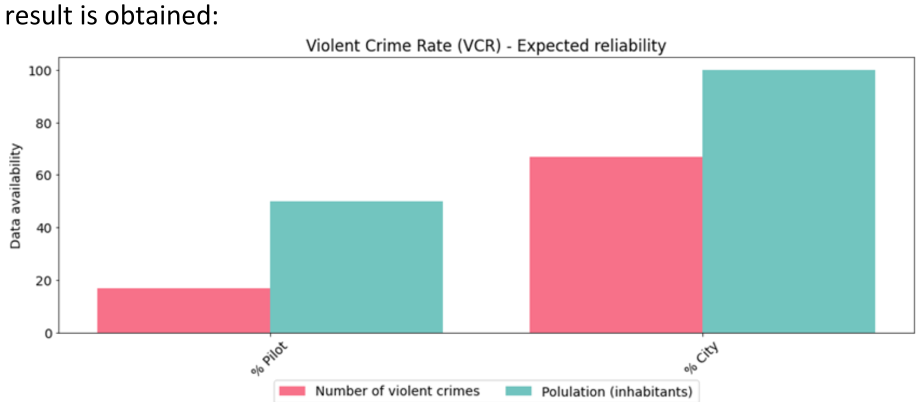
	1: The best possible outcome, indicating that the project has thoroughly considered the KPI, using extensive information, calculations, integral planning, and specifically aims to meet all definitions and proposed objectives.
Relevance	- Aligns with the increasing policy focus on improving energy efficiency in buildings. - Encourages the integration of energy efficiency measures into urban planning.
Limitations	- Lack of a standardized method for evaluating the overall impact of energy efficiency in buildings. - Difficulty in assessing the effectiveness of measures in a generalizable manner.

Data requirements	
Expected data source	Project documentation, including building energy efficiency assessments, energy labels, and reports.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Buildings with High Energy Efficiency Rating, incorporating factors such as the number of buildings with the highest energy efficiency rating and the total number of evaluated buildings.

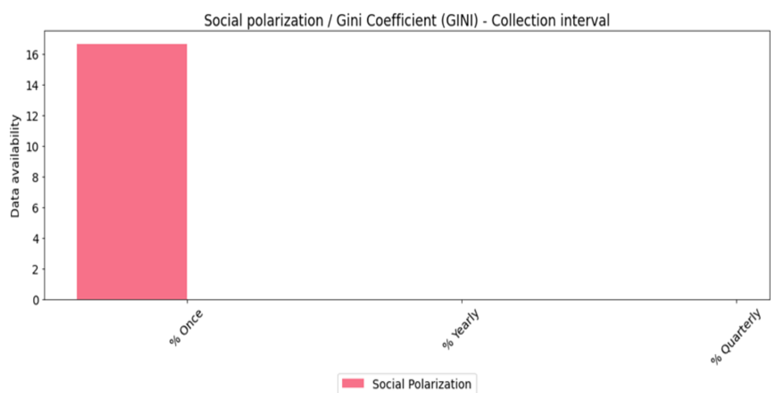
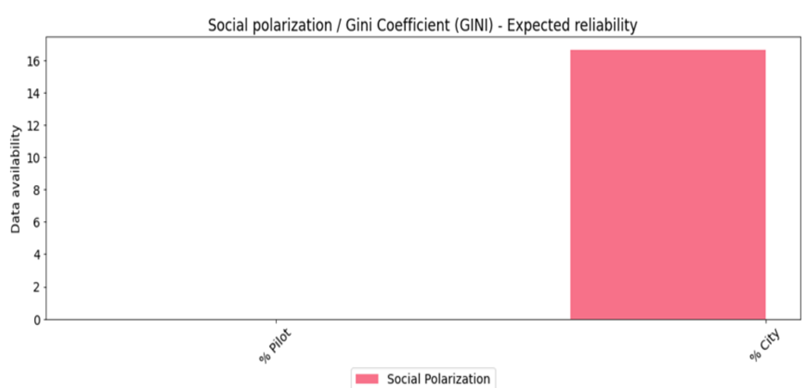
Indicator	**Core KPI-7**
Name of the indicator	**Violent Crime Rate**
Description incl. justification	The Violent Crime Rate indicator seeks to evaluate the incidence of violent crimes in a given area. Specifically, it assesses the number of violent crimes per 100,000 inhabitants, providing critical insights into the safety and security of the community. This indicator is essential for understanding the effectiveness of law enforcement and community safety initiatives. It encompasses various violent crimes, and the assessment is crucial for shaping policies aimed at reducing crime rates.
Definition	The indicator measures the violent crime rate per 100,000 inhabitants. It is calculated as the number of violent crimes committed divided by one 100,000th of the city's population.
Normalization	Normalization involves comparing the Violent Crime Rate against a predetermined standard or benchmark. This process allows for a standardized evaluation of crime rates across different urban areas.
Rating on a Scale	KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, signifying that the area does not meet safety specifications and objectives. Conversely, a score of 1 represents the best-case scenario, indicating that the community fulfils all proposed safety objectives and aligns completely with established definitions. 0: The worst possible outcome, indicating that safety specifications and objectives were not considered, and goals were not achieved. 0.25: Represents a low level of compliance, where safety is of minor importance, and decisions lack a solid foundation, relying on intuition. 0.5: Indicates partial consideration of the KPI in addressing safety concerns. It may have been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the Violent Crime Rate has been considered importantly in shaping safety-related decisions. 1: The best possible outcome, signifying a comprehensive consideration of the Violent Crime Rate, using extensive information, calculations, integral planning, and a specific aim to meet safety objectives.
Relevance	- Aligns with the increasing policy focus on enhancing community safety and reducing violent crime. - Encourages the integration of safety measures into urban planning and law enforcement strategies.

