Participatory Methodology to Assess the Impacts of Artificial Intelligence in urban contexts.

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Abstract

This paper presents a novel methodology for assessing the social impact of Artificial Intelligence (AI) solutions in urban environments, developed within the framework of the CITCOM.ai project, cofinanced by European Union. As cities increasingly adopt AI technologies to enhance public services, a systematic approach to evaluating their societal implications becomes essential. Our methodology addresses the dual challenge of AI's context-specific impacts and rapidly evolving applications through a reflexive participatory process grounded in the European Commission's Assessment List for Trustworthy Artificial Intelligence (ALTAI). We detail a roadmap for conducting Artificial Intelligence Impact Assessments (AIIA) that engages diverse stakeholder groups in identifying potential impacts and developing Key Performance Indicators (KPIs) for monitoring. The methodology builds upon existing frameworks while addressing current gaps in impact assessment practices. We validate our approach through a participatory workshop involving 26 stakeholders in Valencia, Spain, focusing on three urban service domains: Mobility, Tourism, and Waste Management.

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1 Introduction

The current rise of Artificial Intelligence (AI), without questioning the potential contribution it can make to the competitiveness and advancement of our society, also entails risks and uncertainties regarding the impact on human, economic and social dimensions, among others.

AI solutions, like other ICT technologies, are general-purpose technologies that can have varying impacts depending on their utilization. In urban contexts, the integration of AI solutions is driven by the objective of enhancing public services. The entity implementing the solution for the improvement of public service can be either public or private, but the service is aimed at meeting the needs of the community of individuals living in that urban environment. As cities increasingly harness the potential of AI to enhance public services, a pressing need arises to evaluate the societal impact of these technological interventions. Some cities, such as Amsterdam, Helsinki, Copenhagen, and Hamburg, have already begun developing proactive frameworks that incorporate citizen focus groups for the ethical evaluation of AI implementations to analyse citizen complaints and feedback (Ryan & Gregory, 2019), highlighting the growing recognition of participatory approaches in this field..

In this context, the European project CITCOM.ai [1] supports the implementation of AI-based technologies in European cities. The project creates an ecosystem that helps AI innovators overcome technical, business, and legal barriers by offering technical assistance to test their latest AI-based software and hardware technologies at scale in real-world environments. These tests are conducted through the European AI and Robotics Testing and Experimentation Facilities (TEFs) before the technologies are deployed into places where humans live and move around. As part of these efforts, a methodology to evaluate the social impact of AI solutions was designed and tested.

Developing a methodology for conducting an Artificial Intelligence Impact Assessment (AIIA) presents its own challenges. On one hand, the wide-ranging applications of AI solutions determine that impacts and related indicators are inherently solution-specific, complicating the creation of universally applicable metrics. On the other hand, the rapid proliferation of AI applications causes novel and unforeseen impacts, visible only through the insights of users and stakeholders actively engaged in the field. In this context, formulating a methodology for AI Impact Assessment must be rooted in a reflexive participatory process, wherein stakeholders contribute to impact identification under the guidance of a common and recognised conceptual framework as the one set up by the European Commission in its Assessment List for Trustworthy Artificial Intelligence - ALTAI (European Commission 2020). This approach ensures the assessment methodology remains adaptable and responsive to the evolving landscape of AI applications and their associated impacts.

To face these challenges, a Roadmap to conduct an Artificial Intelligence Impact Assessment (AIIA) for solutions implemented in urban public services based on a participatory approach was developed. The proposed methodology was based on a reflective participatory process where actors representing relevant stakeholder groups actively contribute to the identification of social impacts, as well as the construction of a system of Key Performance Indicators (KPIs) that support the measurement and monitoring of these impacts. The methodology builds on the existing work

[1] CITCOM.ai : https://citcom.ai/

of several reputable organisations instead of seeking to replace them; where applicable, some parts of the methodology borrow from existing tools or methods, including the Platform for the Information Society (ECP), UNESCO, the Social Life Cycle Assessment (S-LCA) from United Nations Environment Program, or CITIKEYS project among others, referring to and crediting them in the process. The aim of delivering this methodology was not to reinvent the wheel, but rather to leverage pre-existing knowledge, try to fill existing gaps and create a solid framework to assess the impact of Artificial Intelligence that can be tested and used throughout Europe.

The methodology was tested in a participatory workshop with 26 representatives from different stakeholder groups in Valencia city within the framework of the CITCOM project, focusing on three case studies related to Mobility, Tourism and Waste management. The primary objective of applying this methodology to the three case studies was to test and validate the proposed participation design through realistic scenarios based on actual AI solutions being studied within the CITCOM project. While these case studies were grounded in real solutions and involved, in some cases, the participation of solution developers, they functioned as methodological validation exercises rather than full-scale impact assessments for actual deployments. This approach allowed for detailed access to solution information and stakeholder engagement while maintaining a controlled environment to evaluate the methodology's effectiveness, identify potential improvements, and refine the participatory process design.

2 An overview of AI impact assessment frameworks

A review of the literature on AI impact assessment was conducted, drawing on frameworks and guidelines developed by reputable institutional and academic sources, including among others the European Commission, UNESCO, the Platform for the Information Society - ECP, and the UNEP. The HLEG Ethics Guidelines (European Commission & High Level Expert Group on Artificial Intelligence., 2019) established a foundational set of seven trustworthiness requirements that have become a widely adopted reference for ethical AI development. Building on these, the Assessment List for Trustworthy AI (European Commission, 2020) operationalised these requirements into a structured self-assessment tool, providing concrete evaluation criteria applicable across sectors. The UNESCO Ethical Impact Assessment (UNESCO, 2023) broadened this perspective by incorporating a rights-based approach and introducing a stakeholder engagement plan as part of the assessment process. The ECP AI Impact Assessment (Platform for the Information Society (ECP), 2018) contributed a phased procedural roadmap that guides organisations through the assessment process from need screening to periodic review. The AI Watch framework (European Commission. Joint Research Centre., 2020) advanced the understanding of AI impacts specifically in public service contexts through a public value lens. Finally, the UNEP S-LCA Guidelines (UNEP, 2020) introduced a rigorous hierarchical structure linking stakeholder categories to impact subcategories and inventory indicators, providing a robust foundation for KPI development. Table 1 provides an overview of these frameworks.

Table 1. An overview of AI impact assessment frameworks

Framework	Organisation	Approach	Key characteristics
AI Impact Assessment (AIIA)	Platform for the Information Society – ECP (2018)	Technical / Legal / Ethical	Provides a phased procedural roadmap guiding organisations through 8 steps from need screening to periodic review, covering ethical, legal and technical dimensions
Ethics Guidelines for Trustworthy AI	AI HLEG / European Commission (2019)	Ethical / Normative	Foundational set of seven trustworthiness requirements that have become a widely adopted reference for ethical AI development
Assessment List for Trustworthy AI (ALTAI)	European Commission (2020)	Ethical / Self-assessment	Operationalises the HLEG requirements into a structured self-assessment tool with questions across 7 dimensions, providing concrete evaluation criteria applicable across sectors
S-LCA Guidelines	UNEP (2020)	Life-cycle / Stakeholder-based	Introduces a rigorous four-phase process and hierarchical structure linking stakeholder categories to impact subcategories and inventory indicators, combining quantitative and qualitative data collection
AI Watch: AI in Public Services Framework	European Commission - JRC - Van Noordt & Misuraca (2020)	Policy / Analytical	Advances understanding of AI impacts in public service contexts through a public value lens, analysing AI deployment across EU member states along three dimensions: improved administration, improved public services, and improved social value
UNESCO Ethical Impact Assessment	UNESCO (2023)	Ethical / Rights-based	Rights-based assessment tool structured around UNESCO's ethical principles for AI, including scoping questions, an impact assessment matrix template, and a stakeholder engagement plan covering the full AI lifecycle

Source: Own elaboration.

Building on these foundations, the methodology proposed in this paper seeks to advance the field by addressing gaps that remain across existing frameworks when considered individually. While ALTAI provides a structured ethical self-assessment tool, it does not incorporate participatory processes for stakeholder-driven impact identification, nor does it include a KPI monitoring system. UNESCO's framework introduces stakeholder engagement, including tools such as an impact matrix template, but does not extend to the systematic co-production of measurable indicators. The ECP roadmap offers procedural guidance through a phased approach, yet its focus remains primarily on screening and procedural compliance rather than on participatory impact identification or monitoring. The UNEP S-LCA Guidelines provide a robust hierarchical structure for linking stakeholder categories to impact indicators, informing the KPI

architecture of this methodology, but were not designed specifically for AI applications in urban service contexts. Similarly, the JRC AI Watch framework advances the analytical understanding of AI impacts in public services, but does not provide operational tools for impact assessment or monitoring. In this regard, the methodology proposed in this paper contributes by integrating: (i) a structured multi-stakeholder participatory process for the co-production of impact dimensions; (ii) a consistent conceptual scaffold based on ALTAI trustworthiness requirements; and (iii) a monitoring-oriented KPI system tailored to specific AI solutions in urban service contexts. This combination seeks to bridge the gap between normative frameworks and operational tools, providing a methodology that is both conceptually grounded and practically implementable.

3 Artificial intelligence impact assessment methodology

Drawing on the frameworks reviewed above, the following section presents the proposed methodology for conducting an Artificial Intelligence Impact Assessment (AIIA) in urban public service contexts. Rather than replacing existing approaches, the methodology integrates and adapts selected elements from each of these frameworks — combining the ethical scaffold provided by ALTAI and the HLEG Guidelines, the procedural structure and screening tools of the ECP roadmap, and the impact matrix template developed by UNESCO — into a coherent, participatory, and monitoring-ready assessment instrument. Additionally, the KPI system embedded in the methodology draws on an extensive review of indicator catalogues from reputable sources, including the U4SSC Collection Methodology for Key Performance Indicators for Smart Sustainable Cities (U4SSC, 2017), the CITYkeys indicators for smart city projects (Bosch et al., 2017), and the UNEP Guidelines for Social Life Cycle Assessment (UNEP, 2020), among others.

The proposed roadmap for conducting an Artificial Intelligence Impact Assessment (AIIA) presented in Figure 1 involves 3 phases and 8 steps to comprehensively evaluate the effects of implementing an AI solution.

Phase 1 focuses on determining whether the impact evaluation assessment is necessary and gathers information about the AI solution to build a case study that will be the basis of the participatory process (Phase 2). The first step of phase 1 consists of answering to a set of screening questions that will help decide whether the AIIA is advisable or recommended. Once the need for the AIIA is established, the next step is to describe the AI solution and its context (Step 2). This includes understanding the purpose of the AI solution, the technology used, the data sources utilised, and the identification of relevant stakeholders. This group of stakeholders will be engaged to participate in a collaborative effort that will form the core of the AIIA system (Phase 2), serving as the main actors in the subsequent steps.

Phase 2 is dedicated to the organisation of the Participatory Workshop. In Step 3, the AIIA team will contact selected stakeholders to ask for their collaboration and send them the documentation related to the AI solution that will be assessed. This documentation will be prepared by the AIIA team based on the information gathered in Phase 1, including an introduction of the context and background to understand where the AI solution is implemented, the description of the AI solution, a first draft of the identification of social impact of the AI solution and related KPIs brainstormed internally with the AIIA team. The identification of social impacts is structured around the ALTAI requirements (European Commission, 2020), which provides a comprehensive framework to evaluate trustworthy AI across seven key dimensions (see Box 1). This framework ensures that the impact assessment covers the most relevant aspects of AI implementation while maintaining alignment with European standards for ethical and trustworthy artificial intelligence. In Step 4, using the ALTAI requirements to guide the workshop activity, participants will work

to identify social impacts, using as starting point the first draft sent to them, discussing and proposing new impacts, and modifying what they deem necessary. The structured approach provided by ALTAI facilitates systematic discussion among stakeholders while allowing flexibility for context-specific impacts to emerge during the participatory process. After identifying impacts, stakeholders will be asked to identify potential metrics for evaluating those impacts (Step 5). To achieve this, they will work with the first draft of Key Performance Indicators (KPIs) provided with the documentation and the final list of impacts produced in Step 4.

Box 1. The Assessment List for Trustworthy Artificial Intelligence (ALTAI)

The Assessment List for Trustworthy Artificial Intelligence (ALTAI)

The Assessment List for Trustworthy Artificial Intelligence (ALTAI) is a practical tool developed by the European Commission's High-Level Expert Group on Artificial Intelligence to help organisations assess whether their AI systems are trustworthy. Released in 2020, ALTAI operationalizes the "Ethics Guidelines for Trustworthy AI" by providing a comprehensive checklist organised around seven key requirements:

1. Human Agency and Oversight: Ensuring human control and decision-making authority
2. Technical Robustness and Safety: Guaranteeing reliable and secure AI systems
3. Privacy and Data Governance: Protecting personal data and ensuring proper data management
4. Transparency and Accountability: Ensuring explainability and responsibility
5. Diversity, Non-discrimination and Fairness: Preventing bias and promoting inclusion
6. Societal and Environmental Wellbeing: Considering broader social and environmental impacts
7. Environmental Wellbeing: Addressing sustainability concerns

Each requirement contains specific questions and criteria that organisations can use to evaluate their AI systems.

