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Empowering Urban Transformation: The Role of Citizen Observatories in Inclusive and Data-Driven Governance

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1 ABSTRACT

This paper explores how Citizen Observatories can foster participatory, data-driven governance by actively engaging local communities in co-creating urban knowledge and contributing to evidence-based decision-making processes. Within the EU-funded Innovation Action GREENGAGE (HORIZON 2020), five innovative Citizen Observatories have been established as dynamic ecosystems where technology, citizen science, and policy intersect. These ecosystems empower local communities through interactive socio-technical methodologies and tools, enabling them to monitor environmental conditions, share insights, and collaboratively develop solutions to pressing urban issues. Hence, the creation of Citizen Observatories requires a strong focus on two dimensions: social (socio-economic and political context) and technical (digital tools and platforms). By bringing together citizens, scientists, policymakers, and other stakeholders, GREENGAGE harnesses collective knowledge and expertise to co-create sustainable solutions. In GREENGAGE, Citizen Observatories are located in diverse geographical and social contexts: Bristol (UK), North Brabant (NL), Copenhagen (DK), Turano Valley (IT) and Gerace (IT). This paper highlights initial implementations carried out in these Observatories where local communities, further supported by the consortium members, were provided with skills for collecting valuable, community-sourced data from their neighborhoods using the provided tools. Citizens are involved as Citizen Observers throughout the onboarding, training, and implementation phases, contributing to environmental monitoring and urban planning. The data that is currently being gathered will help directly address local urban challenges that are identified as the most critical by these communities, helping to resolve issues that resonate with local needs and concerns. Furthermore, the paper also illustrates how such initiatives have the potential to not only contribute to healthier, more sustainable urban environments but also foster a culture of participatory governance, where citizens are co-creators of the cities they inhabit.

Keywords: Citizen Observatories; Urban Governance; Sustainable Urban Development; Data-Driven approaches; Community Engagement

2 INTRODUCTION

2.1 Background

As cities increasingly confront challenges posed by climate change and urbanisation – ranging from extreme heat events to increasing demands on infrastructure and resources – there is a growing need for governance models that are both inclusive and data-driven (Asadzadeh et al. 2023). This demand is becoming a key priority in the international arena, highlighting a global recognition of the necessity for more collaborative and inclusive strategies of policy-making (Rocha Menocal et al. 2019; Hölscher et al. 2019; Avoyan 2023). Central to this need are socio-ecological challenges such as extreme weather events, social inequality, climate injustice, biodiversity loss, ecosystem degradation, and the growing mistrust among communities in their local authorities' ability to address these issues effectively. Given the gravity of these challenges, the European Commission has made an ambitious effort to tackle climate change and drive a transition toward

more sustainable development. This commitment is reflected in the EU Green Deal (Broto 2021), a comprehensive policy framework aimed at embedding sustainability and climate action across all EU policies and programs. The Green Deal presents cities with a unique opportunity to drive systemic economic and social transformation.

However, a significant obstacle to reshaping urban governance effectively is the persistent disconnect with local communities, including their concerns, needs, and perspectives. This gap is exacerbated by the absence of robust participatory approaches. As a result, the marginalisation of such grassroots perspectives is expected to exacerbate inequalities and existing disparities in access to opportunities and knowledge. At the same time, it is becoming increasingly clear that traditional top-down urban governance models are often ill-equipped to address the complexity and interconnected nature of these challenges (Baud et al. 2021). These models rely heavily on centralised decision-making by higher authorities, which can overlook the nuanced realities and diverse needs of local communities. Hence, the conventional urban governance approaches are being challenged by an imperative for innovative solutions that transcend institutional silos. Furthermore, there is a significant gap in comprehensive in-situ data (i.e., site-specific, real-time data gathered directly at the location where the phenomena occur) that can effectively capture the intricate and interconnected dynamics of urban environments. This absence of high-quality in-situ data severely limits the ability of decision-makers to identify and address emerging context-specific challenges (Tonne et al. 2020). As a result, responses often lack the timeliness, precision, and relevance needed to tackle complex urban issues in an informed and proactive manner. To address this, cities are increasingly turning to innovative solutions that prioritise public engagement through equitable participation and open dialogue. Prominent among these practices is citizen science, which empowers non-professional volunteers from the general public to contribute and co-produce new and complementary knowledge that benefits both science and society (Haklay et al. 2021). Despite its potential, citizen science has faced criticism for its fragmented landscape, often consisting of isolated activities focused on specific issues (O'Grady et al. 2021). Examples include initiatives centered on air quality monitoring (Mahajan et al. 2022), bird monitoring (Ding et al. 2022), butterfly counts (Butler et al. 2024), biodiversity conservation (Peter et al. 2021), and water quality assessment (Yevenes et al. 2022). This fragmentation highlights the need for more integrated and cohesive approaches that maximise the collective impact of citizen science efforts.