Limitations	- Lack of a standardized method for evaluating the overall impact of safety measures. - Difficulty in assessing the effectiveness of safety initiatives in a generalizable manner.

Data requirements	
Expected data source	Project documentation, including crime reports, law enforcement records, and relevant statistics.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained: 

Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Violent Crime Rate (VCR), incorporating factors such as the number of violent crimes and the city's population.

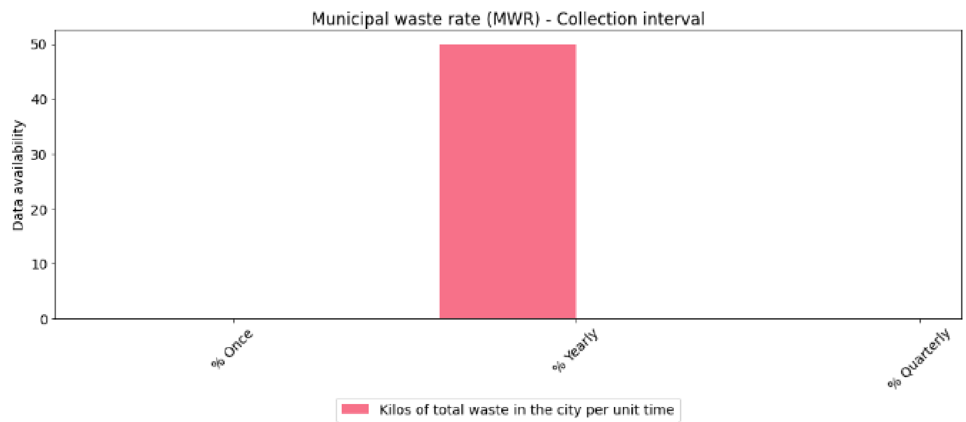
Indicator	**Core KPI-8**
Name of the indicator	**Social polarization / Gini Coefficient**
Description incl. justification	The Social Polarization / Gini Coefficient indicator aims to assess income distribution within a given population. Specifically, it utilizes the Gini coefficient to measure the level of economic inequality. This indicator is crucial for understanding the distribution of wealth and income disparities within a society. By analyzing the Gini coefficient, policymakers can gain insights into social polarization trends and make informed decisions to promote economic equity.
Definition	The indicator measures income distribution using the Gini coefficient. The Gini coefficient quantifies the inequality among values of a frequency distribution, representing the extent of income inequality in a population.
Normalization	Normalization involves comparing the Gini Coefficient against established standards or benchmarks, providing a standardized evaluation of income inequality across different regions.
Rating on a Scale	KPI values are classified on a scale from 0 to 1. A score of 0 represents the best-case scenario, indicating perfect income equality, while a score of 1 represents the worst-case scenario, signifying extreme income inequality. 0: The best possible outcome, indicating a society with perfect income equality. 0.25: This represents a low level of income inequality, where the Gini Coefficient suggests a fair distribution of income. 0.5: Indicates moderate income inequality, with some disparities in income distribution. 0.75: Reflects a significant level of income inequality, where the Gini Coefficient signals pronounced disparities in wealth distribution. 1: The worst possible outcome, indicating extreme income inequality within the population.
Relevance	- Aligns with the increasing policy focus on addressing income inequality and promoting social justice. - Encourages the integration of measures to reduce economic disparities in societal development plans.
Limitations	- Gini Coefficient may not capture all nuances of income distribution.

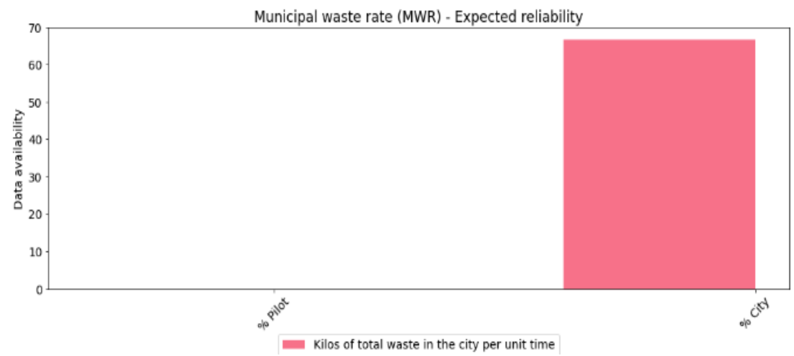
	- Difficulty in addressing the root causes of income inequality without complementary data and analyses.
Data requirements	
Expected data source	Income distribution data, including individual income levels or household income, for calculating the Gini Coefficient.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained: 
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.

Expected data models	Project-specific models outlining the calculation of Social Polarization / Gini Coefficient, incorporating factors such as income levels and the Gini Coefficient calculation.