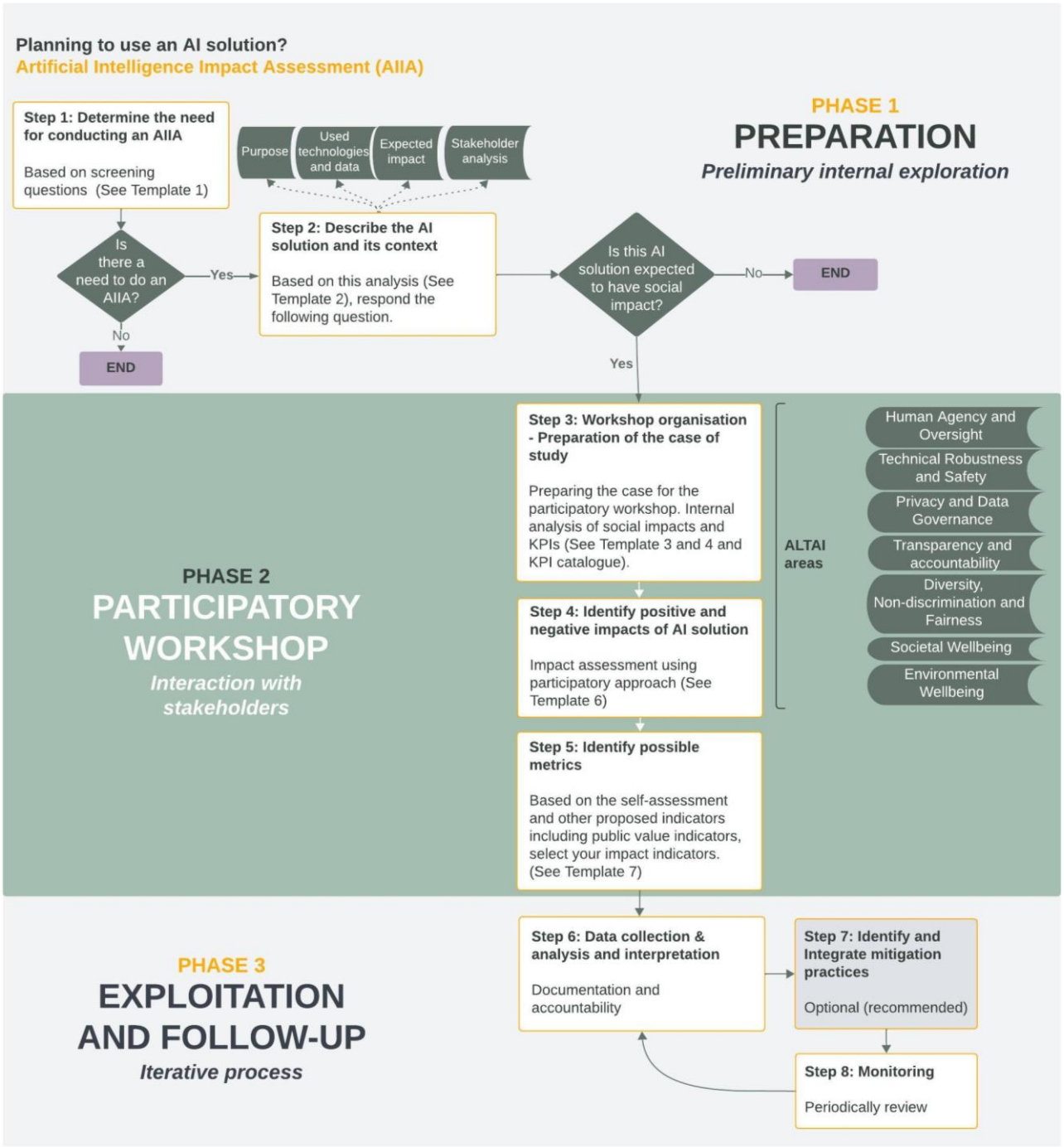
Source: European Commission, 2020

The final phase (Phase 3) entails the exploitation and follow-up process of the AIIA KPI system. Step 6 encompasses gathering pertinent data for the selected KPIs, establishing an initial baseline, analysing the results, and interpreting the findings to inform decision-making.

Step 7 (optional but highly recommended) involves facilitating a second participatory activity where stakeholders are engaged to identify mitigation practices aimed at addressing negative impacts identified during the assessment process. Finally, the process concludes with an iterative review of the data and KPIs, enabling ongoing assessments of impacts over time and facilitating the adjustment of mitigation practices as needed (Step 8).

To support this process, a series of templates were developed to guide each step of the methodology[2]. The following section provides a detailed description of each step of the proposed methodology.

Figure 1. Artificial Intelligence Impact Assessment (AIIA) roadmap



Source: Own elaboration.

[2] The templates for the evaluation methodology are available upon request. If you are interested, please contact gmunares@kveloce.com for further information.

3.1 Phase 0: Establishing the AIIA team

Before initiating the impact assessment process, it is essential to establish a multidisciplinary AIIA team responsible for conducting the entire evaluation. The composition and preparation of this team is critical to the success of the participatory process.

3.1.1 Team composition and expertise requirements:

The AIIA team should include a minimum of 3-5 members with complementary expertise and representing key perspectives:

- **Methodological leader**: Expert in participatory processes, social impact assessment, or similar methodologies
- **Representative from the solution developer/provider**: Professional from the developing organisation who can provide technical insights about the AI solution and facilitate access to the development team
- **Public sector representative**: official from the contracting or implementing public entity
- **Social science expert**: Professional with knowledge of social impacts, community engagement, or relevant domain expertise
- **Independent technical expert (optional but recommended)**: External AI/technology expert who can provide objective technical assessment when needed

3.1.2 Team leadership:

The AIIA team must be led by a designated team leader. Leadership may rest either with a representative from the initiating entity or with an external expert or team contracted to carry out the assessment, depending on the expertise and capacity available within the initiating organisation. When the initiating entity has sufficient expertise and capacity, it may appoint an internal leader. When this is not the case, leadership should be delegated to an independent evaluation expert, academic institution, or specialized consultancy with experience in participatory methodologies and AI impact assessment. In all cases, the initiating entity should remain actively involved to ensure institutional ownership and facilitate access to stakeholders and technical information.

Regardless of the leadership arrangement, the team leader should possess:

- Experience in participatory processes and stakeholder engagement
- Understanding of AI technologies and their social implications
- Ability to maintain neutrality and facilitate inclusive discussions
- Project management skills to coordinate the multi-phase assessment process

3.1.3 Team responsibilities:

The AIIA team will be responsible for:

- Designing and coordinating the entire assessment process
- Preparing case study documentation and materials

- Identifying and engaging stakeholders
- Facilitating participatory workshops
- Analysing results and preparing recommendations
- Coordinating follow-up and monitoring activities

3.1.4 Considerations for team formation:

Team composition may vary depending on who initiates the assessment (solution developer, public contracting entity, or independent third party). Regardless of the initiating entity, ensuring diverse perspectives and maintaining objectivity throughout the process is essential.

3.2 Phase 1: Preparation: preliminary exploration

3.2.1 Step 1: Determine the need for conducting the AIIA

Undertaking an AIIA entails significant effort and resource allocation. Therefore, it is crucial to ascertain the necessity of this process, as not every implementation of an AI solution justifies a comprehensive AIIA. The following screening questions are employed to assess whether an AIIA is necessary or advisable. If the answer to any of these questions is 'yes', conducting an AIIA is advisable. If multiple questions elicit a 'yes' response, conducting an AIIA is strongly recommended.

Figure 2. Screening questions

	Yes
Is a novel kind of AI technology employed?	☐
Is the AI solution implemented in an unfamiliar domain?	☐
Does the AI solution address sensitive social issues?	☐
Is the AI solution deployed in a complex environment?	☐
Does the AI solution have a degree of autonomy?	☐
Is sensitive personal data used by the AI solution?	☐
Do the decisions made by the AI solution significantly affect individuals, entities, or carry legal ramifications?	☐

Source: Own elaboration based on Artificial intelligence Impact Assessment Report (Platform for the Information Society (ECP), 2018)

Screening questions[3]

Is a novel kind of AI technology employed?

The risks associated with technology are usually more prominent when dealing with new and innovative technologies, as opposed to those that have undergone extensive testing and have a longer track record of use.

Definition: For the purposes of this screening process, 'novel AI technology' refers to AI systems or approaches that have not been previously implemented in the specific domain of application, lack extensive historical data on their performance and impacts, or represent significant departures from established AI practices in that context

Is the AI solution implemented in an unfamiliar domain?

An AI solution being implemented in an unfamiliar domain implies its application in a new context. For instance, utilizing an application primarily designed for marketing within the healthcare sector for the first time could introduce novel ethical considerations stemming from this shift in domain.

Does the AI solution address sensitive social issues?

When AI applications extend into sensitive social fields, the risks and ethical dilemmas associated with its deployment may intensify. This is particularly relevant in domains such as criminal justice, finance, healthcare, safety protocols, or educational settings. Furthermore, it is crucial to account for vulnerable demographics such as children, elderly, low-income communities, minority groups, or individuals with disabilities when evaluating these applications.

Is the AI solution deployed in a complex environment?

The stakes heighten when AI functions within a complex environment compared to a controlled one. The range of inputs and unforeseen scenarios that the AI must evaluate in an open environment surpasses those in a controlled environment, possibly resulting in unforeseen or undesirable results. For instance, an AI-driven medical diagnosis system operating within a controlled lab environment presents fewer risks than one deployed in real-world clinical settings where patient conditions and variables are more dynamic and varied.

Definition: For the purposes of this screening questions, a complex environment refers to operational settings characterized by multiple interconnected variables, dynamic conditions, unpredictable interactions, and numerous decision points, in contrast to controlled environments with limited, predictable parameters and well-defined boundaries.

Does the AI solution have a degree of autonomy?

Autonomy refers to the AI's ability to make decisions and take actions independently, without direct human intervention. The degree of autonomy varies across AI systems, with some requiring constant human oversight and others having more freedom to operate on their own. When considering the level of autonomy in an AI solution, it is

[3] Based on Artificial intelligence Impact Assessment Report. Platform for the Information Society (ECP).

crucial to thoroughly analyse its implications. Autonomy in AI can extend beyond decision-making to encompass other aspects, such as autonomous selection of data sources. In other words, the AI may have the capability to independently gather and utilise data from various sources without human intervention.

Definition: For the purposes of this screening process, an AI solution is considered autonomous if it has "the capacity to achieve a set of goals under a set of uncertainties in the system and its environment, by itself, without external intervention" (Antsaklis, 2020).

Is sensitive personal data used by the AI solution?

The inclusion of sensitive personal data in AI implementation increases the level of risk involved. Examples may extend beyond medical records or information regarding ethnicity or sexual orientations to include financial records, biometric data such as fingerprints or facial recognition, location data, and details related to political affiliations or religious beliefs.

The General Data Protection Regulation (GDPR) identifies as special categories of personal data the following: data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation (GDPR.EU, 2025).

Do the decisions made by the AI solution significantly affect individuals, entities, or carry legal ramifications?

Decisions made by an AI may result in legal ramifications or have significant impacts on individuals, such as denying mortgages, causing job loss, providing incorrect medical diagnoses, inflicting reputational harm, breaching privacy regulations, violating intellectual property rights, or discriminating against protected classes, to name a few.

3.2.2 Step 2: Describe the AI solution and its context[4]

Once it is determined that an IAAI is necessary, the initial step involves describing the AI solution and its implementation context. This entails considering several questions pertaining to the purpose of the AI solution, the employed technology, the data utilized by this technology, the expected social impacts, and the identification of affected stakeholders (Figure 3).

[4] Based on Artificial intelligence Impact Assessment Report. Platform for the Information Society (ECP) and OECD framework for classifying AI systems (OECD, 2022)

Figure 2. Description of the AI solution and its context

Sector					
Purpose					
Description *(Used technology and data)*					
Main expected social impacts					
Stakeholder identification	***Stakeholder representative***	***Stakeholder group***	***Contact name***	***Phone***	***e-mail***

Source: Own elaboration based on Artificial intelligence Impact Assessment Report. Platform for the Information Society (ECP).

Stakeholder selection

The stakeholder selection process should be grounded in the quadruple helix framework, which recognises four major actors essential for innovation systems: academia (science), public sector (policy), private sector (industry), and civil society organisations (society) (Schütz et al., 2019). The AIIA team will develop a stakeholder list by identifying relevant entities within each of the four helices, ensuring balanced representation across all stakeholder groups. The participant list should typically include:

- Technical experts with specific knowledge of the AI solution being evaluated
- Public sector representatives responsible for related policies or services
- Private sector representatives from involved industries/sectors
- Civil society representatives appropriate to the specific case study (trade unions, consumer advocacy groups, residents' associations, environmental organisations, etc.)
- Representatives from vulnerable or marginalized communities potentially affected by the AI solution (elderly, disabled persons, ethnic minorities, low-income groups, etc.)
- Considerations for gender balance and age diversity among participants

Access to stakeholders represents a critical challenge in participatory processes, particularly when involving high-level profiles or reaching marginalized communities. Therefore, stakeholder selection must balance ideal representation with practical accessibility while ensuring no critical voices are systematically excluded. The involvement of both public sector actors and solution developers in the evaluation team is crucial, as their networks facilitate access to relevant stakeholders across different sectors.