In response, a complementary concept, known as the Citizen Observatory (CO), has emerged. This concept builds upon the foundations of conventional citizen science while addressing its fundamental limitations and expanding its scope (Lie et al. 2017, O'Grady et al. 2021). Citizen Observatories (COs) function as comprehensive ecosystems of collaborative observation and action, tackling urban planning challenges linked to climate change and community disengagement through diverse and holistic perspectives. Unlike traditional citizen science initiatives, which often focus on singular issues, Citizen Observatories adopt an integrated approach that fosters a multifaceted understanding of complex problems (Rathnayake et al. 2020, O'Grady et al. 2021). This approach brings together the collective knowledge and expertise of citizens, scientists, policymakers, and other stakeholders to co-create solutions. Additionally, while citizen science primarily focuses on collecting objective, scientific data, COs go beyond that by integrating subjective information such as personal perceptions and experiences, which are crucial for understanding how people's attitudes and behaviours evolve. By incorporating diverse perspectives and methodologies, COs enable a more nuanced, participatory, and citizen-centric approach to problem-solving. This, in turn, facilitates deeper reflection and more agile, context-sensitive responses to emerging societal and environmental challenges.

2.2 Overview

The transformative potential of COs is currently being leveraged within the pan-European Innovation Action GREENGAGE, funded by the Horizon Europe program (GREENGAGE 2025). As part of this initiative, five innovative COs in diverse geographical and social contexts have been established as dynamic ecosystems where technology, citizen science, and policy intersect: Bristol (UK), North Brabant (the Netherlands), Copenhagen (Denmark), Turano Valley (Italy), and Gerace (Italy). The five pilots serve as living laboratories of innovation, showing how citizen engagement, technological advancement, and governance transformation can intersect to reshape civic participation and policymaking. To achieve this, a range of initiatives is being implemented within these COs, supported by the GREENGAGE consortium. By providing expertise, resources, and guidance, the consortium ensures that local communities are equipped with tailored socio-

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technical methodologies and tools to observe, monitor, and actively engage with their neighborhoods. In this collaborative process, community members take on the role of Citizen Observers, actively participating in environmental monitoring, mobility pattern analysis, and the evaluation of public space usage in tourism. These thematic areas are selected based on the priorities identified by the communities themselves, ensuring that the initiatives address issues most relevant to their specific needs and concerns.

3 METHODOLOGY

3.1 Innovation pilots in GREENGAGE

GREENGAGE innovation pilots span diverse geographical and social contexts, with activities specifically designed to address local environmental and sustainability challenges, further aligned with the broader Green Deal priorities (see Figure 1). In Bristol, a densely populated city in southwest England, the CO operates at a neighbourhood level, engaging local communities in reimagining their neighbourhoods as people-centred, liveable spaces of clean air, quality green spaces, and a strong sense of community. In North Brabant, a predominantly rural and peri-urban province in the south of the Netherlands, the CO functions at the regional level, fostering community participation in the transition to a sustainable and smart mobility while enhancing climate resilience. Copenhagen, the capital of Denmark known for its waterfront developments and green urban planning, hosts its CO at the district level, mobilising citizens to contribute to the city's climate targets through air quality monitoring and climate adaptation initiatives. In the Turano Valley, a sparsely populated rural region in central Italy close to Rome, the CO operates at the municipal level, empowering communities to support climate resilience, regenerative practices, and the preservation of its rich cultural heritage. Similarly, Gerace, a historic hilltop town in southern Italy, hosts its CO at the municipal level, involving local communities in climate adaptation efforts and sustainable heritage conservation.
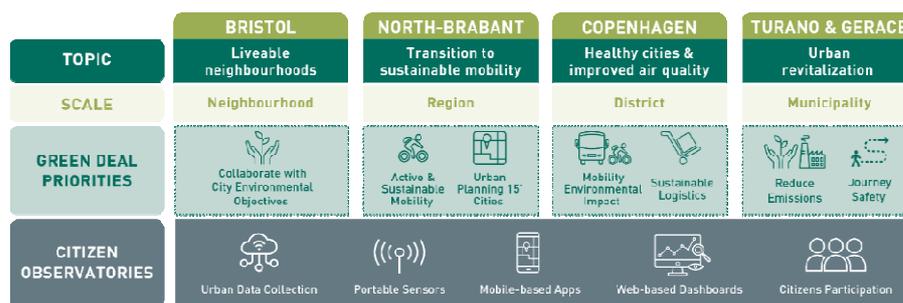

Fig. 1: Overview of the GREENGAGE pilots, highlighting their specific topic areas, scales of impact, Green Deal priorities, and core components of Citizen Observatories.

3.2 Foundational aspects of Citizen Observatories

The process of establishing Citizen Observatories in five pilot areas involves both social and technical dimensions. From a social perspective, it requires a deep understanding of the local socio-economic and political context, such as identifying key decision-makers, assessing community dynamics, and evaluating the unique challenges and opportunities within the area. From a technical perspective, it entails designing and implementing a robust technological framework, including digital tools and platforms, to facilitate data collection, analysis (including data validation), and collaboration effectively. The social dimension and its corresponding socio-political context are thoroughly mapped through a combination of surveys and interviews with key project partners leading each pilot area (i.e., pilot owners), offering a comprehensive overview of the local context with valuable insights into the social fabric, political structures, and community perspectives. The technical dimension was conceptualised through a series of collaborative discussions within the consortium to determine the appropriate tools and their intended applications, as well as the necessary levels of training and support.