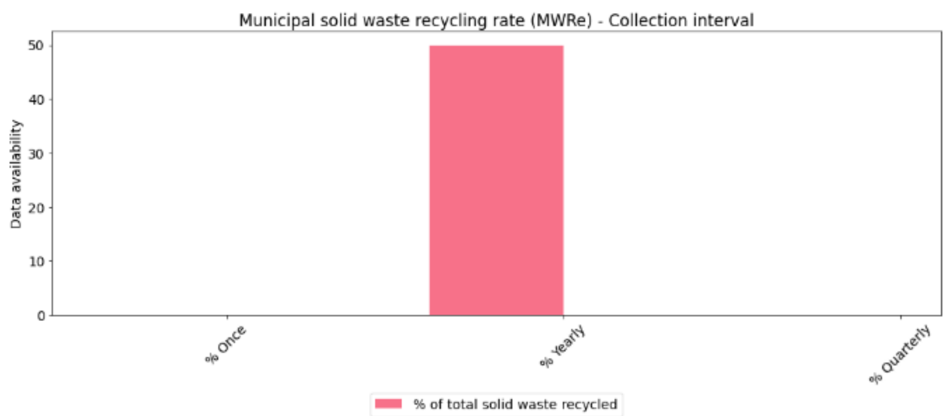
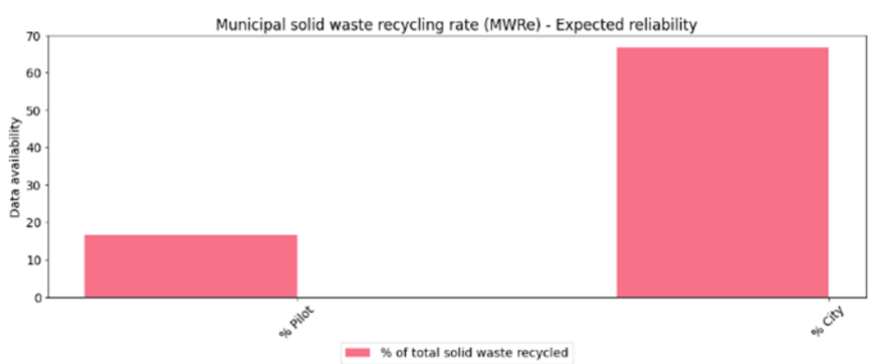
Indicator	**Core KPI-9**
Name of the indicator	**Municipal waste rate**
Description incl. justification	The Municipal Waste Rate indicator focuses on evaluating the efficiency of waste management by assessing the amount of waste generated by households, businesses, and institutions within a municipality or specific area. This includes various materials such as household garbage, recyclables, and organic matter, measured in kilograms (Kg). The MWR provides crucial insights into waste generation patterns, guiding policymakers in implementing effective waste reduction and recycling strategies to promote environmental sustainability.
Definition	The indicator measures the amount of waste generated by households, businesses, and institutions within a municipality or specific area. This waste encompasses materials such as household garbage, recyclables, and organic matter, expressed in kilograms (Kg).
Normalization	Normalization involves comparing the Municipal Waste Rate against established standards or benchmarks, providing a standardized assessment of waste management efficiency across different regions.
Rating on a Scale	KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, indicating inefficient waste management practices, while a score of 1 represents the best-case scenario, signifying optimal waste reduction and recycling efforts. 0: The worst possible outcome, indicating inefficient waste management practices and high waste generation. 0.25: Represents a low level of waste management efficiency, with moderate efforts in waste reduction. 0.5: Indicates moderate waste management efficiency, with significant progress in reducing and recycling waste. 0.75: Reflects a high level of waste management efficiency, demonstrating effective waste reduction and recycling practices. 1: The best possible outcome, indicating optimal waste reduction and recycling efforts, minimizing environmental impact.
Relevance	- Aligns with the increasing emphasis on sustainable waste management practices.

	- Encourages the integration of measures to reduce waste generation and enhance recycling.
Limitations	- Variation in waste composition may influence waste management efficiency. - Challenges in achieving uniform waste management practices across diverse urban areas.

Data requirements	
Expected data source	Municipal waste management data, comprising the quantity of recycled municipal solid waste and the total municipal waste generated.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

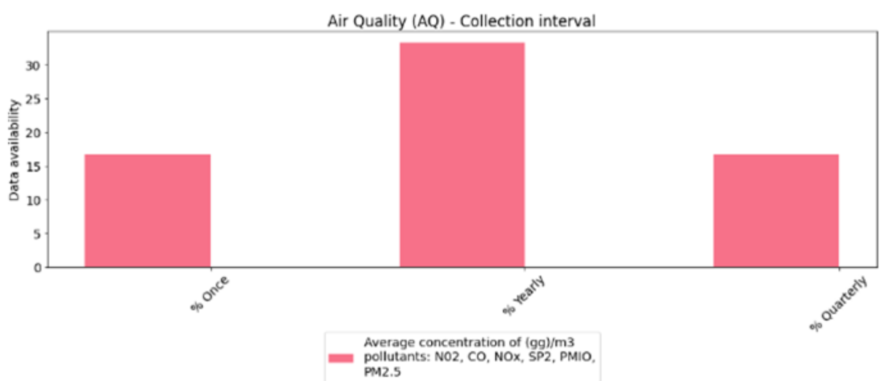
	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models delineating the calculation of Municipal Waste Rate, integrating factors such as the quantity of recycled municipal solid waste and the total municipal waste generated.

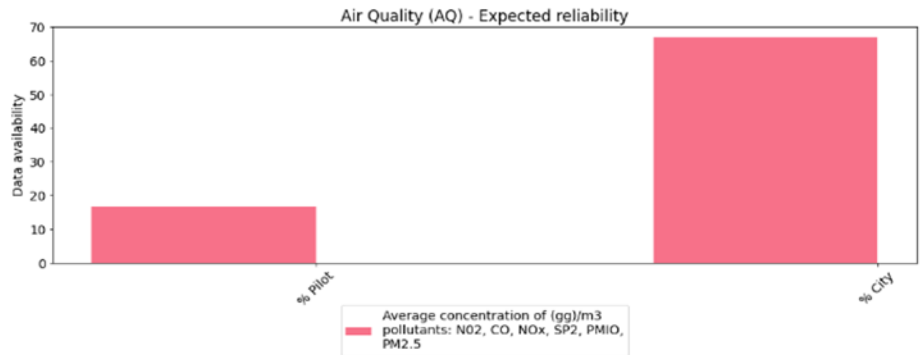
Indicator	**Core KPI-10**
Name of the indicator	**Municipal solid waste recycling rate**
Description incl. justification	The Municipal Solid Waste Recycling Rate indicator focuses on evaluating the efficiency of waste management by assessing the percentage of municipal solid waste that is recycled compared to the total waste generated. This includes various materials such as household garbage, recyclables, and organic matter. The indicator provides crucial insights into recycling practices, guiding policymakers in implementing effective waste reduction and recycling strategies to promote environmental sustainability.
Definition	The indicator measures the percentage of municipal solid waste that is recycled compared to the total waste generated.
Normalization	Normalization involves comparing the Municipal Solid Waste Recycling Rate against established standards or benchmarks, providing a standardized assessment of recycling efficiency across different regions.
Rating on a Scale	KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, indicating inefficient recycling practices, while a score of 1 represents the best-case scenario, signifying optimal recycling efforts. 0: The worst possible outcome, indicating inefficient recycling practices and low recycling rates. 0.25: Represents a low level of recycling efficiency, with moderate efforts in waste reduction. 0.5: Indicates moderate recycling efficiency, with significant progress in reducing and recycling waste. 0.75: Reflects a high level of recycling efficiency, demonstrating effective waste reduction and recycling practices. 1: The best possible outcome, indicating optimal recycling efforts, minimizing environmental impact.
Relevance	- Aligns with the increasing emphasis on sustainable waste management and recycling practices. - Encourages the integration of measures to enhance recycling and reduce the environmental impact of waste.
Limitations	- Variation in waste composition may influence recycling efficiency.