3.3 Phase 2: Participatory workshop: interaction with stakeholders

3.3.1 Step 3: Workshop organisation – Preparation of the case of study

Documentation of the case of study:

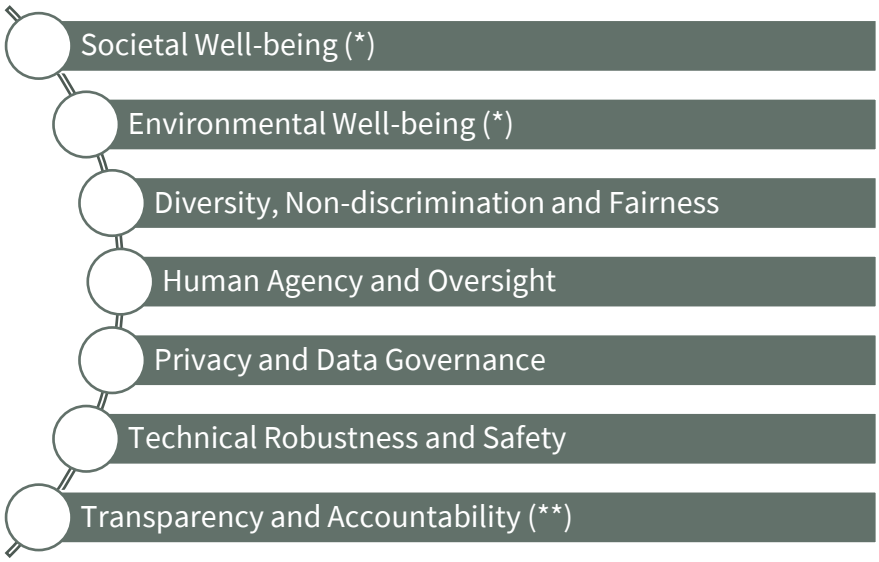
1. Background: An introduction to the context where the AI solution will be implemented, the problems it aims to address, and a brief explanation of the Workshop's goals and the contents included in the documentation.
2. Summary sheet: A one-page table summarizing the purpose of the AI solution, its description, the affected stakeholder groups, and the main expected impacts.
3. Simplified Matrix of social impacts: The AIIA team will conduct an internal brainstorming exercise to identify the positive and negative social impacts of the AI solution. For this purpose, the team will use the template designed based on resources developed by UNESCO in its Ethical Impact Assessment: A Tool of the Recommendation on the Ethics of Artificial Intelligence (UNESCO, 2023), adapted to align with the Assessment List for Trustworthy Artificial Intelligence (ALTAI) requirements established by the European Commission (European Commission, 2020) (Figure 4). These requirements provide the foundational framework for the impact identification process, both internally within the AIIA team and during the participatory workshop with stakeholders, integrating ethical considerations into the impact assessment process.

The templates created will guide the AIIA team through this first exercise of impact identification process providing useful information of each ALTAI requirement and guiding questions (Figure 5)[5].

a. Impacts: list of all impacts pertaining to the specific ALTAI requirement, with a brief description of each impact.
b. Impact type (positive or negative): classification of each impact as either positive or negative.
c. Significance level: evaluation of the scale of each impact, considering its potential significance. Impacts are assessed by their magnitude on a scale ranging from high to low.
d. Likelihood of occurrence: in this case impacts are assessed by their likelihood of occurrence, rating it as low, medium, high.

Figure 4. Assessment List (ALTAI)

[5] The templates for the evaluation methodology are available upon request. If you are interested, please contact gmunares@kveloce.com for further information.



Notes: (*) For operational purposes Societal and Environmental Well-being have been separated
(**) For operational purposes Transparency and Accountability have been merge
Source: Own elaboration based on ALTAI.

Figure 5. Social impact simplified Matrix

a	b	c	d
Impacts	**Impact type**	**Significance level**	**Likelihood of occurrence**
Please describe briefly the impact by ALTAI area	*Please indicate the type of impact (positive / negative)*	*Please assess the scale of the impact (low / medium / high)*	*Please assess the likelihood of ocurrence of the impact (low / medium / high)*
Societal Wellbeing			
Environmental Wellbeing			
Diversity, Non-discrimination and Fairness			
Human Agency and Oversight			
Privacy and Data Governance			
Technical Robustness and Safety			
Transparency and accountability			

Source: Own elaboration based on Ethical Impact Assessment: A Tool of the Recommendation on the Ethics of Artificial Intelligence (UNESCO, 2023).

4. First proposal of Key Performance Indicators list (KPIs): The AIIA team will create an initial list of KPIs related to the identified impacts. To facilitate this task, a KPI catalogue has been developed. This catalogue stems from an extensive review of pertinent documents and methodologies[6], as well as input from various stakeholder representatives who participated in the first Participatory Workshop where this methodology was validated. The collection of KPIs has been categorized according to ALTAI principles and sectors to facilitate the search for indicators related to specific topics and impacts[7].

Organisation of the Workshop:

Using the list prepared during the stakeholder analysis, the AIIA team will invite relevant stakeholders to participate in the workshop to assess the social impacts of the AI solution. Once they agree to participate, the team will send them the case study documentation that will serve as the basis for the workshop dynamics.

The workshop should last at least three hours. The AIIA team must make the necessary arrangements to reserve a venue that allows for group work (in case more than one case is discussed) and provides all the required materials. The description of the participatory activities conducted in the testing exercise of this methodology is included in Section 3.

3.3.2 Step 4: Identification of positive and negative impacts of the AI solution with stakeholders

The first workshop activity is devoted to the identification of social impacts of the AI solution. Participants will work in groups to complete the list of social impacts by ALTAI area included in the case of study documentation.

Given that the design of participatory dynamics will depend on the specific context framing the assessment, time constraints, participant characteristics, and other contextual factors, this methodology only describes the generic structure of this activity.

The core structure of this activity consists of two stages: In the first stage, each participant will work independently to identify impacts that concern the stakeholder group they represent, focusing on both positive and negative consequences within each ALTAI requirement area. Once this stage concludes, the impacts identified by each participant will be aggregated and presented to the group for discussion, constituting the second stage of the participatory activity. This collaborative discussion allows for the validation, refinement, and expansion of the initial impact list through diverse stakeholder perspectives.

The new consolidated list of social impacts will serve as the foundation for the subsequent step: the identification of potential metrics.

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[6] Notable among these documents are the Collection Methodology for Key Performance Indicators for Smart Sustainable Cities by U4SSC (U4SSC, 2017), CITYkeys indicators for smart city projects and smart cities from the CITIkeys project (Bosch et al., 2017), A novel taxonomy of smart sustainable city indicators by Milad Pirad (Pira, 2021), and Guidelines for Social Life Cycle Assessment of Products and Organizations 2020 by UNEP (UNEP, 2020)

[7] These indicators are included in the Excel file accompanying the methodology templates, which are available upon request. If you are interested, please contact gmunares@kveloce.com for further information.

Although this methodology does not require a particular approach for this participatory dynamic, we can reference some interesting methodologies that can be adapted, such as the Consequence Scanning (Doteveryone, 2019), or the World Cafe Method (The World Café Community Foundation, 2025).

3.3.3 Step 5: Identification of possible metrics with stakeholders

Continuing with the participatory exercise, participants proceed to identify possible metrics and Key Performance Indicators (KPIs) to assess and monitor the identified impacts of the AI solution's implementation (for a practical example see Section 3).

Following the workshop, the final list of impacts and related KPIs will be compiled, capturing the most significant social impacts arising from the implementation of the AI solution and the KPI monitoring system.

3.4 Phase 3: Exploitation and follow-up

3.4.1 Step 6: Data collection, analysis, and interpretation

Once impacts and related KPI have been established, it is time to proceed with the data collection process. This pivotal phase involves sourcing relevant data aligned with each identified KPI, needing a comprehensive examination of various sources. Depending on the nature of the KPI, the data collection process may entail reviewing reports from public institutions, analysing census or statistical data, or conducting surveys to generate new datasets. The initial data collection exercise will lay the foundation for establishing an initial baseline, which will function as a reference point for subsequent assessments.

Employing a blend of quantitative and qualitative analysis methodologies tailored to the selected KPIs, a rigorous examination and interpretation of the collected data will be undertaken. These efforts will yield findings that will offer insights into how the AI solution impacts the lives of citizens, enabling the extraction of actionable knowledge to inform decision-making processes.

3.4.2 Step 7: Identification and integration of mitigation practices (optional)

In Step 7, an optional yet recommended step, stakeholders will be invited to engage in a second collaborative exercise aimed at identifying and integrating mitigation practices to address the impacts identified during the assessment process. This participatory activity will provide stakeholders with the opportunity to contribute their expertise and insights towards the development of effective mitigation strategies.

During this phase, stakeholders will collectively brainstorm potential mitigation practices. Drawing on their diverse perspectives and knowledge, stakeholders will explore various approaches to mitigate negative consequences and enhance positive outcomes associated with the AI solution's implementation.

Once mitigation practices have been identified, they will be integrated into the broader framework of the AI solution's deployment. This integration process may involve revising policies, procedures, or operational protocols to incorporate the identified mitigation practices effectively.

3.4.3 Step 8: Monitoring

In Step 8 (monitoring), organisations will establish a system for periodically measuring the identified Key Performance Indicators (KPIs) to assess the ongoing impacts of the AI solution. This iterative process involves regularly collecting and analysing data related to the established KPIs, allowing organisations to track changes over time and evaluate the impact of the AI and/or the effectiveness of mitigation practices implemented in Step 7.

During the monitoring phase, organisations will revisit the initial baseline established in Step 6, using it as a reference point for comparison with subsequent assessments. By consistently measuring KPIs and analysing trends, organisations can identify any emerging patterns, challenges, or opportunities related to the AI solution's impacts.

Figure 6. Iterative monitoring process

Source: Own elaboration.

The data collected during the monitoring phase will be subjected to the same rigorous analysis and interpretation processes as in Step 6, enabling organisations to extract actionable insights and inform decision-making processes. Based on the findings of the monitoring phase, organisations may choose to refine existing mitigation practices, implement new strategies, or adjust operational protocols to address evolving needs and challenges.

Ultimately, the monitoring phase serves as a crucial component of the AI Impact Assessment (AIIA) process, facilitating continuous learning and improvement. By adopting an iterative approach to monitoring, organisations can ensure that their AI solutions remain responsive to the needs of the community and aligned with the overarching goals of enhancing public services.

This methodology was tested in an exercise involving three case studies of interest identified by the CITCOM project, focused on AI solutions applied to three strategic sectors for the city of Valencia: Waste Management, Tourism, and Mobility.

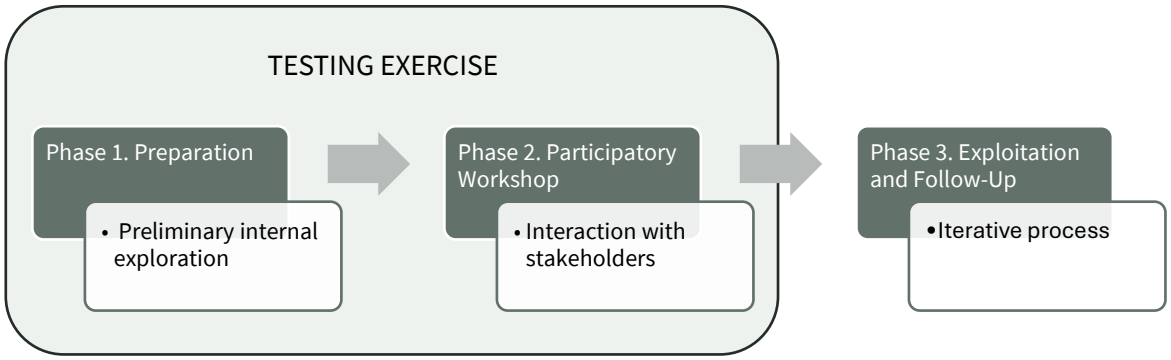
The following section describes how this exercise was carried out and presents its results.

4 Testing the methodology

4.1 Implementation Context

The initial step was to identify the AI solutions to be evaluated in the selected social context: the city of Valencia. Within the framework of the CITCOM project, Valencia Innovation Capital (VIC) [8] had previously conducted a broader baseline study mapping a range of AI solutions with potential for implementation in European cities. Drawing on this baseline, VIC selected three AI solutions for the pilot exercise, focused on three key areas of urban service: Tourism, Waste Management and Mobility. This baseline documentation served as the primary information source for the preparation of the case study materials, which were subsequently complemented with hypothetical, yet feasible data to fill specific information gaps and enable a comprehensive participatory exercise. The exercise concentrated on Phases 1 and 2 of the methodology, with particular emphasis on Phase 2, which involved the organisation of the participatory Workshop with selected stakeholders.

Figure 3. Definition of the testing exercise



Source: Own elaboration.