However, both aspects are inherently dynamic and continuously evolving, shaped by the ever-changing real-world conditions, shifts in local power structures, and the evolving expectations and needs of communities. Therefore, to navigate the fluid nature of these challenges, our approach emphasizes flexibility through adaptable strategies and continuous reassessment to ensure the COs remain relevant, responsive, and effective in tackling the priorities of the communities they serve. Hence, we have established a series of

structured bi-weekly intra-consortia meetings, known as Pilot Support Teams (PST), to regularly reassess the local conditions, actively incorporate stakeholder feedback, and adjust our collective strategies accordingly. The PSTs consist of dedicated consortium members representing both technical domains (i.e., technology providers) and non-technical domains (i.e., participatory and social sciences). Together, they provide ongoing support to the pilot owners, who act as community representatives, ensuring a collaborative and holistic approach to addressing the needs of the communities involved. These meetings serve as a channel for ongoing collaboration and monitoring, enabling assessment of shifts in local power dynamics, as well as evolving community concerns and goals. This approach ensures agility, and through the iterative process, a continuous adaptation of the pilots to meet the changing needs and challenges.

Fig. 2: Foundational aspects of Citizen Observatories: social and technical dimensions.

The PST sessions also provided the foundation for in-depth discussions on technical aspects. They facilitated the identification of the most suitable digital platforms, data collection methods, and socio-technical tools that would be most effective in meeting the goals of each CO. Specifically, participants in the COs have access to a diverse suite of technological assets designed to support the entire data-to-policy lifecycle. Curated for interoperability and scalability, these assets form the GREEN Engine – a comprehensive toolbox comprising three categories: (1) GREENGAGE tools, developed by the project consortium enabling data collection, visualisation, and analysis, also effective collaboration and engagement; (2) pilot-specific tools, tailored to the unique needs of individual pilots; and (3) open-source tools adopted by GREENGAGE, which enhance functionality and adaptability. Within proprietary GREENGAGE suite of tools, the starting point is the Collaborative Environment (Collaborative Environment 2025), a foundational tool for COs that facilitates the setup and management of co-production processes within a CO. Following, a range of mobile-based applications enables real-time mapping and image analysis (MindEarth app 2025), mobility patterns capture and modes of travel detection (MODE Software Library 2025), and qualitative spatial data collection on, e.g., local air quality or safety levels (GREENGAGE app 2025). Additionally, wearable environmental data capture devices (AtmoTube 2025), combined with visualisation dashboards and data analytics platforms, equip participants with powerful capabilities to visualise, analyse, and interpret environmental information effectively (Superset 2025). Altogether, these three categories of tools serve to facilitate community and process management as well as data crowdsourcing, empowering participants to contribute effectively to environmental monitoring and policy development.

3.3 Preparing for participatory data collection & analysis

In a participatory setting, individuals are not passive recipients of information; rather, they are recognized as active contributors, with their perspectives, knowledge, and skills integral to the process (Vaughn and Jacquez 2020). This collaborative principle is central to the GREENGAGE framework, which leverages co-creation and crowdsourcing to develop innovative data-driven solutions to urgent environmental challenges. At its core, the GREENGAGE project ensures that local communities are actively engaged from the very beginning, fostering a sense of shared responsibility and ownership in addressing these critical issues.

This process is realized through several steps that aim to co-deliver a thematic co-exploration (GREENGAGE Documentation 2025). Essentially, a thematic co-exploration is a collaborative process in which diverse stakeholders – including citizens, scientists, policymakers, and other relevant actors – jointly investigate, analyse, and develop insights on a specific theme or issue. This process unfolds in four key stages: (1) preparing, which involves identifying the theme, onboarding the core team, and providing necessary training; (2) designing, where experiments are specified, tools are selected, refined, and tested; (3) experimenting, which includes onboarding and training observers, followed by data collection and analysis; and (4) sharing, where findings are communicated through storytelling and advocacy to drive awareness and

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action. All these aspects are addressed in the PST meetings, ensuring a structured and collaborative approach to planning, execution, and knowledge sharing throughout the process.

Once the theme of co-exploration is identified based on community concerns, the process moves forward with onboarding and training. Onboarding focused on identifying who should be involved, when and how they can best contribute to the co-creation process within COs. It defined the roles of key actors in collaborative efforts and assesses their technological and scientific capabilities. Essentially, it ensured a clear understanding of the communities to engage, the best timing and methods for their involvement, and their specific needs. Building on these insights, particularly technological and scientific needs, the next step focused on training. To support this, a range of training resources is developed as a part of the GREENGAGE Academy, including video tutorials on project-specific digital tools from the GREEN Engine toolbox, as well as guidance on the scientific methods, data standards, collection, processing, handling, and analysis. These were delivered through interactive online workshops, referred to as "Train the Trainers" training series. Initially, the training targeted the core team of Citizen Observers (i.e., selected members of the consortium), equipping them with the knowledge needed to oversee and support external participants (i.e., key actors from the onboarding phase), ensuring effective knowledge dissemination and capacity building beyond the consortium. The external training was conducted through community-oriented workshops held on-site in pilots, designed to foster hands-on learning and active engagement with key actors. These workshops were tailored to the specific needs of participants, ensuring accessibility and relevance while also incorporating their feedback on the proposed materials. This iterative approach allowed for continuous refinement, ensuring that emerging needs and perspectives were effectively addressed.