	- Challenges in achieving uniform recycling practices across diverse urban areas.
Data requirements	
Expected data source	Municipal waste management data, encompassing the quantity of recycled municipal solid waste and the total municipal waste generated.
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and completeness of the project documentation. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained: 
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.

Expected data models	Project-specific models outlining the calculation of Municipal Solid Waste Recycling Rate, incorporating factors such as the quantity of recycled municipal solid waste and the total municipal waste generated.

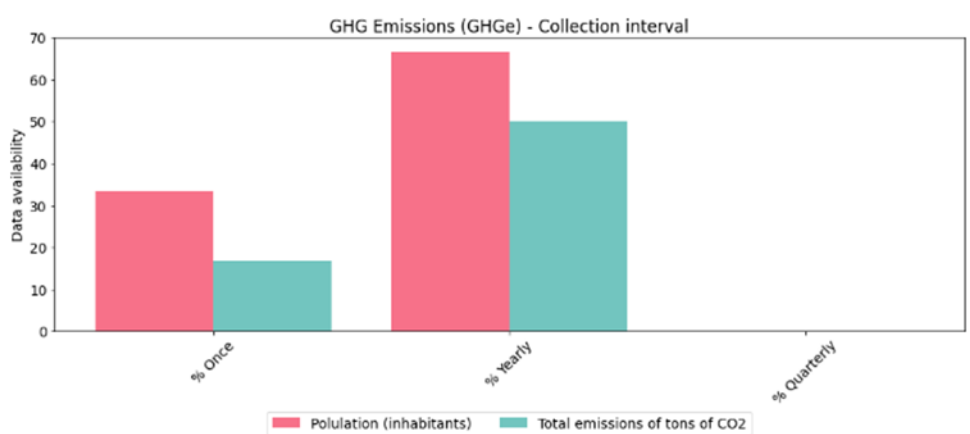
Indicator	**Core KPI-11**
Name of the indicator	**Air Quality**
Description incl. justification	The Air Quality indicator focuses on assessing the air quality index (AQI) based on reported values for specific pollutants, including particulate matter (PM10 and PM2.5), nitrogen dioxide, sulphur dioxide, and ozone. This comprehensive approach provides insights into the overall air quality, guiding policymakers in understanding potential health risks and implementing measures to improve air quality.
Definition	The indicator measures the AQI based on reported values for particulate matter (PM10 and PM2.5), nitrogen dioxide, sulphur dioxide, and ozone.
Normalization	Normalization involves comparing the Air Quality Index against established standards or benchmarks, providing a standardized assessment of air quality across different regions.
Rating on a Scale	The AQI for this project is scaled between 0 and 1, adhering to the recommendations of the World Health Organization (WHO). In this context, a score of 0 represents suboptimal air quality, exceeding WHO recommendations, with emissions reaching levels that may adversely affect the entire population. Conversely, a score of 1 signifies optimal air quality, meeting or surpassing WHO recommendations with zero emissions. The intermediate scale reflects varying degrees of air quality, providing a nuanced assessment of pollution levels. 0.0: Suboptimal air quality, exceeding WHO recommendations, with emissions reaching levels that may adversely affect the entire population. 0.25: Reflects higher pollution levels, posing health risks, particularly for sensitive groups. 0.5: Indicates moderate air quality, with acceptable pollution levels but potential concerns for sensitive individuals. 0.75: Represents very low pollution levels, indicating minimal impact on air quality. 1.0: Optimal air quality, meeting or surpassing WHO recommendations with zero emissions.

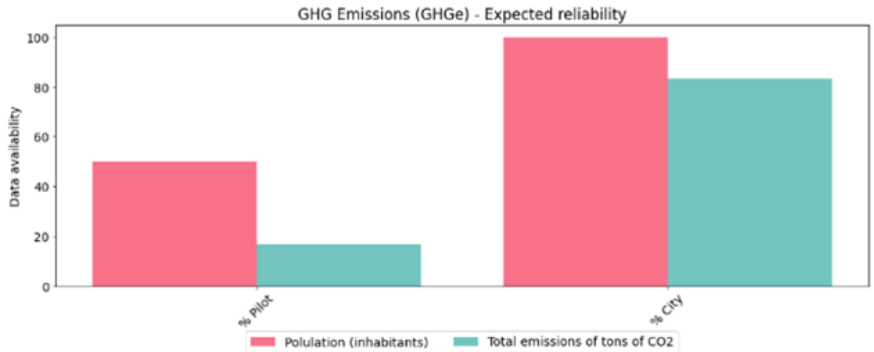
Relevance	- Aligns with the increasing emphasis on monitoring and improving air quality for public health. - Encourages the implementation of measures to reduce air pollution and enhance overall air quality.
Limitations	- Variation in pollutant sources and meteorological conditions may influence air quality measurements. - Challenges in achieving uniform air quality standards across diverse urban areas.
Data requirements	
Expected data source	Air quality data will be sourced from comprehensive monitoring systems, covering various pollutants such as particulate matter (PM10 and PM2.5), nitrogen dioxide, sulphur dioxide, and ozone. These data sources include reliable reporting mechanisms and advanced air quality measurement technologies.
Expected availability	Continuous availability of air quality data is anticipated throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring of air quality will occur during the project development and implementation phases. Regular sampling and reporting intervals will ensure the timely collection of accurate data, enabling informed decision-making regarding environmental interventions. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	The reliability of air quality data depends on the accuracy and comprehensiveness of monitoring systems and reporting mechanisms. Rigorous quality control measures will be implemented to ensure the precision of collected data, enhancing the overall reliability of the information. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