The testing exercise was structured as a trial where three AI solutions with potential for implementation in the city of Valencia would be evaluated by representatives from actual stakeholder groups across the sectors involved in each case. Since this involved potential rather than actual implementation, the methodology needed to be simplified to respond to the available information.

[8] Valencia Innovation Capital : https://valenciainnovationcapital.com/. Valencia Innovation Capital (VIC)[8], one of the consortium partners in the CITCOM project which brings together entities from 11 European Union countries

Table 2. Overview of selected AI solutions for the pilot

	Case 1. Mobility	Case 2. Tourism	Case 3. Waste management
Type of AI	Predictive analytics	Recommender system with conversational AI assistant	Recommender system with conversational AI assistant
Data used	Images and sound from security cameras; air quality sensors	Tourist preferences; location data; local attractions and events data	User interaction data; recycling point locations; environmental impact data
Level of autonomy	Semi-autonomous: generates real-time congestion predictions to support human traffic controllers	Low autonomy: provides personalized recommendations to tourists; no automated decisions	Low autonomy: provides personalized guidance and gamified incentives to users; no automated decisions
Primary users	Traffic management authorities; urban residents	Tourists; local residents; tourism businesses	Valencia residents; waste management companies; local authorities

Source: Own elaboration.

4.2 AIIA Team Formation – Phase 0

A multidisciplinary AIIA team was established to conduct the evaluation across the three case studies. The team composition included:

Methodological leaders: 2 Professionals from Kveloce with expertise in participatory processes, social impact assessment, and evaluation methodologies

Public sector liaison: 2 Representatives from Valencia Innovation Capital (VIC), member the CitCom consortium and in close relationship with Valencia City Council, facilitating access to public sector stakeholders, AI solution developers, and academic institutions

Key implementation adaptations and limitations:

Rather than forming separate teams for each case study, a single integrated team managed the three assessments simultaneously. This approach offered efficiency gains by enabling cross-case learning and resource optimization although it also presented limitations in terms of case-specific specialization and potentially reduced focus on individual solution contexts. The team's connection through VIC proved essential for stakeholder access, though this

also meant the assessment was conducted within a specific institutional framework that may have influenced stakeholder participation behaviour patterns.

4.3 Preliminary internal exploration – Phase 1

The first steps of the methodology focused on gathering information to describe the AI solution intended for implementation (its purpose and technologies used) and the social, economic and environmental context in which it would be implemented, with a certain level of depth.

Key implementation adaptations and limitations:

As described in the Implementation Context section, the case study documentation was built upon the baseline information provided by VIC within the CITCOM project, complemented with hypothetical, yet feasible data to fill specific information gaps. The hypothetical elements were constructed by the evaluation team drawing on general contextual information about each urban service domain, informed by publicly available data and the team's professional expertise in social impact assessment. While this approach was valid for methodological validation purposes, it introduces an important limitation: participants may have responded to solution descriptions that do not fully reflect the actual technical characteristics, data sources, or autonomy levels of the evaluated systems, potentially influencing the impacts identified during the workshop. In real-case applications of this methodology, direct and sustained engagement with solution developers from Phase 0 onwards is essential to ensure that all technical information is accurate and complete before stakeholder documentation is prepared.

Participant Selection and Engagement

The AIIA team conducted a stakeholder analysis for each case, creating a lists of potential entities and participants for each of the three cases. Subsequently, with support from the Valencia Innovation Capital (VIC) team, invitations to the participatory workshop were issued, using the European CITCOM project as the institutional framework, which facilitated the recruitment of participants from various stakeholder groups. These included representatives from public administration, AI developers, municipal service companies, research centres, universities, and consumer associations.

The objective of gathering at least eight participants for each case was achieved, with confirmation of participation received from 26 individuals.

Table 3. Entities represented in the Participatory Workshops

Case 1. Mobility	**Case 2. Tourism**	**Case 3. Waste management**
Consumers Union	Consumers Union	EMTRE (Municipal waste management company
FISABIO (Research Centre)	Las Naves (Social Innovation Centre)	Las Naves (Social Innovation Centre)

Case 1. Mobility	Case 2. Tourism	Case 3. Waste management
Las Naves (Social Innovation Centre)	Materia Naranja (Consulting company)	Nunsys (IA solutions' developer)
Libelium (IA solutions' developer)	Universidad Politécnica de Valencia - UPV	Valencia City Council
Universidad Politécnica de Valencia - UPV	Universitat de Valencia	
Valencia City Council	S2Grupo (IA solutions' developer)	
	Valencia City Council	

Source: Own elaboration.

Key implementation adaptations and limitations:

A drawback of the study has been the insufficient representation of civil society organisations (CSOs) across case studies. This limitation stemmed from the institutional origin of the evaluation team: as the assessment was conducted by a consulting firm (Kveloce) in partnership with VIC (a platform linked to Valencia City Council and part of the CitCom project), the existing networks were predominantly concentrated within public sector, private sector, and academic spheres. Consequently, the team lacked strong connections with relevant civil society associations specific to each case study area (mobility, tourism, and waste management). This bias proved problematic given that vulnerable groups are predominantly represented within the civil society sphere. The recruitment process revealed that establishing effective contact channels with civil society organisations requires dedicated relationship-building efforts that extend beyond the typical institutional networks available to public-private partnerships, potentially compromising the comprehensiveness and representativeness of the social impact evaluation.

Beyond the challenges related to civil society participation, the assessment team acknowledges additional limitations regarding participant diversity and equity. No formal bias mitigation strategy was implemented during stakeholder recruitment, and no systematic efforts were made to include representatives from marginalized or underrepresented groups (e.g., elderly citizens, persons with disabilities, low-income communities, or ethnic minorities). This constitutes a significant limitation, as these groups are often disproportionately affected by AI implementations in urban services. The assessment team was primarily embedded in institutional networks linking public sector, private sector, and academic actors, which structurally limited access to civil society and vulnerable populations. Future applications of this methodology should incorporate dedicated outreach strategies targeting these groups, potentially through partnerships with community organisations, and should apply formal stakeholder mapping tools prior to participant selection to identify and mitigate representational gaps.

The implications of this limitation are not uniform across the assessment process. The underrepresentation of civil society and vulnerable groups is most consequential in the identification of social impacts, particularly within the Social Welfare and Diversity, Non-discrimination and Fairness ALTAI requirement areas, where the lived experience

of affected communities is essential to identify impacts that institutional actors may not anticipate or prioritise. The impact identification outputs for these areas should therefore be interpreted with caution, as they likely reflect a predominantly institutional perspective. The effect on KPI identification is comparatively more limited, as indicator development draws more heavily on technical and domain expertise. Within the context of this pilot exercise, the participatory outputs from these areas should therefore be treated as a preliminary baseline, to be expanded and validated through dedicated engagement with civil society organisations and representatives of affected communities as the assessment process progresses towards the monitoring phases.

4.4 Workshop organisation – Phase 2

Following the methodology, the evaluation team started the organisation of the Participatory Workshop. The team prepared the documentation for each case of study based on the information gathered in Phase 1. This documentation was meant to be sent to all participants so they could be well informed previously the event.

The documentation sent for each case of study included:

- **Context info**: a brief information about the socio-economic context where the AI solution would be implemented, including data and indicators related to the problem needed to be solved in the city of Valencia.
- **Basic Information Summary Sheet**: one page summarizing the purpose of the AI solution, its description, identified users, affected stakeholders and main expected impacts.
- **First draft of the Impact Identification Matrix following ALTAI principles**: using the Matrix presented in Figure 5, the evaluation team prepared a first draft of the matrix including potential impacts related to the different ALTAI principles.
- **First draft with identified indicators**: based on the catalogue of general indicators collected during the research work, the evaluation team identified a list of indicators that could be used for each specific case.

Each participant was asked to review the documentation prior to the workshop. This preparation enabled them to contribute more effectively to the further development of the Matrix and related KPIs, incorporating perspectives representative of their respective stakeholder groups.

Table 4. Example of Basic Information Summary Sheet prepared for the Study Case related to Waste Management

Purpose of the application	Promote effective recycling among the citizens of Valencia, providing customised information and interactive tools to improve their recycling habits and contribute to environmental sustainability.
Application Description	RECICLABOX uses artificial intelligence techniques to engage citizens in an interactive learning experience focused on effective waste recycling methods. Through its intuitive communication channel, individuals receive personalized advice and guidance, empowering them to make informed

	recycling decisions in real time. In addition, it incorporates gamification elements to make the process attractive and rewarding, promoting a community culture of environmental responsibility. Its interactive map feature allows users to locate key waste collection points, recycling facilities and track environmental impact data, enabling active participation in Valencia's circular economy initiatives. Supported by an artificial intelligence assistant, it offers personalized assistance to users, helping them improve their recycling performance and contribute to the overall improvement of the solid waste value chain in the city.
Affected stakeholder groups	RECICLABOX users include Valencia residents, local authorities, waste management companies and other actors involved in environmental management and the circular economy. The groups affected by the application are broad and include the entire urban population, as well as companies and organisations interested in improving waste management and environmental protection.
Main expected impacts	• Increase in the recycling rate and reduction in the amount of waste sent to landfills. • Awareness and environmental education of the population on effective recycling practices. • Promotion of a culture of environmental responsibility and citizen participation. • Improving efficiency in waste management and the circular economy in Valencia. • Reduction of the negative environmental impact of solid waste in the city. • Promotion of technological innovation and sustainable development in the field of waste management.

Source: Own elaboration.

Key implementation adaptations and limitations:

The limited technical information available from Phase 1 directly affected the quality and depth of the preparatory materials provided to stakeholders. The documentation sent to participants necessarily included hypothetical elements alongside factual data, which potentially influenced participants' ability to provide fully informed input during the workshop discussions. This limitation required the facilitation team to be particularly transparent about information gaps and encourage participants to contribute with their expertise to refine the AI solution descriptions during the workshop.

4.5 The Participatory Workshop

The Participatory Workshop took place in June 2024 at "Las Naves" building, the headquarters of Valencia Innovation Capital (VIC) and a reference space for promoting social innovation in Valencia. Over a three-hour session, participants were engaged in collaborative work through two participatory dynamics:

Figure 4. Participatory activities

Identification of social impacts

- Work in groups using post-its and posters
- Complete / edit the proposed Matrix guided by the ALTAI principles

Identification of related KPIs and data sources

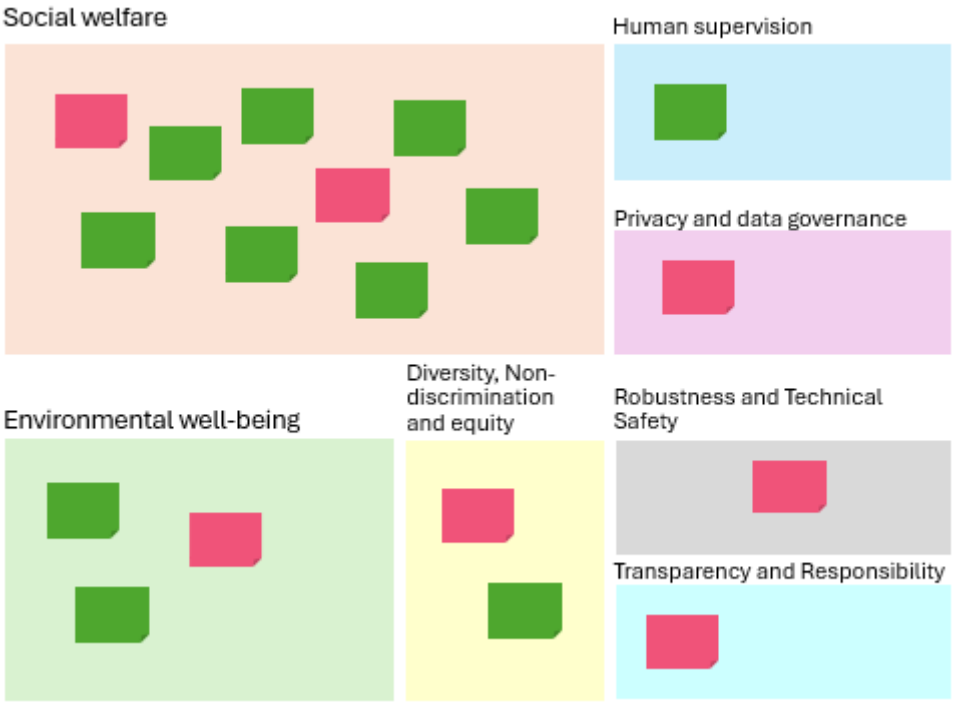
- Complete / edit the proposed list of KPIs
- Complete KPIs technical sheets including data sources

Source: Own elaboration.

Identification of social impacts

Participants worked in 3 groups to complete the Impact Matrix presented in a poster displayed in the room. They were asked to identify positive (green post-it) and negative (red post-it) impacts. For each impact, its significance level, the likelihood of occurrence and related KPIs had to be indicated.