3.4 Advancing participatory governance models

To advance participatory governance models, the GREENGAGE project employs a robust approach grounded in transparency and inclusivity while fostering meaningful collaboration between local communities, policymakers, and experts. A crucial element of this approach is maintaining an open and continuous dialogue with these stakeholder groups, ensuring their voices are not only heard but actively integrated into decision-making processes. Efforts have been made to govern the co-creation process through the Collaborative Environment, supported by the thematic co-exploration process model. This model provides a structured framework that guides communities through the various phases, steps, and assets from the GREENGAGE Knowledge Base, ensuring they can effectively navigate and utilise the resources available at each stage of the process. However, not all aspects of this model have been fully embraced or implemented across GREENGAGE pilot contexts. This is primarily due to the varying local conditions, needs, and capacities of different communities, which can influence how certain tools or steps are adopted and integrated. To further facilitate a meaningful engagement, the GREENGAGE project is actively engaging in several structured activities, including public talks at international conferences, community forums, academic symposiums, and environmental summits. These events serve as a platform to connect with diverse audiences, share insights on participatory governance, and discuss innovative solutions to environmental challenges on both local and global scales. By bridging all these perspectives, we aim to create more effective and resilient governance structures.

In addition, we are organising a series of participatory workshops and are actively preparing for an upcoming datathon in Turano pilot in Italy. The aim of these activities is to create interactive spaces for co-creation, knowledge exchange, and data-driven decision-making. Specifically, participatory workshops empower both communities directly involved in the project and those beyond its scope to share firsthand experiences and insights. For instance, a series of workshops held with local communities from each pilot site are providing a valuable context on community dynamics, helping identify local priorities and better understand typical decision-making processes. Additionally, participatory workshops aimed at external audiences are engaging with students, academics, and other stakeholders to gather fresh perspectives on GREENGAGE activities. By incorporating external viewpoints, these workshops are continuously enriching the project's impact and ensuring its relevance across diverse contexts. Our upcoming datathons aim to engage citizens, researchers, technologists, and local stakeholders in collaboratively analysing real-world data and generating innovative, evidence-based approaches to environmental and urban challenges. The citizens who previously participated in data collection will be invited to participate in the datahon, which should further deepen engagement and enrich the analysis.

4 RESULTS

4.1 Situational context and dynamics of pilot areas

We begin our discussion by reporting on the distinct situational context and dynamics of innovative pilots involved in the GREENGAGE project, as highlighted by our survey results, which collectively shaped the specific needs and priorities of each pilot area and influenced the design and implementation of COs.

Bristol, UK: The Bristol Pilot focuses on the East Bristol Liveable Neighbourhood (EBLN) initiative, which aims to enhance the quality of life in East Bristol through a smart urban governance approach. This approach involves co-discovery and co-development phases to understand the needs of the community, identify desired changes, and uncover barriers to creating a more liveable neighbourhood. During these phases, Bristol City Council (the GREENGAGE pilot owner) used a design toolkit to gather community aspirations through events and an online platform (Commonplace 2025). These phases served as precursors to a trial scheme design and delivery, where some of the community's aspirations will be tested. The EBLN project went through the Traffic Regulation Order (TRO) process. Bristol City Council held official consultations on proposed measures like bus gates and modal filters, which need TROs to make legal changes to the roads. Based on these consultations, the city council approved the trial scheme. At the time of writing this article, the trial scheme is being delivered. In addition to traditional methods, the GREENGAGE project plays a crucial role in monitoring the trial scheme. Continuous monitoring during the trial scheme will help assess the impact of changes on mobility, air quality, and equality. This monitoring will provide a basis for consultation with the community and implementing permanent changes in the EBLN.

North Brabant, NL: The North Brabant pilot focuses on exploring COs as a sustainable means of citizen participation. Following the Omgevingswet (Environmental Law) (Ministerie van Koninksrijkrelaties, 2024), public authorities (amongst others) have a duty to include citizen participation in projects. However, how this change in procedure should be sustainably integrated into the governance process is still debated. The pilot experiments with using a CO to structure citizen participation for the benefit of public authorities, civic organisations, and citizens alike. Following Pappers et al. (2022), the focus is on exploring COs as a valid method of policy participation by initiating a discussion rather than large-scale data collection. To test the validity of COs, a strong foundation was necessary. Therefore, the CO was built to complement existing governance processes with citizen data or input, rather than replacing or merely supplementing already existing practices. By consulting the citizen cyclist collective of the Fietsersbond (Fietsersbond 2025), cycle path maintenance was identified as a key topic for citizen engagement (in this case cyclists), ensuring intrinsic motivation. Currently, cycle path maintenance governance is a two-way but disconnected process. Public authorities assess and maintain paths through periodic expert judgment, while citizens can report maintenance needs through online mapping portals, often unsure of the correct authority to report to. Alternatively, citizens can collaborate with civic advisory organisations like the Fietsersbond, which collect subjective experiences to public authorities. The pilot aims to see how this two-directional process could complement each other to make the cycle path maintenance more inclusive and effective, enhancing the attractiveness of cycling overall.