	
Expected accessibility	Project documentation, including air quality data, will be made readily accessible to relevant stakeholders, policymakers, and the public. Access to this information will be facilitated through online platforms, official reports, and collaboration with environmental agencies responsible for air quality monitoring.
Expected data models	Project-specific models will outline the calculation of the Air Quality Index, incorporating factors such as the mass of pollutants collected (in μg), volume of air sampled (in m^3), and the maximum allowable mass of pollutants as defined by WHO standards. These models will provide a standardized evaluation of air quality, supporting decision-makers in implementing strategies to address environmental concerns.

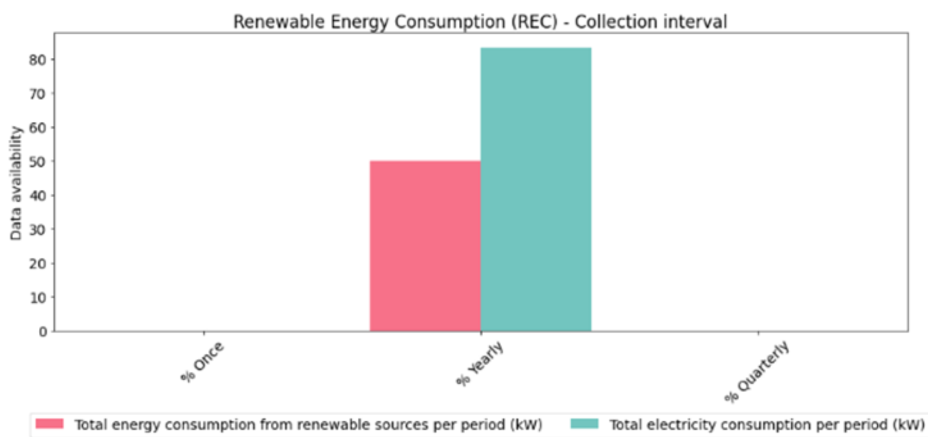
Indicator	**Core KPI-12**
Name of the indicator	**GHG Emissions**
Description incl. justification	The Greenhouse Gas Emissions per Capita indicator focuses on evaluating the environmental impact of a city by assessing the amount of greenhouse gas emissions produced per individual within the population. This includes gases such as carbon dioxide, methane, and nitrous oxide, measured in tons of equivalent carbon dioxide (eCO2). The indicator is crucial for understanding the carbon footprint of urban areas, guiding policymakers in implementing strategies to reduce emissions and mitigate climate change.
Definition	The indicator measures the amount of greenhouse gas emissions produced per capita within a city. This includes gases such as carbon dioxide, methane, and nitrous oxide, expressed in tons of equivalent carbon dioxide (CO2).
Normalization	Normalization involves comparing the Greenhouse Gas Emissions per Capita against established standards or benchmarks, providing a standardized assessment of emission efficiency across different regions.
Rating on a Scale	KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, indicating that the area does not meet environmental sustainability specifications and objectives related to greenhouse gas emissions per capita. Conversely, a score of 1 represents the best-case scenario, indicating that the community fulfils all proposed environmental sustainability objectives and aligns completely with established definitions. 0: The worst possible outcome, indicating that environmental sustainability specifications and objectives related to greenhouse gas emissions per capita were not considered, and goals were not achieved. 0.25: Represents a low level of compliance, where environmental sustainability is of minor importance, and decisions lack a solid foundation, relying on intuition. 0.5: Indicates partial consideration of the KPI in addressing environmental sustainability concerns related to greenhouse gas emissions per capita. It may have been considered to some extent, possibly with basic information, but not comprehensively. 0.75: Reflects a significant level of compliance, where the Greenhouse Gas Emissions has been considered importantly in shaping decisions related to environmental sustainability. 1: The best possible outcome, signifying a comprehensive consideration of the Greenhouse Gas Emissions, using extensive information, calculations, integral planning, and a specific aim to meet environmental sustainability objectives.

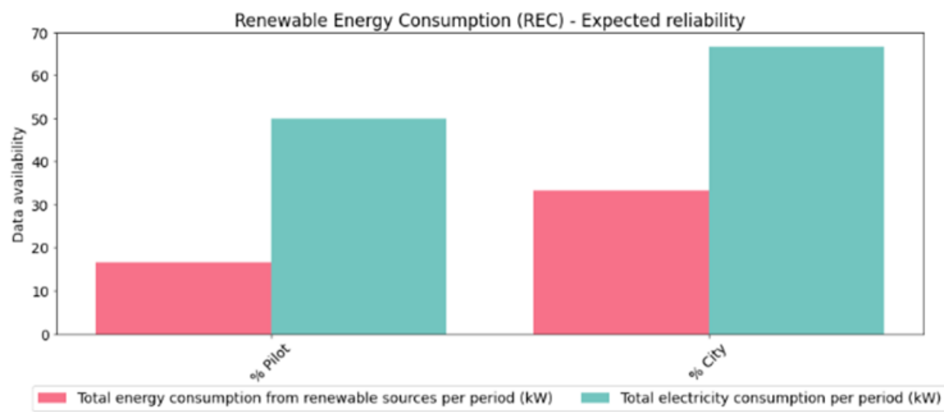
Relevance	- Aligns with the increasing global focus on mitigating climate change and reducing carbon footprints. - Encourages the integration of measures to lower emissions and enhance environmental sustainability.
Limitations	- Variation in emission sources may influence emission efficiency. - Challenges in achieving uniform emission reduction practices across diverse urban areas.