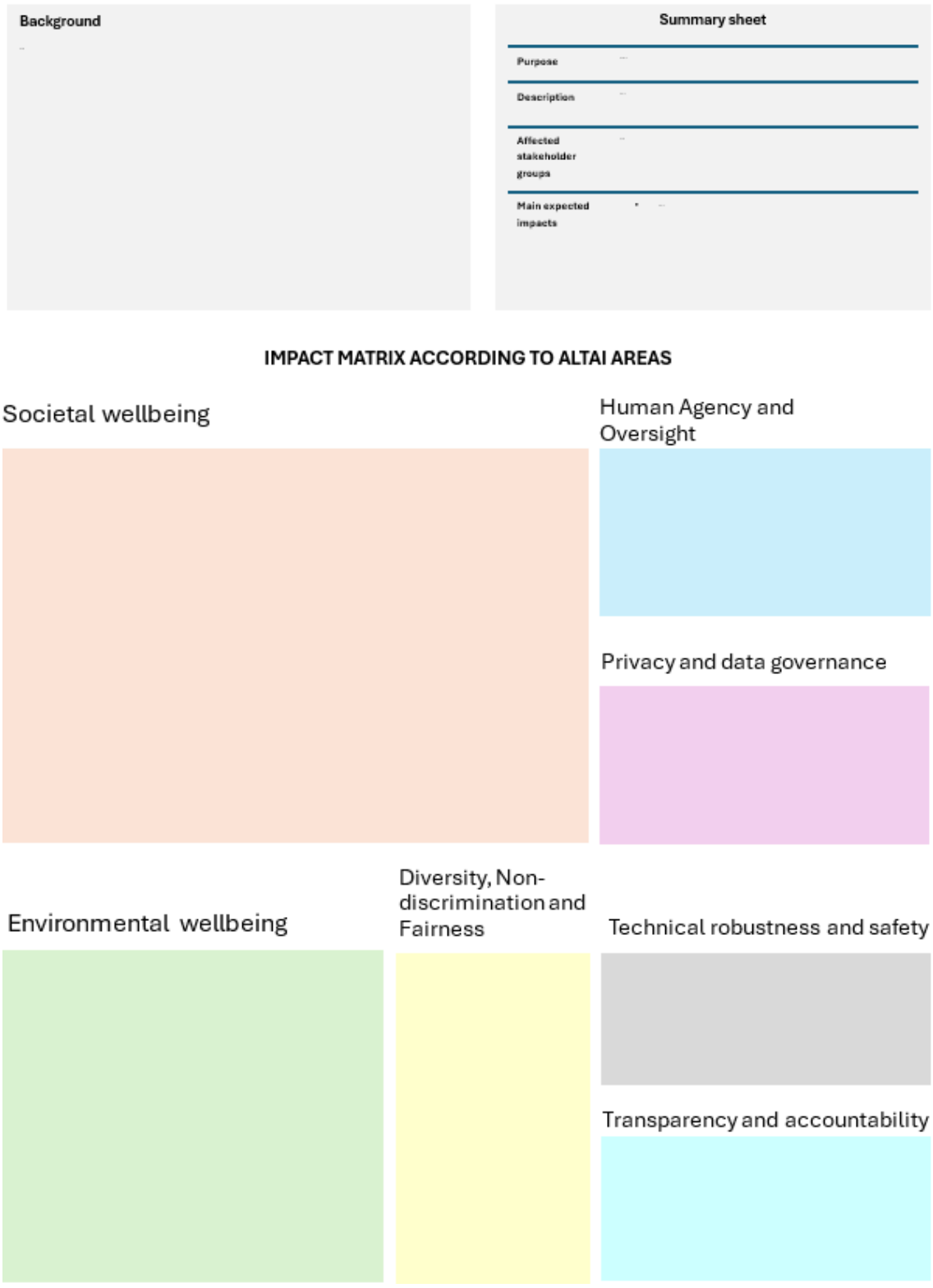
Figure 5. Identification of social impacts' activity



Source: Own elaboration.

At the end, a moderator in each group read all impacts identified, giving the opportunity to participants to explain and discuss the impacts.

Figure 6. Matrix poster prepared for each Case of study



Source: Own elaboration.

Identification of related KPIs and data sources

In the subsequent group activity, participants were tasked with completing the list of KPIs taking into consideration the impacts identified in the previous activity. The objective was to identify indicators that could effectively track the evolution of each identified impact.

To facilitate this task, the support team distributed Simplified Indicator Datasheets, which provided participants with a structured format to propose new or refine existing KPIs.

Figure 7. Simplified indicator Datasheet

KPI Name	Id:
Sector/Case	
Definition	
Unit of measurement	
Data source	
Frequency	
Observations	

Source: Own elaboration.

Key implementation adaptations and limitations:

The three-hour timeframe, while adequate for completing the planned activities, constrained the depth of the discussion for each identified impact, particularly during the explanation and debate phases. Additionally, significant variations in group dynamics were observed across the three case study teams, directly influenced by group composition and the presence of particularly engaged participants. Some groups developed highly interactive discussions with active contribution from multiple stakeholders, while others exhibited a more reserved participation behaviour with limited cross-stakeholder exchange. This variability in group dynamics affected both the quantity and quality of impacts identified, suggesting that careful attention to group composition and the inclusion of natural facilitators or highly engaged stakeholders can significantly enhance the participatory process outcomes. The presence of participants with strong facilitation skills or deep domain expertise appeared to catalyse more dynamic discussions and comprehensive impact identification.

4.6 Participatory Analysis Process

Following the workshop, the evaluation team collated and analysed all information generated during the event to produce a definitive version of the Impact Matrix and a comprehensive database of KPIs specific to each case. Supplementary files include the resultant Impact Matrixes and related KPIs generated in the Participatory Workshop for the 3 cases of studies. To illustrate the quality and scope of the proposed indicator system, Table 4 presents a selection of representative KPIs from the Waste Management case study, covering the main ALTAI requirement areas:

Table 5. Representative KPIs from the Waste Management case study by ALTAI area (*)

KPI	Case study	ALTAI area	Unit	Recommended data source
Annual evolution of urban solid waste collection per capita by fraction (organic, glass, paper, plastics)	Waste Management	Societal Well-being	kg/inhab/year	Municipal waste management records
Variation in the percentage of people who declare carrying out waste separation and recycling tasks at home	Waste Management	Societal Well-being	percentage points	Household surveys (Municipal Statistics Office)
Evolution of CO2 equivalent emissions attributed to waste	Waste Management	Environmental Well-being	tons CO2 eq. and var%	Municipal greenhouse gas emissions inventory
People/users reached: percentage of target population using the AI solution	Waste Management	Diversity, Non-discrimination and Fairness	%	Platform usage analytics
Number of user complaints related	Waste Management	Privacy and Data Governance	N./year	Platform complaint registry

to privacy violation or data loss				
Number of cybersecurity incidents	Waste Management	Technical Robustness and Safety	N.	System security logs
User questions incorrectly resolved by the platform	Waste Management	Human Agency and Oversight	N.	Human review of platform interactions
Number of user complaints about transparency	Waste Management	Transparency and Accountability	N./year	Platform complaint registry

(*) Note: This table presents a selection of KPIs extracted from the complete indicator list generated during the Participatory Workshop. The full KPI catalogue for all three case studies is available in the Appendix I.
Source: Own elaboration.

The three case studies reveal both common patterns and unique characteristics in their identified impacts according to the ALTAI framework areas.

In the Social Welfare domain, all three cases identify significant positive impacts, including economic sector dynamization, and quality of life improvements. The Mobility case particularly emphasizes time savings and stress reduction, while the Tourism case uniquely highlights both strong positive impacts (customised experiences) and significant negative impacts (price increases, overcrowding, and gentrification). The Waste Management case focuses on circular economy advancement and cost optimization as key benefits.

Regarding Environmental Well-being, all three cases identify positive environmental impacts, though with varying emphasis. The Mobility case strongly emphasizes air quality improvement and noise pollution reduction, while noting the potential negative impact of high resource consumption by AI systems. The Waste Management case identifies numerous positive environmental impacts related to pollution reduction and resource conservation. The Tourism case shows a more balanced mix, recognising both sustainable practice promotion and potential negative impacts from increased waste in tourist areas.

In the areas of Diversity/Non-Discrimination, Privacy/Data Governance, and Technical Security, all three cases consistently identify similar negative impacts, particularly digital exclusion concerns, data privacy issues, and cybersecurity risks. Notably, the Tourism case places greater emphasis on bias-related concerns (cultural, social, economic, and gender bias), rating these as high significance with high probability. All cases identify digital gap issues as a significant negative impact, highlighting concerns about technology accessibility across different demographic groups.

5 Conclusions and recommendations

From traffic control, security monitoring, and waste collection optimization to personalized tourism services, public transportation optimization, and the creation of customised environmental education tools, AI is revolutionizing the way cities provide services to their citizens. Two key areas exemplify this transformation: in traffic management, cities are deploying intelligent sensor systems and cameras to predict traffic density and automatically adjust traffic control systems, significantly reducing travel times and congestion. In waste management, AI-powered systems are optimizing collection routes and schedules based on real-time monitoring of bin levels, achieving substantial reductions in operational costs and environmental impact. These applications demonstrate how AI can enhance urban efficiency while improving quality of life for residents.

In this evolving landscape, it is essential that policymakers at all levels implement a systematic approach to social impact assessments when deploying AI solutions. The methodology proposed in this document seeks to contribute to these efforts by highlighting the importance of ensuring that affected stakeholders participate in the assessment process so that all voices are represented, and by establishing a monitoring system that allows implementing corrective measures and analysing their effects.

Built on participation from key stakeholder groups potentially affected by AI implementations, this approach facilitates the integration of innovative solutions in complex urban environments where varied interests intersect.

The participatory process allows and promotes a critical reflection of society as a whole, ensuring no voice is excluded from the discussion. In this regard, the methodology establishes a conceptual framework based on the European Commission's Assessment List for Trustworthy Artificial Intelligence (ALTAI), from which an ad-hoc, flexible, and adapted approach to each AI solution can be built.

The design of this methodology involved a series of deliberate choices that shaped both its structure and scope. ALTAI was selected as the core conceptual scaffold because it is the most operationalised expression of the EU's ethical requirements for trustworthy AI, enjoys broad institutional recognition across European contexts, and its seven-requirement structure provides a sufficiently granular yet manageable framework for multi-stakeholder impact identification. Rather than selecting a single framework, the methodology deliberately integrates complementary elements from three sources: the ALTAI requirements provide the conceptual structure for organising impact dimensions; the ECP procedural roadmap informs the phased screening and preparation process; and UNESCO's impact matrix template and stakeholder engagement plan provide the operational tools for the participatory workshop dynamics. The KPI monitoring system was similarly built through integration rather than invention, drawing on an extensive review of existing indicator catalogues from sources including U4SSC, CITYkeys, UNEP S-LCA, and others, which were reviewed, adapted, and organised according to ALTAI requirement areas to produce a catalogue tailored to AI solutions in urban service contexts. This integrative approach was driven by the recognition that no single existing framework offered, on its own, all the components needed to implement a fully participatory assessment process — from ethical grounding and procedural guidance to practical workshop instruments and a deployable KPI monitoring system.

The decision to organise a single workshop was determined by the scope and purpose of the assessment and the resources available, rather than a fixed methodological rule. As Patton (Patton, 2002, p. 244) notes, design decisions

in qualitative inquiry — including sampling scope — depend on "*what you want to know, the purpose of the inquiry, what's at stake, what will be useful [...] and what can be done with available time and resources.*" This aligns with Patton's (Patton, 2002, p. 194) recognition of rapid reconnaissance as a legitimate qualitative approach when the goal is to gather targeted, actionable information within defined time and resource constraints. In practice, a multi-session design would have allowed for deeper deliberation and iterative refinement of impacts and KPIs; however, this was not viable given the operational constraints of the project timeline and, critically, the limited availability of recruited stakeholders — several of whom held senior positions in public administration with significant scheduling constraints. Ensuring their participation within a single, well-structured session was therefore prioritised over a more iterative format, with the three-hour workshop design carefully structured to maximise the quality of outputs within those constraints.

These design choices, and the lessons learned from their implementation, inform the following recommendations for future applications of the methodology:

- The selection of stakeholder representatives to be part of the Participatory Workshop is a key factor. This selection will determine whether the identified impacts represent the entire society and reflect reality. Lessons learned from the case studies conducted reveal that establishing contacts with relevant civil society organisations is very time consuming. While public sector representatives (stakeholders applying the AI solution) and technical experts (AI solution developers) typically have better connections with private sector, business, and academic actors, civil society represents the area where the greatest challenges arise in reaching appropriate contacts. Moreover, vulnerable groups are predominantly found within this sphere, making extra efforts to secure their participation particularly important.
- In case we are dealing with specific sectors where the inclusion of vulnerable groups is fundamental, such as people with disabilities, mental health conditions, or other circumstances that may require special accommodations, appropriate informed consent protocols and adapted communication channels and workshop formats to accommodate their needs are required. Particular attention must be paid to power imbalances and ensuring that all voices can be heard effectively regardless of participants' technical expertise, socioeconomic status, or communication needs.
- It is very important to have the support of the application developer in all phases of the assessment, as a lot of information is required that only they possess.
- It is very difficult to bring together the various stakeholders, so the participatory workshop must make efficient use of time, and the date and time should be as flexible as possible.
- The composition of working groups significantly influences the quality and depth of participatory discussions. When organising multi-stakeholder workshops, facilitators should strategically distribute participants to ensure each group includes at least one highly engaged participant with strong communication skills and relevant domain expertise. Additionally, balancing stakeholder representation within each group (rather than grouping similar stakeholders together) can enhance cross-sectoral dialogue and generate more comprehensive impact identification. Pre-workshop participant profiling or brief introductory sessions can help identify potential group catalysts and inform more effective group formation strategies.
- For many of the indicators, ad-hoc studies will be necessary, so it is crucial to carefully choose which indicators are truly necessary and how to obtain them in the most efficient way possible.