Copenhagen, DK: Copenhagen pilot focuses on discovering new solutions and alternatives to fossil-based behaviours, particularly within the current transport systems, towards creating a climate-positive neighbourhood. At the core of the initiative is the definition of a new local traffic plan, introduced by the City Hall with a strong emphasis on citizen participation and a vision for a new approach to urban mobility. The plan has sparked political controversy, as the residents resist the City Hall's plan of creating a new island in the Copenhagen area without fully considering the impact of heavy traffic in the district – given the added pressure from ongoing urbanisation. To address this, the pilot aims to develop a truly citizen-driven traffic plan for its Amager Vest district. Given the contentious nature of the project, the CO seeks to build a reliable and widely accepted dataset that can serve as a shared foundation for decision-making among all stakeholders. A key principle of the pilot is that data collection, when integrated with community engagement, can drive sustainable change. To achieve this, the project has focused on developing a citizen-led data collection methodology, ensuring the final dataset is credible and trusted by all involved parties. Beyond data quality, the initiative also prioritises inclusivity, ensuring diverse representation in the data and identifying the key parameters that matter to both citizens and stakeholders.

Turano Valley & Gerace, IT: Turano Valley and Gerace, though located in different regions of Italy, share historical significance and face similar issues. Both regions struggle with hydrogeological instability, inadequate road infrastructure, and insufficient public transport. Additionally, poor broadband connectivity hampers economic development and exacerbates depopulation and aging population challenges, straining social services. The villages in these areas are part of the National Programme for Resilience and Recovery (NPRR 2024) and the 'Borghi più Belli d'Italia' consortium, which aims to preserve their significance by regenerating and revitalising heritage villages. The goal is to balance historic preservation with modern needs to attract investments, stimulate economic growth, and support local communities through cultural initiatives, despite demographic challenges. The CO in these areas aims to analyse socio-economic dynamics, focusing on mobility, environment and tourism. Improving infrastructure, connectivity, and urban revitalisation are essential to attract investment, enhance liveability, and support economic growth. The CO aims to achieve this through direct data collection from citizens, engaging with both political and social realities, and community datathons. A big focus of the Observatory is to educate residents on understanding and analysing the risks of degradation to natural and built heritage, assessing the current conditions, such as pollution and mobility, and raising awareness about interventions needed to protect the villages. Timely action can set a precedent for the wider region and serve as a model for other municipalities with similar characteristics. Therefore, the Observatory emphasises citizen science and a participatory approach in environmental monitoring. The goal is to involve citizens in monitoring their environment, advocating for inclusive and participatory decision-making processes that improve community sustainability and resilience.

4.2 Individual readiness of pilot areas

The maturity levels of each pilot significantly influence the activities and approaches employed throughout the project. More mature pilots, like those located in Bristol and North Brabant, build upon already established frameworks that provide a solid foundation for citizen engagement and the implementation of more tangible activities. In Bristol, this foundation is rooted in the Liveable Neighbourhood concept, which embraces a co-design approach that actively seeks community feedback to reimagine local streetscapes. The North Brabant pilot integrates COs into a larger public participation scheme that explores the contribution of cycle path users in ensuring a maintenance pattern more attuned to daily and recreational use, to remove deterrents for taking the bicycle. These strong foundations allow for a more seamless integration of planned GREENGAGE initiatives and a smoother real-world implementation process. In contrast, pilots in Copenhagen and Italy, still in earlier stages of execution, focus more on experimentation and future-oriented transformations. Without established frameworks to build upon, these pilots rely on testing new concepts, fostering cross-sector collaboration, and actively involving citizens in shaping the direction of the initiatives. This exploratory nature allows for innovative solutions but may also present challenges in securing long-term stability and integration.

4.3 First steps towards functioning Citizen Observatories

Building on the structured approach of continuous reflection established in the GREENGAGE methodology, our pilot implementations demonstrate varying degrees of progress in engaging local communities and integrating COs. As previously noted, some pilots remain in the experimental phase and have yet to implement concrete actions.