Data requirements	
Expected data source	Greenhouse Gas Emissions data will be sourced from comprehensive monitoring systems, covering various emissions such as carbon dioxide (eCO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases. These data sources include reliable reporting mechanisms and advanced emission measurement technologies.
Expected availability	Continuous availability of Greenhouse Gas Emissions data is anticipated throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring of the indicator will occur during the project development and implementation phases. Regular sampling and reporting intervals will ensure the timely collection of accurate data, enabling informed decision-making regarding environmental interventions. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	The reliability of data depends on the accuracy and comprehensiveness of monitoring systems and reporting mechanisms. Rigorous quality control measures will be implemented to ensure the precision of collected data, enhancing the overall reliability of the information. The more data obtained on the Pilot, the more reliable the measurement will be. From the surveys of the cities on the variables that can be measured, the following result is obtained:

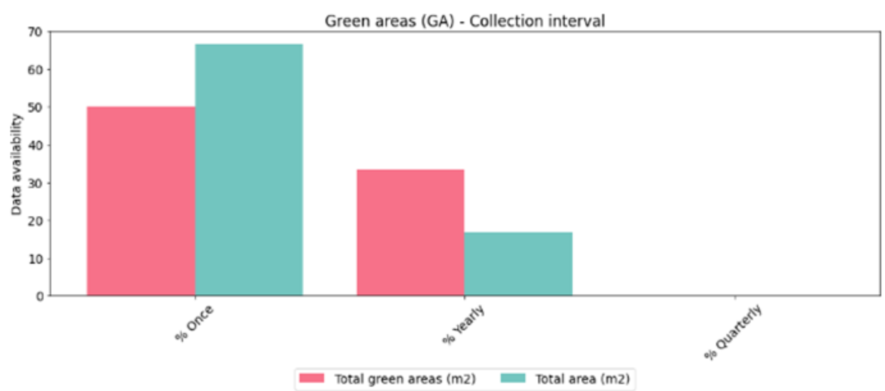
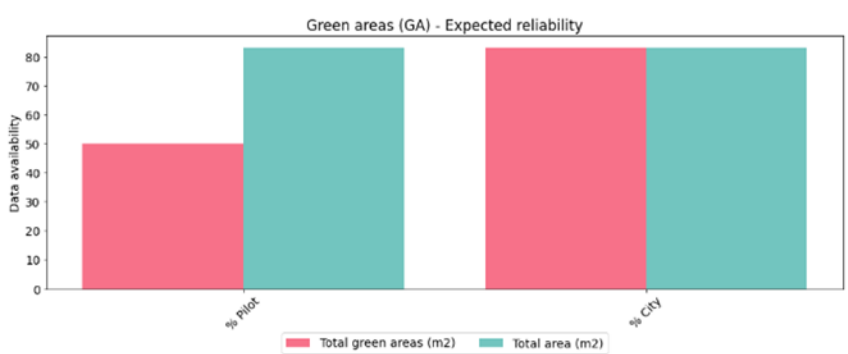
	
Expected accessibility	Project documentation, including GHG emissions data, will be made readily accessible to relevant stakeholders, policymakers, and the public. Access to this information will be facilitated through online platforms, official reports, and collaboration with environmental agencies responsible for Greenhouse Gas Emissions monitoring.
Expected data models	Project-specific models will outline the calculation of Greenhouse Gas Emissions, incorporating factors such as the total GHG emissions (in tonnes of eCO2) and the total number of city inhabitants. These models will provide a standardized evaluation of GHG emissions per capita, supporting decision-makers in implementing strategies to address environmental concerns.

Indicator	Core KPI-13
Name of the indicator	**Renewable Energy Consumption**
Description incl. justification	The Renewable Energy Consumption indicator aims to evaluate the percentage of renewable energy consumed within a city. Specifically, it quantifies the proportion of energy derived from renewable sources, providing insights into the city's commitment to sustainable and environmentally friendly energy practices. This indicator is crucial for understanding the city's reliance on renewable energy, promoting a shift towards cleaner energy alternatives, and contributing to global efforts to combat climate change. The example includes the utilization of solar panels as a renewable energy source.
Definition	The indicator measures the percentage of renewable energy consumed in the city. It calculates the ratio of total consumption of electricity from renewable sources (kWh/yr) to the total city electricity consumption (kWh/yr), expressed as a percentage.
Normalization	Normalization involves comparing the Renewable Energy Consumption against established standards or benchmarks, providing a standardized evaluation of the city's progress in adopting renewable energy sources.
Rating on a Scale	Rating on a Scale: KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, indicating minimal reliance on renewable energy, while a score of 1 represents the best-case scenario, signifying complete dependence on renewable energy sources. 0: The worst possible outcome, indicating minimal reliance on renewable energy consumption in the city. 0.25: Represents a low level of renewable energy consumption, with some utilization of renewable sources. 0.5: Indicates moderate renewable energy consumption, with a significant but not complete shift towards sustainable energy practices. 0.75: Reflects a substantial level of renewable energy consumption, showcasing a notable commitment to sustainable energy alternatives. 1: The best possible outcome, signifying complete dependence on renewable energy sources in the city.
Relevance	- Aligns with the increasing policy focus on transitioning to sustainable and renewable energy sources.