Further research and development are essential to refine and operationalize the approach. Future work should focus on creating more accessible tools and streamlined processes that make impact assessments both comprehensive and practical. Pilot testing across additional sectors would be particularly valuable, especially in complex domains such as security, healthcare, education, and critical infrastructure where AI applications present unique challenges and considerations. These sensitive sectors require special attention to specific vulnerable groups: in healthcare, patients with chronic conditions, elderly populations, and people with disabilities who may be disproportionately affected by AI diagnostic or treatment systems; in education, minors, students from disadvantaged backgrounds, and minorities who may face algorithmic bias in educational AI systems; in justice and security, individuals from marginalized communities, people with criminal records, and ethnic minorities who are often overrepresented in predictive policing and judicial AI applications. Additionally, these sectors require incorporating highly specialized stakeholders such as ethicists, legal scholars, and domain-specific professionals to ensure comprehensive evaluation. By expanding the methodology's application to these specialized contexts, we can develop sector-specific frameworks that address the ethical, social, and technical concerns unique to each field. This continued research will help ensure that AI implementation across all urban services remains not only innovative but also aligned with societal values and priorities.

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Link to the website: EU F&T portal

Conflict of interests

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Author contributions

Gabriela Munares Sánchez: Investigation, Formal analysis, Data curation, Visualization, Writing – original draft and review & editing.
Rebeca Lucas: Conceptualization, Investigation, Methodology.
Maite Ferrando, PhD – Conceptualization, Methodology, Supervision, Writing – review & editing.
Empar Soriano - Writing – review & editing.

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APPENDIX I

Waste management case study results

Table 6. Impact Matrix generated in the Participatory Workshop for the Study Case related to Waste Management

Impacts	Impact type	Significance level	Probability of occurrence
Please briefly describe the impact	Please indicate the type of impact *(positive negative)*	Please evaluate the magnitude of the impact *(very high, high, medium, moderate)*	Please assess the probability of the impact occurring *(low, medium, high, very high)*
Social welfare			
Dynamization of economic activity in the recycling sector: adequate waste separation gives more value to recycled materials	Positive		
Reduction of food waste	Positive		
Promotion of the circular economy	Positive		
Promotion of sustainable practices in the population (chain effect)	Positive		
Job creation in the waste management sector	Positive		
Increasing circular economy practices	Positive	High	Medium
Increased knowledge in the field of waste management	Positive	High	High
Lower waste management costs	Positive	Very high	Medium-low
Optimization of the waste collection service	Positive	Medium	Medium
Minimization of bad odours caused by full containers	Positive	Medium	Medium
Democratization of information	Positive	Medium	Medium
Compliance with recovery objectives	Positive	High / Very high	Medium
Environmental well-being			
Reduction of waste destined for landfills	Positive	High	Medium
Reducing soil pollution	Positive	High	Medium
Reducing water pollution	Positive	High	Medium
Reduction of GHG emissions	Positive	Medium	Medium
Reduction of consumption of natural resources	Positive	High	Medium
Reduction in waste generation	Positive	High / Very high	Medium
Diversity, Non-Discrimination and Equity			

Impacts	Impact type	Significance level	Probability of occurrence
People who do not have access to mobile phones or who do not use these technologies would be excluded (digital gap)	Negative	High average	Very high
AI training can leave out minorities, without taking into account their customs or culture	Negative	Low	Low
Widen urban-rural gap	Negative	Medium	Medium
Human supervision			
Need to provide human technical support to the APP to resolve user doubts that are new to the platform	Negative	Low	Medium
Generation of erroneous statistics / conclusions due to misuse of the application	Negative	Medium	Medium
Privacy and data governance			
Use of personal data such as name, age, location, etc.	Negative	Low	Medium
Robustness and technical security			
Risk of cyber attacks	Negative		
Confusion among users due to possible inconsistencies with other similar platforms	Negative	High average	High
Transparency and responsibility			
Interest in how the process works	Positive	High	Medium
Greater knowledge of the sector by obtaining a higher level of geographical disaggregation on the use of containers	Positive	Medium	

Source: Own elaboration.

Table 7. KPIs list generated in the Participatory Workshop for the Study Case related to Waste Management

KPIs	Unit	Description	Thematic
Evolution of CO2 equivalent emissions according to activity	tons of CO2 equivalent and var %	Evolution of the city's equivalent CO2 emissions according to activity	Climate change
Evolution of CO2 equivalent emissions according to activity: Waste	tons of CO2 equivalent and var %	Evolution of the city's equivalent CO2 emissions attributed to Waste	Climate change
Population evolution	Number of people and interannual variation %	Evolution of the number of inhabitants of the city	Demography
Population pyramid	%	Distribution of the population in age groups and sex	Demography
Population density	People per square kilometer	Number of population (as of January 1 of each year) per square kilometer (for the last 5 years) divided by the area of the territory in square kilometers	Demography
Distribution of the population per level of education	%	Distribution of the population according to their level of education	Education
Monthly evolution of registered unemployment	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of registered unemployment in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Social Security Affiliations	No. of affiliations, % month-on-month, Var % year-on-year	Evolution of the number of Social Security affiliations in absolute terms, inter-month % variation and inter-annual % variation with respect to the same month of the previous year	Employment
Contact with ICT: internet access	%	Evolution of the percentage of the population that has access to the internet	ICTs
Contact with ICT: has a smartphone	%	Evolution of the percentage of the population that has a smartphone	ICTs
Digital gap: internet access by age groups and sex	%	Percentage of people who access the internet at least 5 days per week by age group and sex	ICTs
Digital gap: Have a smartphone according to age groups and sex	%	Percentage of people who have a smartphone by age group and sex	ICTs
Monthly evolution of urban solid waste collection by fraction (including selective waste collection): Total	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: a. Organic waste b. Glass c. Paper-cardboard d. Plastics and packaging e. Vegetable oil f. Batteries g. Used clothes	Waste management

KPIs	Unit	Description	Thematic
Monthly evolution of urban solid waste collection by fraction: Organic waste	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: Organic waste	Waste management
Monthly evolution of urban solid waste collection by fraction: Glass	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: b. Glass	Waste management
Monthly evolution of urban solid waste collection by fraction: Paper-cardboard	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: c. Paper-cardboard	Waste management
Monthly evolution of urban solid waste collection by fraction: Plastics and packaging	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: d. Plastics and packaging	Waste management
Monthly evolution of urban solid waste collection by fraction: Vegetable oil	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: e. Vegetable oil	Waste management
Monthly evolution of urban solid waste collection by fraction: Batteries	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: f. Batteries	Waste management
Monthly evolution of urban solid waste collection by fraction: Used clothing	tons and % var	Monthly evolution of urban solid waste collection by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: g. Used clothes	Waste management
Annual evolution of urban solid waste collection by fraction: Total	tons and % var	Annual evolution of urban solid waste collection by fraction: a. Organic waste b. Glass c. Paper-cardboard d. Plastics and packaging e. Vegetable oil f. Batteries g. Used clothes	Waste management
Annual evolution of urban solid waste collection by fraction: Organic waste	tons and % var	Annual evolution of urban solid waste collection by fraction: a. Organic waste	Waste management
Annual evolution of urban solid waste collection by fraction: Glass	tons and % var	Annual evolution of urban solid waste collection by fraction: b. Glass	Waste management
Annual evolution of urban solid waste collection by fraction: Paper-cardboard	tons and % var	Annual evolution of urban solid waste collection by fraction: c. Paper-cardboard	Waste management
Annual evolution of urban solid waste collection by fraction: Plastics and packaging	tons and % var	Annual evolution of urban solid waste collection by fraction: d. Plastics and packaging	Waste management

KPIs	Unit	Description	Thematic
Annual evolution of urban solid waste collection by fraction: Vegetable oil	tons and % var	Annual evolution of urban solid waste collection by fraction: e. Vegetable oil	Waste management
Annual evolution of urban solid waste collection by fraction: Batteries	tons and % var	Annual evolution of urban solid waste collection by fraction: f. Batteries	Waste management
Annual evolution of urban solid waste collection by fraction: Used clothing	tons and % var	Annual evolution of urban solid waste collection by fraction: g. Used clothes	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Total	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: a. Organic waste b. Glass c. Paper-cardboard d. Plastics and packaging e. Vegetable oil f. Batteries g. Used clothes	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Organic waste	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: a. Organic waste	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Glass	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: b. Glass	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Paper-cardboard	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: c. Paper-cardboard	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Plastics and packaging	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: d. Plastics and packaging	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Vegetable oil	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: e. Vegetable oil	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Batteries	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: f. Batteries	Waste management
Monthly evolution of urban solid waste collection per capita by fraction: Used clothing	kg and % var	Monthly evolution of urban solid waste collection per capita by fraction in absolute terms and interannual % variation with respect to the same month of the previous year: g. Used clothes	Waste management

KPIs	Unit	Description	Thematic
Annual evolution of urban solid waste collection per capita by fraction: Total	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction a. Organic waste b. Glass c. Paper-cardboard d. Plastics and packaging e. Vegetable oil f. Batteries g. Used clothes	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Organic waste	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: a. Organic waste	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Glass	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: b. Glass	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Paper-cardboard	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: c. Paper-cardboard	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Plastics and packaging	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: d. Plastics and packaging	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Vegetable oil	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: e. Vegetable oil	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Batteries	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: f. Batteries	Waste management
Annual evolution of urban solid waste collection per capita by fraction: Used clothing	kg/inhab/year	Annual evolution of urban solid waste collection per capita by fraction: g. Used clothes	Waste management
Recycling / Recovery: Annual evolution of the mass balance of urban waste treatment plants	%	Annual evolution of the relationship between the annual tons of materials recovered in treatment plants with respect to the total received	Waste management
Assessment of the garbage collection service	LIKERT scale	Average rating of the city's waste collection service	Waste management
Improvement of environmental awareness	LIKERT scale	The extent to which the AI solution has taken advantage of opportunities to increase environmental awareness and educate about sustainability and the environment.	Awareness
Level of knowledge of users in environmental matters	Variation %	Evolution of the percentage of correct answers achieved by platform users in the game/surveys (for example on topics of recycling, energy saving, etc.)	Awareness
Carbon footprint	tons/capita	Greenhouse gas emissions measured in tons per capita	Climate change

KPIs	Unit	Description	Thematic
Number of cybersecurity incidents	N.	Number of times intruders have managed to breach the system by accessing information or networks	Cybersecurity
Number of intrusion attempts	N.	Number of times intruders have tried to access the system	Cybersecurity
Mean Time To Detect (MTTD)	minutes	Average time until a cybersecurity threat is identified	Cybersecurity
Mean Time to Repair (MTTR)	hours	Average response time of the team to solve a computer attack since the attack has been detected	Cybersecurity
Number of user complaints regarding security of the AI solution	Number of complaints/year	The number of security-related complaints in the last year registered	Cybersecurity
Number of user complaints about discrimination	Number of complaints/year	The number of discrimination complaints registered in the last year	Discrimination and diversity
Participation of vulnerable groups	%	Comparison of the percentage of people in a population who use the solution (app, platform) depending on whether or not this population belongs to a specific vulnerable group	Discrimination and diversity
Monthly evolution of unemployment among workers in a specific sector	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of unemployment registered in the sector in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Quarterly evolution of Social Security affiliations in a specific sector	Number of unemployed, Inter-quarterly % change, Inter-annual % change	Quarterly evolution of Social Security affiliations in the sector in absolute terms, inter-quarterly variation and inter-annual variation with respect to the same month of the previous year	Employment
Creation or loss of jobs in the services in which the AI solution is implemented	N. of affiliations, % var month-on-month, % var year-on-year	Percentage change in the number of jobs since the implementation of the AI solution in a specific group that may be affected by said implementation	Employment
Improvement of the working conditions of employees in the sector in which the AI solution is implemented	LIKERT scale	Level of satisfaction with the working conditions of employees in the sector in which the AI solution is implemented (for example: bus drivers of a public transport company; traffic controllers; tourism information service workers, etc.)	Employment
Number of user complaints related to privacy violation or data loss	Number of complaints/year	Reports on the number of complaints related to privacy violation or data loss during the last year	Privacy and data protection
User questions incorrectly resolved	N.	Number of doubts incorrectly resolved by the APP (human analysis of doubts and answers)	Human supervision
Evolution of the number of users on the platform	% Variation	Evolution of the number of users registered on the platform / application (month-on-month / year-on-year) ((No. of	Satisfaction