Bristol, UK: Through its methodology and tools, GREENGAGE reached out to seldom-heard voices, such as school children and youth groups, to identify their aspirations. It aligned these aspirations with the previously collected needs during the co-discovery and co-development phases, particularly through participatory workshops, and identified key gaps. The process began with awareness workshops focusing on sustainable travel and the environment, gathering around 35 participants, followed by a second round of workshops (15 participants per workshop and a wrap-up session with 24 attendees) to discuss possible solutions and highlight key issues. As a result, issues such as anti-social behaviour, poor lighting, narrow kerbs for pedestrians, safety concerns, lack of CCTV (Closed-Circuit Television, a video surveillance system), and public transport accessibility were highlighted. Although most of the issues are not directly relevant to the transport focus of the EBLN project, they can indirectly influence the implementation of the scheme. For instance, anti-social behaviour, inadequate CCTV, and safety concerns while walking in poorly lit areas or on narrow kerbs were key barriers identified by the target (children and youth) groups. These issues were directed to relevant departments of Bristol City Council for action. Travel diaries were collected over a

specific period, and a soft approach (without technology) was used to identify key points of interest and roads needing urgent attention. This data will be used to design experiments within the GREEN Engine, particularly using the GREENGAGE app and MindEarth app, in the upcoming phase. Both apps require setting up experimental tasks, such as Points of Interests (PoIs), research questions, and tasks for recording images between predefined geographical points (routes), to collect qualitative and quantitative observation data. The specifics on how these tools will be applied in the Bristol context are outlined as follows:

(1) Monitoring the environment and automatically identifying safety/threat levels: This use case helps the Bristol pilot owner gain insights into safety concerns and mobility conditions, enabling informed policy decisions on transportation and public safety in liveable neighbourhoods. MindEarth app will be used to gather images on specific roads at different times of a day to perform image analysis and predefined features such as road crossings, cars parked over kerbs, poor lighting, littering, accessibility such as level surfaces for people with disabilities etc will be detected from the collected images using AI. This will be complemented with the qualitative data collected through GREENGAGE app that will provide PoIs on a 2D map and residents will be able to identify spots of concerns and provide textual response to specific questions.

(2) Analysing and visualising the impact on the quality of journeys due to road closures: This use case provides valuable data on how road closures affect travel experiences, helping to optimize traffic management and improve journey quality. The GREENGAGE app with MODE integration is able to detect which routes people take to reach to specific PoIs (e.g., shops, schools, and other local amenities) and what mode of journey (walking, cycling, vehicle) is used. This data will be complemented with qualitative data of rating the overall journey experience by the participants.

Overall, the GREENGAGE methodology ensured that seldom-heard voices are included in the decision-making process, leading to more inclusive and representative outcomes. This bottom-up information collection contributes to top-down decision-making. The data collected and analysed through GREENGAGE tools will provide a robust basis for making informed policy decisions, thereby improving the effectiveness of interventions.

North Brabant, NL: A five-step process was set up, to streamline the expectation management of all parties, and explore the needs and contribution of each partner. Following the suggestions from Keseru et al. (2019), the CO would make use of the existing pilot-specific technology and collaboration infrastructures provided by the Fietsersbond. These technologies have the benefit of familiarity in interface and language to the volunteers of the Fietsersbond, while being comparable to the GREEN Engine technology. The process is carried out in the following steps:

(1) Voice of the Volunteers: Members from the Fietsersbond were onboarded (9 participants) and asked what they understand by 'Maintenance' and what they specifically look for in cycle path maintenance.

(2) Voice of the Road Authority: Public authorities explained their approach to bike path maintenance and considered where the volunteer additions from step 1 could potentially be of use. Volunteer representatives (30 participants) were present in this step to immediately attune the data complementation. The complement was found in a subjective assessment of bike paths qualified good, medium, and bad, according to the road authority. The contrast on seven scored characteristics provides added information for the maintenance departments and elaborates on the observations through subjective descriptions.

(3) Voice of the Bike Path: Volunteers go out and gather the data.

(4) Voice of the Data: A scientific partner analyses the data on maintenance, environmental, and traffic safety level, and visualises the results in a data platform.

(5) Voice of All: The visualisations are presented, and the road authority and volunteers discuss contrasts and similarities. A systematic continuation is discussed as well.

Copenhagen, DK: The pilot aims to establish a reliable and consistent data foundation as grounds for informed decision-making and democratic participation in the new Local Traffic Plan. To achieve this, the pilot builds on past and ongoing neighbourhood initiatives, prioritising areas where local contributions can have the most impact, but also integrating diverse data sources to provide a comprehensive picture of how the neighbourhood's current layout affects its use. Ultimately, the goal is to use data as a tool for engagement, encouraging broader participation and cross-sector collaboration to develop innovative solutions. This approach considers three strategic steps:

(1) Baseline Assessment: Engaging citizens to document existing living and environmental conditions, ensuring data is both trustworthy and verifiable. The first implementation engaged around 40 participants in air quality measurement activities.

(2) Shared Dialogue: Creating a feedback loop where stakeholders recognize findings, leading to actionable steps for monitoring and improvement.

(3) Implementation Planning: Securing funding and political support to achieve long-term outcomes.

Two main use cases have been developed:

- Analysis of Public Space Usage: Examining how people interact with urban areas, how factors like traffic, trees, and urban design influence usage patterns, and identifying areas that should be protected from traffic.

- Participatory Traffic and Environmental Monitoring: Tracking traffic volumes, composition, and their impact on air and noise pollution to inform the Local Traffic Plan.