	- Encourages the integration of renewable energy measures into urban development plans.
Limitations	- Variability in renewable energy availability may influence consumption levels. - Challenges in achieving complete dependence on renewable energy without comprehensive infrastructure and policy support.
Data requirements	
Expected data source	Renewable energy consumption data, including the total consumption of electricity from renewable sources (kWh/yr).
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and comprehensiveness of project documentation. From the surveys of the cities on the variables that can be measured, the following result is obtained:

	
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Renewable Energy Consumption, incorporating factors such as energy consumption levels and the specified calculation methodology.

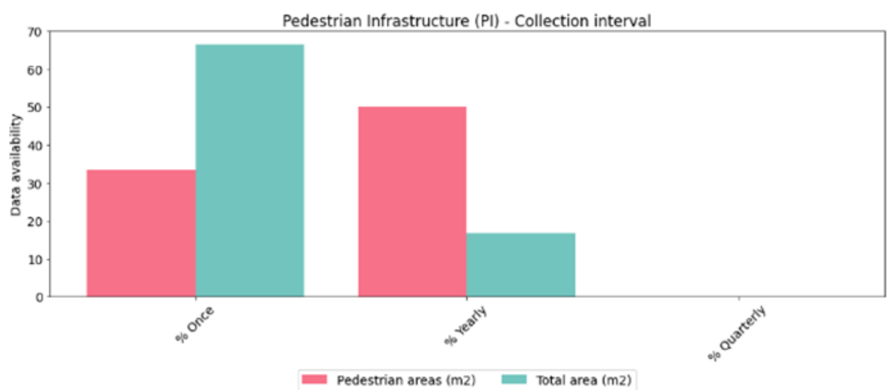
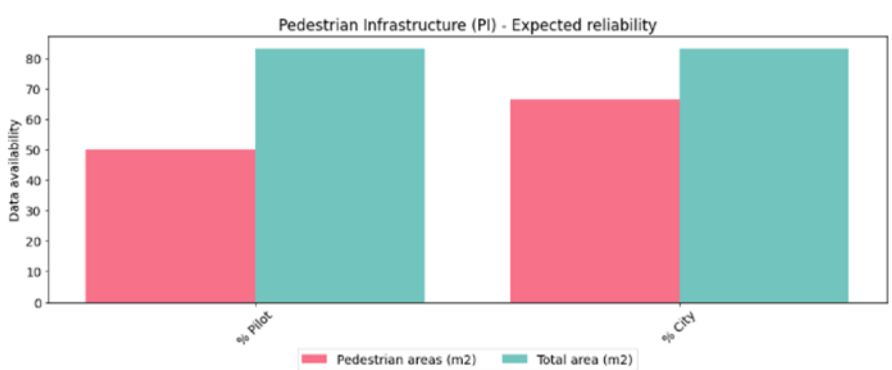
Indicator	**Core KPI-14**
Name of the indicator	**Green areas**
Description incl. justification	The Green Areas indicator aims to evaluate the amount of green space per 100,000 inhabitants within a city. It quantifies the proportion of the city's area that is dedicated to green spaces, providing insights into the city's commitment to environmental sustainability and residents' access to nature. This indicator is crucial for understanding the city's efforts in promoting biodiversity, improving air quality, and enhancing residents' mental and physical health.
Definition	The indicator measures the percentage of green area per 100,000 inhabitants in the city. It calculates the ratio of the total green area (in square meters) to the total city area (in square meters), expressed as a percentage, or the total green area per 100,000 inhabitants.
Normalization	Normalization involves comparing the Green Areas indicator against established standards or benchmarks, providing a standardized evaluation of the city's progress in maintaining and expanding green spaces.
Rating on a Scale	Rating on a Scale: KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, indicating minimal green spaces, while a score of 1 represents the best-case scenario, signifying a high proportion of green spaces. 0: The worst possible outcome, indicating minimal green spaces in the city. 0.25: Represents a low level of green spaces, with some areas dedicated to nature. 0.5: Indicates a moderate level of green spaces, with a significant but not complete shift towards environmental sustainability. 0.75: Reflects a substantial level of green spaces, showcasing a notable commitment to environmental sustainability. 1: The best possible outcome, signifying a high proportion of green spaces in the city.
Relevance	- Aligns with the increasing policy focus on promoting environmental sustainability and biodiversity. - Encourages the integration of green spaces into urban development plans.

Limitations	- Variability in the availability and distribution of green spaces may influence the indicator. - Challenges in achieving a high proportion of green spaces without comprehensive infrastructure and policy support.
Data requirements	
Expected data source	Green area data, including the total green area (in square meters).
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and comprehensiveness of project documentation. From the surveys of the cities on the variables that can be measured, the following result is obtained: 
Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.

Expected data models	Project-specific models outlining the calculation of Green Areas, incorporating factors such as green area levels and the specified calculation methodology.

Indicator	**Core KPI-15**
Name of the indicator	**Pedestrian Infrastructure**
Description incl. justification	The Pedestrian Infrastructure indicator aims to evaluate the percentage of the city designated as a pedestrian/car-free zone. It quantifies the proportion of the city's area that is dedicated to pedestrian zones, providing insights into the city's commitment to promoting walkability and reducing vehicular traffic. This indicator is crucial for understanding the city's efforts in promoting pedestrian safety, improving air quality, and enhancing the quality of urban life.
Definition	The indicator measures the percentage of the city designated as a pedestrian/car-free zone. It calculates the ratio of the total area of pedestrian/car-free zones (in square meters) to the total city area (in square meters), expressed as a percentage.
Normalization	Normalization involves comparing the Pedestrian Infrastructure indicator against established standards or benchmarks, providing a standardized evaluation of the city's progress in creating pedestrian-friendly spaces.
Rating on a Scale	Rating on a Scale: KPI values are classified on a scale from 0 to 1. A score of 0 represents the worst-case scenario, indicating minimal pedestrian infrastructure, while a score of 1 represents the best-case scenario, signifying a high proportion of pedestrian/car-free zones. 0: The worst possible outcome, indicating minimal pedestrian infrastructure in the city. 0.25: Represents a low level of pedestrian infrastructure, with some areas designated as pedestrian/car-free zones. 0.5: Indicates a moderate level of pedestrian infrastructure, with a significant but not complete shift towards pedestrian-friendly spaces. 0.75: Reflects a substantial level of pedestrian infrastructure, showcasing a notable commitment to creating pedestrian-friendly spaces. 1: The best possible outcome, signifying a high proportion of pedestrian/car-free zones in the city.
Relevance	- Aligns with the increasing policy focus on promoting walkability and reducing vehicular traffic. - Encourages the integration of pedestrian infrastructure into urban development plans.