KPIs	Unit	Description	Thematic
		users in T1 – No. of users in T0) / No. of users in T0)	
People/users reached	% from the people	Percentage of people in the target group who are users of the AI solution	Satisfaction
App usage rate	%	Percentage of active users with respect to total registered users	Satisfaction
Ease of use of the tool for end users	LIKERT scale	The degree to which the AI solution is perceived as difficult for potential end users to understand and use.	Satisfaction
Ease of use for stakeholder professionals	LIKERT scale	The degree to which the AI solution is perceived as difficult for professional users to understand, implement and use.	Satisfaction
Number of complaints about AI solution malfunctions	Number of complaints/year	Report on the number of complaints about malfunctions of the AI solution (technical failures)	Satisfaction
Number of user complaints about transparency	Number of complaints/year	Report on the number of complaints about transparency in the last year	Transparency
Waste characterization	% improper waste found	Weight of improper waste found versus the total weight of the sample analysed	Waste management
Perception of bad odour problems coming from outside the home	%	Percentage of the population over 15 years of age that perceives problems with their home related to bad odours coming from outside	Waste management
Assessment of city cleanliness	LIKERT scale	Evolution of residents' average assessment of the cleanliness of their city	Waste management
Variation in the percentage of people classified in the category of Undecided and Indifferent with respect recycling practices	percentage points	Variation in the percentage of people classified in the category of Undecided and Indifferent with respect recycling practices	Waste management
Variation in the percentage of people who declare that they carry out waste separation and recycling tasks in their homes	percentage points	Variation in the percentage of people who declare that they carry out waste separation and recycling tasks in their homes	Waste management
Variation in the percentage of people who identify barriers to recycling related to lack of information	percentage points	Variation in the percentage of people who identify barriers to recycling related to lack of information	Waste management
Evolution of waste management costs by fraction	€ / % variation	Evolution of waste management costs by fraction	Waste management
Effectiveness of the waste collection service: overflowing waste bins	% Variation	Evolution of the number of overflowing waste bins	Waste management

KPIs	Unit	Description	Thematic
Doubts and questions about the waste management process	Number of doubts and questions	Number of questions and doubts asked to the platform's user service related to the waste management process	Waste management

Source: Own elaboration.

Tourism case study results

Table 8. Impact Matrix generated in the Participatory Workshop for the Study Case related to Tourism

Impacts	Impact type	Significance level	Probability of occurrence
Please briefly describe the impact	Please indicate the type of impact *(positive negative)*	Please evaluate the magnitude of the impact *(very high, high, medium, moderate)*	Please assess the probability of the impact occurring *(low, medium, high, very high)*
Social welfare			
Dynamization of economic activity in the tourism sector	Positive	High	Medium
Employment generation in the tourism sector	Positive	High	Medium
Improving user satisfaction with the tourist information service	Positive		
Improving the satisfaction of the tourist experience in the city thanks to customisation	Positive	High	High
Increase tourism to the city	Positive		
Eliminate language barriers in the tourist information service	Positive		
Detection of opportunities to offer advantages to city residents	Positive	High	Medium/high
Greater accessibility to information	Positive	Medium	high
Clustering by age/tourist profile	Positive		high
Decrease in the number of jobs at the Tourist Office	Negative		
Rise of gentrification	Negative		
Price increase	Negative	High	High
Overcrowding of different parts of the city due to tunnel effect	Negative	High	High
Shortage of certain products due to excessive tourist demand	Negative	High	High
Environmental well-being			
Promotion of sustainable tourism practices	Positive	Medium	Medium
Avoid crowds and vehicular traffic	Positive	Medium	Medium
Increase in waste in areas without adequate management capacity	Negative	Medium	Medium
Diversity, Non-Discrimination and Equity			
People who do not have access to mobile phones or who do not use these technologies would be excluded (digital gap)	Negative	Medium	Medium
AI training can leave out minorities, without taking into account their customs or culture	Negative	High	High
Social, cultural, economic or gender bias	Negative	High	High

Impacts	Impact type	Significance level	Probability of occurrence
Guarantee of numerical standards if the service is provided by a public entity	Positive	High	High
Human supervision			
AI communication with the user would be totally autonomous, risk of lack of human supervision	Negative		
Lack of critical spirit to monitor what the tool says	Negative	High	Medium
Privacy and data governance			
Use of personal data such as name, age, location, etc.	Negative	Low/medium	High
Robustness and technical security			
Risk of cyber attacks	Negative	High	High
Risk of IA hallucinations	Negative	Low	High
Transparency and responsibility			

Source: Own elaboration.

Table 9. KPIs list generated in the Participatory Workshop for the Study Case related to Tourism

KPIs	Unit	Description	Thematic
Population evolution	Number of people and interannual variation %	Evolution of the number of inhabitants of the city	Demography
Population pyramid	%	Distribution of the population in age groups and sex	Demography
Population density	People per square kilometer	Number of population (as of January 1 of each year) per square kilometer (for the last 5 years) divided by the area of the territory in square kilometers	Demography
Number of companies in the service sector by subsector: Commerce, transportation and hospitality	Number of companies, and % var	Number of active companies by sector: Commerce, transport and hospitality	Economy
Distribution of the population per level of education	%	Distribution of the population according to their level of education	Education
Monthly evolution of registered unemployment	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of registered unemployment in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Social Security Affiliations	No. of affiliations, % month-on-month, Var % year-on-year	Evolution of the number of Social Security affiliations in absolute terms, inter-month % variation and inter-annual % variation with respect to the same month of the previous year	Employment
Monthly evolution of unemployment among workers in a specific sector	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of unemployment registered in the sector in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Monthly evolution of unemployment registered in the Hospitality sector in Valencia	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of unemployment registered in the Hospitality sector in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Quarterly evolution of Social Security affiliations in a specific sector	Number of unemployed, Inter-quarterly % change, Inter-annual % change	Quarterly evolution of Social Security affiliations in the sector in absolute terms, inter-quarterly variation and inter-annual variation with respect to the same month of the previous year	Employment
Quarterly evolution of Social Security affiliations in	Number of unemployed,	Quarterly evolution of Social Security affiliations in the Hospitality sector in	Employment

KPIs	Unit	Description	Thematic
the Hospitality sector in the city	Inter-quarterly % change, Inter-annual % change	absolute terms, inter-quarterly variation and inter-annual variation with respect to the same month of the previous year	
Evolution of the feeling of calmness or anger	% according to LIKERT scale	Evolution of the percentage of people according to the anger/calm self-perception scale	Health
Housing price: evolution of the price per square meter	€, quarter-on-quarter % variation	Evolution of the price per square meter of vacant homes in absolute terms and % quarterly variation	Housing
Contact with ICT: internet access	%	Evolution of the percentage of the population that has access to the internet	ICTs
Contact with ICT: has a smartphone	%	Evolution of the percentage of the population that has a smartphone	ICTs
Digital gap: internet access by age groups and sex	%	Percentage of people who access the internet at least 5 days per week by age group and sex	ICTs
Digital gap: Have a smartphone according to age groups and sex	%	Percentage of people who have a smartphone by age group and sex	ICTs
Evolution of the population exposed to noise according to decibel intervals	%, % var	Evolution of the distribution of the population exposed to noise according to different noise intervals (Day-Evening-Night)	Noise
Perception of noise problems coming from outside the home	%	Percentage of the population over 15 years of age that perceives problems with their home related to noise coming from outside	Noise
Total travelers arriving to the city per year	people	Number of travelers arriving to the city per year	Tourism
Total travelers arriving to the city per month	people	Number of travelers arriving to the city per month	Tourism
Evolution of the percentage of households that consider that they have inconveniences related to tourist/local hospitality activities	%	Evolution of the percentage of households that consider that they have inconveniences related to tourist/local hospitality activities	Tourism
Evolution of the number of users of the tourist information office	N. users, var %	Evolution of the number of users of the tourist information office	Tourism
Improvement of environmental awareness	LIKERT scale	The extent to which the AI solution has taken advantage of opportunities to increase environmental awareness and educate about sustainability and the environment.	Environmental Wellbeing
Level of knowledge of users in environmental matters	Variation %	Evolution of the percentage of correct answers achieved by platform users in the game/surveys (for example on topics of recycling, energy saving, etc.)	Societal Wellbeing

KPIs	Unit	Description	Thematic
Number of cybersecurity incidents	N.	Number of times intruders have managed to breach the system by accessing information or networks	Technical robustness and safety
Number of intrusion attempts	N.	Number of times intruders have tried to access the system	Technical robustness and safety
Mean Time To Detect (MTTD)	minutes	Average time until a cybersecurity threat is identified	Technical robustness and safety
Mean Time to Repair (MTTR)	hours	Average response time of the team to solve a computer attack since the attack has been detected	Technical robustness and safety
Number of user complaints regarding security of the AI solution	Number of complaints/year	The number of security-related complaints in the last year registered	Technical robustness and safety
Number of user complaints about discrimination	Number of complaints/year	The number of discrimination complaints registered in the last year	Diversity, Non-discrimination and Fairness
Participation of vulnerable groups	%	Comparison of the percentage of people in a population who use the solution (app, platform) depending on whether or not this population belongs to a specific vulnerable group	Diversity, Non-discrimination and Fairness
Creation or loss of jobs in the services in which the AI solution is implemented	N. of affiliations, % var month-on-month, % var year-on-year	Percentage change in the number of jobs since the implementation of the AI solution in a specific group that may be affected by said implementation	Societal Wellbeing
Improvement of the working conditions of employees in the sector in which the AI solution is implemented	LIKERT scale	Level of satisfaction with the working conditions of employees in the sector in which the AI solution is implemented (for example: bus drivers of a public transport company; traffic controllers; tourism information service workers, etc.)	Societal Wellbeing
Number of user complaints related to privacy violation or data loss	Number of complaints/year	Reports on the number of complaints related to privacy violation or data loss during the last year	Privacy and Data Governance
User questions incorrectly resolved	N.	Number of doubts incorrectly resolved by the APP (human analysis of doubts and answers)	Human Agency and Oversight
Evolution of the number of users on the platform	% Variation	Evolution of the number of users registered on the platform / application (month-on-month / year-on-year) ((No. of users in T1 – No. of users in T0) / No. of users in T0)	Technical robustness and safety
People/users reached	% from the people	Percentage of people in the target group who are users of the AI solution	Diversity, Non-discrimination and Fairness
App usage rate	%	Percentage of active users with respect to total registered users	Technical robustness and safety
Ease of use of the tool for end users	LIKERT scale	The degree to which the AI solution is perceived as difficult for potential end users to understand and use.	Transparency and accountability

KPIs	Unit	Description	Thematic
Ease of use for stakeholder professionals	LIKERT scale	The degree to which the AI solution is perceived as difficult for professional users to understand, implement and use.	Transparency and accountability
Number of complaints about AI solution malfunctions	Number of complaints/year	Report on the number of complaints about malfunctions of the AI solution (technical failures)	Technical robustness and safety
User satisfaction level with the tourist information service	LIKERT scale	User satisfaction level with the tourist information service	Societal Wellbeing
Number of user complaints about transparency	Number of complaints/year	Report on the number of complaints about transparency in the last year	Transparency and accountability

Source: Own elaboration.

Mobility case study results

Table 10. Impact Matrix generated in the Participatory Workshop for the Study Case related to Mobility

Impacts	Impact type	Significance level	Probability of occurrence
Please briefly describe the impact	Please indicate the type of impact *(positive negative)*	Please evaluate the magnitude of the impact *(very high, high, medium, moderate)*	Please assess the probability of the impact occurring *(low, medium, high, very high)*
Social welfare			
Improving the health of the general population and vulnerable groups (the elderly, children, people who work outdoors)	Positive	High average	High average
Increased quality of life for residents of areas suffering from traffic congestion	Positive	High	Medium
Reduction in travel times which means an increase in the quality of life for citizens	Positive	Very high	Very high
Reduction in fuel consumption for road transport	Positive	Medium	High
Increase in road safety / decrease in the number of traffic accidents	Positive	High	
Improvement of working conditions for drivers (buses, delivery people, truck drivers, etc.)	Positive	High	Medium
Simplification of the work of traffic controllers	Positive	High	Medium
Loss of jobs related to traffic control	Negative		
Less stress by knowing the traffic points in real time and arriving at the destination on time	Positive	High average	High average
Greater efficiency of public transport services	Positive	High	Medium
More space for people	Positive	High	Low
Reduction in response time for emergency services	Positive	High	High
Optimization of urban works planning	Positive	High	Medium
Feeling of hypervigilance, lack of privacy	Negative	High	High
Environmental well-being			
Improved air quality	Positive	High	High
Decreased contribution of land transport to climate change	Positive		
Reduction in noise pollution caused by automobile traffic	Positive	High/medium	
High resource consumption by AI	Negative	High	High
Due to less traffic, increased use of private transportation	Negative		High
Diversity, Non-Discrimination and Equity			

Impacts	Impact type	Significance level	Probability of occurrence
Areas that do not have surveillance systems would not be represented in the model	Negative		
Digital gap	Negative	High	High
Human supervision			
Risk of automatization of traffic management decisions	Negative		
Privacy and data governance			
Use of image and sound data that may violate the privacy of citizens	Negative		
Robustness and technical security			
Risk of cyber attacks	Negative		
Transparency and responsibility			
Publication of information and indicators in annual reports for studies and open science	Positive	Very high	Very high

Source: Own elaboration.