Turano & Gerace, IT: The Italian pilots adopted a similar approach to Copenhagen, focusing on collecting air quality data using portable sensors. This demonstrates that despite differing local contexts, the CO model can be effectively implemented in a comparable manner. It highlights the framework's adaptability, enabling diverse communities to engage in participatory data collection, analysis, and decision-making while addressing their unique environmental and social challenges. By following a structured yet flexible methodology, the Italian pilots demonstrate that COs can be scaled and replicated across various settings, fostering inclusive and data-driven policy development. The participatory workshops engaged between 19 and 39 participants varying across these sessions based on availability and relevance of the topics discussed.

4.4 Insights from first Citizen Observatory implementations

Bristol, UK: In the context of the Bristol pilot use cases, the GREENGAGE project has demonstrated its potential to contribute to creating safer and more livable neighborhoods by addressing safety concerns and environmental issues. Despite these benefits, the project faces several challenges. Key difficulties include collecting and integrating accurate data from a wide variety of sources and ensuring it is representative for informing policy decisions. Onboarding and maintaining sustained engagement, particularly from seldom-heard voices, requires ongoing effort and innovative strategies. Targeting existing communities of interest and collaborating with local schools has been crucial for expanding the participant base and increasing readiness to collaborate. The resulting benefits extended beyond the project itself, supporting Bristol schools in rewarding young people for engaging in sustainable practices. The scale of issues in the EBLN is widespread, requiring significant resources and coordination across multiple departments and stakeholders, which extends beyond the GREENGAGE project's scope and may affect its perceived effectiveness. Clear communication is essential to help stakeholders understand that GREENGAGE serves as a method for collecting observations on specific topics. While the evidence-based information gathered can influence policy, decision-making power ultimately lies with the pilot owner.

North Brabant, NL: The North Brabant Citizen Observatory demonstrated that, within a government mandated participation strategy and an existing data-rich environment, citizen observers can provide a valuable addition to maintenance of data, planning, and processes. The addition of more contextualised data provides a detailed layer to the objective maintenance inventory, offering insights into when safety and environmental departments (and their respective budgets) need to be involved in maintenance activities. This enriches decision-making and ensures that the relevant departments are informed and can allocate resources more effectively. Despite the promising complementary insights from closer collaboration with citizens, engaging new members presented several challenges. Firstly, intrinsic motivation for bike maintenance was predominantly found among avid cyclists, resulting in a less representative sample of respondents. Secondly, a more relaxed participatory setting proved more effective in fostering engagement, whereas overly complex and technical content hindered participation. This also limited the reach and data quality of the citizens observers. For future engagement, a specified approach for more specific target audiences is required.

Copenhagen, DK: Unlike municipal or authority-led pilots, the Copenhagen pilot is managed by a community organization that mediates in a politically sensitive environment. This highlights the importance of high-quality, citizen-led data in fostering democratic debates among diverse stakeholders. A key challenge

identified is developing methodologies for citizen engagement that integrate new technologies while operating within resource constraints to ensure effectiveness and long-term sustainability. Additionally, the Copenhagen use case has shown the difficulty of aligning data collection timelines with municipal processes, often delayed by the procurement of external advisors and differing approaches – particularly due to municipal departments' limited interest in adopting a "new paradigm". Despite these challenges, the pilot has revealed greater-than-expected public interest in political participation. Many residents are eager to engage in discussions about the city's future but prefer accessible and time-efficient ways to contribute without becoming deeply involved in formal politics.

Turano & Gerace, IT: Italian pilots faced more challenges than other cases, due to the target community's demographics, which are predominantly older with limited digital and data literacy. Thus, a key challenge was building capacity within the community to effectively use the provided tools and to interpret the data collected through the CO activities. This pilot demonstrated that reliance on expert support throughout all stages of the process is absolutely essential to ensure meaningful participation and data utilisation. Also, constant interaction and communication with local communities to identify and align activities with the most pressing concerns and motivations proved to be essential for engagement consistency and deeper commitment. This sustained interaction equally affected the readiness to participate and fostered a stronger responsibility among participants, as the issues addressed are directly relevant to their everyday lives.

4.5 Reflections on participant profiles and participatory readiness

While each pilot area implemented tailored engagement strategies, a cross-cutting analysis reveals important differences in profiles, motivations, and readiness of participants across contexts. In more mature pilots such as North Brabant and Bristol, citizens were already involved in community or civic initiatives (e.g., Fietsersbond, school programs), which facilitated recruitment and sustained participation. These groups had higher digital and organizational readiness and required minimal support to use GREENGAGE tools. In contrast, Italian pilots faced challenges due to older and less digitally literate participants, requiring hands-on facilitation and social incentives. This highlights the need for inclusive governance models that consider participants diversity in demographics, digital skills, and prior civic involvement. Motivations also varied widely: from climate and mobility concerns (Copenhagen), to improving daily commuting experiences (North Brabant), to heritage preservation (Italy). These intrinsic motivations played a key role in participants' motivation and interest retention. However, ensuring that participants understood how their input would influence decisions remained a shared challenge across pilots. Ultimately, participatory governance in COs depends not only on tools and methodologies, but on the alignment between participant capabilities, expectations, and the governance structures in place. Future GREENGAGE phases will explore more systematic ways to match engagement strategies with local conditions and to create clearer pathways from participation to impact.