Limitations	- Variability in the availability and distribution of pedestrian zones may influence the indicator. - Challenges in achieving a high proportion of pedestrian zones without comprehensive infrastructure and policy support.

Data requirements	
Expected data source	Pedestrian zone data, including the total area of pedestrian/car-free zones (in square meters).
Expected availability	Throughout the project lifecycle, from planning to completion.
Collection interval	Continuous monitoring during the project development and implementation phases. From the information obtained from the surveys with the cities, the availability of data collection is as follows: 
Expected reliability	Reliability depends on the accuracy and comprehensiveness of project documentation. From the surveys of the cities on the variables that can be measured, the following result is obtained: 

Expected accessibility	Project documentation should be accessible to relevant stakeholders, policymakers, and the public.
Expected data models	Project-specific models outlining the calculation of Pedestrian Infrastructure, incorporating factors such as pedestrian zone levels and the specified calculation methodology.

APPENDIX B: Open data sources

City	KPI Source
Milano	- Air pollution and greenhouse gases (NO2): https://dati.comune.milano.it/en/group/ener?page=1 (2020, 2021) - Municipal waste generated (domestic and commercial), total-1000t: https://portali.arpalombardia.it/rifiuti/grul/estrattoGRUL2020/ReportComuniDett_Milano2020.pdf, https://portali.arpalombardia.it/rifiuti/grul/estrattoGRUL2019/ReportComuniDett_Milano2019.pdf, https://ec.europa.eu/eurostat/web/main/data/database (2012 to 2018) - Net business population growth (%): https://ec.europa.eu/eurostat/web/main/data/database (2016 to 2020) - Length of bicycle network (km): https://ec.europa.eu/eurostat/web/main/data/database (2019, 2020) - Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2022) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2021)
Budapest	- Air pollution and greenhouse gases (NO2): https://ec.europa.eu/eurostat/web/main/data/database (2018 to 2023) -Municipal waste generated (domestic and commercial), total-1000t: https://ec.europa.eu/eurostat/web/main/data/database (2012 to 2021) - Net business population growth (%): https://ec.europa.eu/eurostat/web/main/data/database (2016 to 2020) - Length of bicycle network (km): https://ec.europa.eu/eurostat/web/main/data/database (2015 to 2021) - Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2022) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2020)
Zagreb	- Air pollution and greenhouse gases (NO2): https://ec.europa.eu/eurostat/web/main/data/database

City	KPI Source
	(2018 to 2023) - Municipal waste generated (domestic and commercial), total-1000t: https://ec.europa.eu/eurostat/web/main/data/database (2015 to 2018) - Net business population growth (%): https://ec.europa.eu/eurostat/web/main/data/database (2016, 2020) - Length of bicycle network (km): https://ec.europa.eu/eurostat/web/main/data/database (2015, 2021) - Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2022) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2015 to 2021)
Münster	- Municipal waste generated (domestic and commercial), total-1000t: https://ec.europa.eu/eurostat/web/main/data/database (2012 to 2020) - Length of bicycle network (km): https://ec.europa.eu/eurostat/web/main/data/database (2017 to 2021) - Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2015 to 2021)
Lisbon	- Air pollution and greenhouse gases (NO2): https://ec.europa.eu/eurostat/web/main/data/database - Municipal waste generated (domestic and commercial), total-1000t: https://ec.europa.eu/eurostat/web/main/data/database (2012 to 2020) - Net business population growth (%): https://ec.europa.eu/eurostat/web/main/data/database (2016 to 2020) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2015 to 2021)
Belfast	- Air pollution and greenhouse gases (NO2): https://uk-air.defra.gov.uk/data/compliance-map/ (2020, 2021) -Municipal waste generated (domestic and commercial), total-1000t: https://ec.europa.eu/eurostat/web/main/data/database (2016 to 2018)

City	KPI Source
	- Municipal waste generated (domestic and commercial), total-1000t: https://www.daera-ni.gov.uk/publications/northern-ireland-local-authority-collected-municipal-waste-management-statistics-2021, https://www.daera-ni.gov.uk/sites/default/files/publications/daera/lac-municipal-waste-2020-21-report.pdf - Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2019) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2018)
Granollers	- People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2015 to 2020)
Istanbul	- Open Data: https://data.ibb.gov.tr/en/
Rotterdam	- Municipal waste generated (domestic and commercial), total-1000t: https://ec.europa.eu/eurostat/web/main/data/database (2012, 2013, 2019, 2020) - Net business population growth (%): https://ec.europa.eu/eurostat/web/main/data/database (2016 to 2020) - Length of bicycle network (km): https://ec.europa.eu/eurostat/web/main/data/database (2019, 2020) - Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2022) - People killed in road accidents per 10.000 pop: https://ec.europa.eu/eurostat/web/main/data/database (2019, 2020)
Thessaloniki	- Unemployment Rate (15 years or over): https://ec.europa.eu/eurostat/web/main/data/database (2013 to 2022)