Table 11. KPIs list generated in the Participatory Workshop for the Study Case related to Mobility

KPIs	Unit	Description	Thematic
Monthly evolution of average emissions per pollutant	concentration in micrograms, var %	Monthly evolution of average emissions measured at the stations of the Municipal Air Pollution Monitoring Network (sulfur dioxide SO2, nitrogen dioxide NO2, ozone O3, carbon monoxide CO, suspended particles smaller than 2.5 µm (PM2 .5) and to 10 µm (PM10), etc)	Air quality
Evolution of average monthly emissions: Sulfur dioxide (SO2)	concentration in micrograms	Monthly evolution of average sulfur dioxide SO2 emissions measured at the stations of the Municipal Air Pollution Monitoring Network: average of the averages	Air quality
Evolution of average monthly emissions: Nitrogen dioxide (NO2)	concentration in micrograms	Monthly evolution of average nitrogen dioxide emissions measured at the stations of the Municipal Air Pollution Monitoring Network: average of the averages	Air quality
Evolution of average monthly emissions: Ozone (O3)	concentration in micrograms	Monthly evolution of average ozone emissions measured at the stations of the Municipal Air Pollution Monitoring Network: average of the averages	Air quality
Evolution of average monthly emissions: Carbon monoxide (CO)	concentration in micrograms	Monthly evolution of average carbon monoxide emissions measured at the stations of the Municipal Air Pollution Surveillance Network: average of the averages	Air quality
Evolution of average monthly emissions: Suspended particles smaller than 2.5 µm (PM2.5)	concentration in micrograms	Monthly evolution of the average emissions of suspended particles smaller than 2.5 µm (PM2.5) measured at the stations of the Municipal Air Pollution Monitoring Network: average of the averages	Air quality
Evolution of average monthly emissions: Suspended particles smaller than 10 µm (PM10)	concentration in micrograms	Monthly evolution of the average emissions of suspended particles smaller than 10 µm (PM10) measured at the stations of the Municipal Air Pollution Monitoring Network: average of the averages	Air quality
Assessment of the city's air quality	LIKERT scale	Evolution of residents' average assessment of the air quality in their city	Air quality
Evolution of CO2 equivalent emissions according to activity	tons of CO2 equivalent and var %	Evolution of the city's equivalent CO2 emissions according to activity	Climate change
Evolution of CO2 equivalent emissions by activity: Public and municipal transport	tons of CO2 equivalent and var %	Evolution of the city's equivalent CO2 emissions attributed to public and municipal transport	Climate change
Evolution of energy consumption of the city according to activity	MWh and var %	Evolution of energy consumption of the city according to activity	Climate change
Evolution of energy consumption in the city according to activity: Public and municipal transportation	MWh and var %	Evolution of the city's energy consumption attributed to public and municipal transportation	Climate change

KPIs	Unit	Description	Thematic
Population evolution	Number of people and interannual variation %	Evolution of the number of inhabitants of the city	Demography
Population pyramid	%	Distribution of the population in age groups and sex	Demography
Population density	People per square kilometer	Number of population (as of January 1 of each year) per square kilometer (for the last 5 years) divided by the area of the territory in square kilometers	Demography
Monthly evolution of registered unemployment	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of registered unemployment in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Social Security Affiliations	No. of affiliations, % month-on-month, Var % year-on-year	Evolution of the number of Social Security affiliations in absolute terms, inter-month % variation and inter-annual % variation with respect to the same month of the previous year	Employment
Evolution of self-perceived health status	LIKERT scale	Assessment of self-perceived health status	Health
Evolution of the feeling of calmness or anger	% according to LIKERT scale	Evolution of the percentage of people according to the anger/calm self-perception scale	Health
Evolution of the percentage of people who report suffering from a chronic respiratory disease	Number, % Variation	Evolution of the number of people who report suffering from a chronic respiratory disease	Health
Mortality Rate from Respiratory Diseases (Bronchitis, Pneumonia, Chronic Obstructive Pulmonary Disease (COPD)) per 100,000 inhabitants	Deaths per 100,000 people	Number of deaths attributed to respiratory diseases (bronchitis, pneumonia, COPD) within a specific population during the last year divided by the total population and multiplied by 100,000	Health
Mental health: anxiety and depression	LIKERT scale	Level of anxiety or depression reported in the adult population	Health
Contact with ICT: internet access	%	Evolution of the percentage of the population that has access to the internet	ICTs
Contact with ICT: has a smartphone	%	Evolution of the percentage of the population that has a smartphone	ICTs
Digital gap: internet access by age groups and sex	%	Percentage of people who access the internet at least 5 days per week by age group and sex	ICTs
Digital gap: Have a smartphone according to age groups and sex	%	Percentage of people who have a smartphone by age group and sex	ICTs

KPIs	Unit	Description	Thematic
Annual evolution of the number of trips by means of public transport	N., % interannual var	Annual evolution of the number of trips by means of public transport (metro, bus, train)	Mobility
Annual evolution of the number of trips by means of transport: Metro	N., % interannual var	Annual evolution of the number of trips by means of public transport: Metro	Mobility
Annual evolution of the number of trips by means of transport: Bus	N., % interannual var	Annual evolution of the number of trips by means of public transport: Bus	Mobility
Monthly evolution of the number of trips by means of public transport	N., % interannual var	Monthly evolution of the number of trips by means of public transport (metro, bus, train)	Mobility
Monthly evolution of the number of trips by means of public transport: Metro	N., % interannual var	Monthly evolution of the number of trips by means of public transport: Metro	Mobility
Monthly evolution of the number of trips by means of public transport: Bus	N., % interannual var	Monthly evolution of the number of trips by means of public transport: Bus	Mobility
Trips by public transport per capita by mode of transport	Number of trips/year/person	Annual number of public transport trips per capita	Mobility
Trips in public transportation per capita by mode of transportation: Metro	Number of trips/year/person	Annual number of public transport trips per capita: Metro	Mobility
Trips by public transportation per capita by mode of transportation: Bus	Number of trips/year/person	Annual number of public transport trips per capita: Bus	Mobility
Evolution of the vehicle fleet	Number of vehicles	Number of vehicles according to type (cars, motorcycles, trucks) and total	Mobility
Evolution of the number of traffic accidents	Number and % Variation	Evolution of the number of traffic accidents, inter-monthly and inter-annual variation	Mobility
Monthly evolution of the number of victims in traffic accidents	Number and % Variation	Evolution of the number of accidents with victims in traffic accidents, inter-monthly variation and inter-annual variation	Mobility
Evolution of daily time spent traveling	% by timeslots	Percentage of the population surveyed according to timeslots, sex, age	Mobility
Assessment of traffic in the city	LIKERT scale	Evolution of residents' assessment of traffic in their city (0 very bad - 10 very good)	Mobility
Commonly used means of transportation	%	Distribution of the population over 15 years of age according the mean of transportation commonly used	Mobility
Evolution of the population exposed to noise according to decibel intervals	%, % var	Evolution of the distribution of the population exposed to noise according to different noise intervals (Day-Evening-Night)	Noise
Evolution of the population exposed to road traffic noise according to decibel intervals	%, % var	Evolution of the distribution of the population exposed to road traffic noise according to different noise intervals (Day-Evening-Night)	Noise

KPIs	Unit	Description	Thematic
Evolution of the monthly sound level according to measuring station	dBA and % var	Evolution of the monthly sound level according to measuring station	Noise
Evolution of the monthly sound level according to measuring station: Pista de Silla	dBA and % var	Evolution of the monthly sound level according to measuring station: Pista de Silla	Noise
Evolution of the monthly sound level according to measuring station: Ayuntamiento	dBA and % var	Evolution of the monthly sound level according to measuring station: Ayuntamiento	Noise
Evolution of the monthly sound level according to measuring station: Av. Aragón	dBA and % var	Evolution of the monthly sound level according to measuring station: Av. Aragón	Noise
Evolution of the monthly sound level according to measuring station: Olivereta	dBA and % var	Evolution of the monthly sound level according to measuring station: Olivereta	Noise
Evolution of the monthly sound level according to measuring station: Patraix	dBA and % var	Evolution of the monthly sound level according to measuring station: Patraix	Noise
Perception of noise problems coming from outside the home	%	Percentage of the population over 15 years of age that perceives problems with their home related to noise coming from outside	Noise
Assessment of noise in the city	LIKERT scale	Evolution of the average rating of residents regarding the noise in their city (0 Very bad - 10 Very good)	Noise
Safety assessment in the city	LIKERT scale	Respondents' rating of the city's safety on a scale from 0 (Very unsafe) to 10 (Very safe)	Protection and security
Perception of security problems in the city	%	Evolution of the percentage of the population over 15 years of age that perceives problems with their housing related to citizen insecurity	Protection and security
Perception of high air pollution problems due to causes other than the industry near their home	%	Percentage of the surveyed population that perceives problems with their housing related to high air pollution due to causes other than proximity to industries	Air quality
Carbon footprint	tons/capita	Greenhouse gas emissions measured in tons per capita	Climate change
Number of cybersecurity incidents	N.	Number of times intruders have managed to breach the system by accessing information or networks	Cybersecurity
Number of intrusion attempts	N.	Number of times intruders have tried to access the system	Cybersecurity
Mean Time To Detect (MTTD)	minutes	Average time until a cybersecurity threat is identified	Cybersecurity
Mean Time to Repair (MTTR)	hours	Average response time of the team to solve a computer attack since the attack has been detected	Cybersecurity

KPIs	Unit	Description	Thematic
Number of user complaints regarding security of the AI solution	Number of complaints/year	The number of security-related complaints in the last year registered	Cybersecurity
Number of user complaints about discrimination	Number of complaints/year	The number of discrimination complaints registered in the last year	Discrimination and diversity
Participation of vulnerable groups	%	Comparison of the percentage of people in a population who use the solution (app, platform) depending on whether or not this population belongs to a specific vulnerable group	Discrimination and diversity
Monthly evolution of unemployment among workers in a specific sector	Number of unemployed, Inter-month % change, Inter-annual % change	Monthly evolution of unemployment registered in the sector in absolute terms, inter-monthly variation and inter-annual variation with respect to the same month of the previous year	Employment
Quarterly evolution of Social Security affiliations in a specific sector	Number of unemployed, Inter-quarterly % change, Inter-annual % change	Quarterly evolution of Social Security affiliations in the sector in absolute terms, inter-quarterly variation and inter-annual variation with respect to the same month of the previous year	Employment
Creation or loss of jobs in the services in which the AI solution is implemented	N. of affiliations, % var month-on-month, % var year-on-year	Percentage change in the number of jobs since the implementation of the AI solution in a specific group that may be affected by said implementation	Employment
Improvement of the working conditions of employees in the sector in which the AI solution is implemented	LIKERT scale	Level of satisfaction with the working conditions of employees in the sector in which the AI solution is implemented (for example: bus drivers of a public transport company; traffic controllers; tourism information service workers, etc.)	Employment
Hospitalization rate for respiratory diseases (bronchitis, pneumonia, chronic obstructive pulmonary disease (COPD))	Hospitalized people per 100,000 people	Number of hospitalizations attributed to respiratory diseases (bronchitis, pneumonia, COPD) within a specific population during the last year divided by the total population and multiplied by 100,000	Health
Prevalence of asthma, bronchitis, chronic obstructive pulmonary disease (COPD), or emphysema	%	Percentage of people diagnosed with Asthma, Bronchitis, Pneumonia, Chronic Obstructive Pulmonary Disease (COPD) or Emphysema in the last year	Health
Means of transportation usually used to go to school	%	Distribution of the population over between 6 and 14 years old according to the mean of transportation commonly used to go to school	Mobility
Quality of public transport.	LIKERT scale	User perception of the quality of public transport service	Mobility
Number of user complaints related to privacy violation or data loss	Number of complaints/year	Reports on the number of complaints related to privacy violation or data loss during the last year	Privacy and data protection

KPIs	Unit	Description	Thematic
Evolution of the number of users on the platform	% Variation	Evolution of the number of users registered on the platform / application (month-on-month / year-on-year) ((No. of users in T1 – No. of users in T0) / No. of users in T0)	Satisfaction
People/users reached	% from the people	Percentage of people in the target group who are users of the AI solution	Satisfaction
App usage rate	%	Percentage of active users with respect to total registered users	Satisfaction
Ease of use of the tool for end users	LIKERT scale	The degree to which the AI solution is perceived as difficult for potential end users to understand and use.	Satisfaction
Ease of use for stakeholder professionals	LIKERT scale	The degree to which the AI solution is perceived as difficult for professional users to understand, implement and use.	Satisfaction
Number of complaints about AI solution malfunctions	Number of complaints/year	Report on the number of complaints about malfunctions of the AI solution (technical failures)	Satisfaction
Number of user complaints about transparency	Number of complaints/year	Report on the number of complaints about transparency in the last year	Transparency

Source: Own elaboration.