5 LESSONS LEARNED & FUTURE DIRECTIONS

As noted at the outset, GREENGAGE project adopts a reflexive approach that is used to derive recommendations for public authorities as well as the general public, highlighting crucial aspects of designing and managing COs, including methodological frameworks, digital tools, data use and validation, piloting, governance, evaluation, and impact assessment. These recommendations can be summarised across several critical dimensions, derived from the insights gathered across individual pilots:

- Methodological Framework: The situational scoping framework requires a context-sensitive, inclusive, and iterative approach that empowers local authorities to collaboratively develop customised solutions that address specific community needs. Central to this process is effective communication, which ensures that all stakeholders are engaged and informed, fostering a clear and collaborative development of customised solutions.

- Governance & Policy: Innovation in governance must be grounded in the unique challenges of each neighbourhood, district, city, or region where COs are situated. While existing models provide some guidance, it is essential for local partners to actively engage in experimentation and collective learning, tailoring solutions to the unique context and dynamics of their specific environment.

- Public/Stakeholder Engagement: Understanding stakeholder motivations is crucial for the success of COs. COs must offer adaptable engagement pathways that go beyond mere data collection, fostering

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deeper involvement. Continuous dialogue is key to ensuring that stakeholder expectations are aligned, especially when navigating the complexities and limitations of policy frameworks.

- Pilot Readiness & Data Governance: Iterative co-design strengthens usability and builds trust, while scalable technologies enhance adaptability across diverse contexts. Transparent data workflows and interoperability are essential for ensuring accessibility and encouraging broad engagement. A well-structured data management plan ensures clarity in managing the entire data lifecycle, ensuring consistency and transparency throughout the process. Given the challenge of diverse levels of digital and data literacy at the pilot areas, the approach needs to be adapted to the local capabilities and needs.

- Training & Capacity Building: Engaging training methods, such as storytelling and visual aids, empower non-technical audiences by making complex concepts more accessible. Online platforms like the GREENGAGE Academy support continuous learning, while feedback mechanisms help refine and improve training effectiveness. Given the challenge of building capacity to interpret data collected by Citizen Observatories, collaboration with the scientific community can play a crucial role in enhancing understanding and providing expert support for data analysis and interpretation.

- Piloting & Experimentation: Iterative piloting helps refining tools and methodologies while effectively managing participant expectations, having solutions evolve based on real-world feedback. The use cases should be closely aligned with socio-political needs, integrating diverse dimensions such as cultural, economic, and environmental, to achieve impactful results.

- Evaluation & Impact Assessment: Defining measurable KPIs, such as evaluating the usability of provided solutions (digital tools) and assessing their impact, particularly in terms of innovation in governance, remains a challenge. This process requires a combination of quantitative and qualitative approaches. Simplifying assessment methods enhances evaluation clarity, focusing on practical applicability and ensuring that outcomes are both actionable and meaningful.

6 CONCLUSION

This paper introduces the GREENGAGE framework as a concrete example of how participatory approaches within Citizen Observatories can foster evidence-based decision-making. By utilising collaborative tools and methodologies, the GREENGAGE framework enables communities to actively engage with and address local urban/rural challenges, ensuring that solutions are not only relevant but also tailored to the specific needs and priorities of each context. While there are similarities across pilots, it is important to acknowledge that each observatory has a unique governance structure and diverse needs. Citizens' engagement can be workshop-based, targeting specific groups such as school children, minority communities, and employees, or sensor-based data collection, such as mobile air quality sensors. These co-creation and co-design processes help refine the technology, improve its accessibility, and enhance participant adoption. Our approach not only highlights the potential of citizen-driven initiatives to create more sustainable and responsive urban environments, but also draws attention to the challenges and limitations that can arise in their implementation, offering valuable insights for future initiatives. Ultimately, the GREENGAGE project is laying the groundwork for full-scale deployment of the Citizen Observatories.

7 ACKNOWLEDGEMENT

8 REFERENCES

ASADZADEH, A., Fekete, A., Khazai, B., Moghadas, M., Zebardast, E., Basirat, M., Kötter, T. (2023). Capacitating urban governance and planning systems to drive transformative resilience. Sustainable Cities and Society, 96, 104637. https://doi.org/10.1016/j.scs.2023.104637

ATMOTUBE 2025. Available online: https://atmotube.com/

AVOYAN, E. (2023). Collaborative Governance for Innovative Environmental Solutions: Qualitative Comparative Analysis of Cases from Around the World. Environmental Management 71, 670–684. https://doi.org/10.1007/s00267-022-01642-7

BAUD, I., Jameson, S., Peyroux, E., Scott, D. (2021). The urban governance configuration: A conceptual framework for understanding complexity and enhancing transitions to greater sustainability in cities. Geography Compass, 15(5), e12562. https://doi.org/10.1111/gec3.12562

BROTO, V.C. (2021). The European Green Deal and the challenge of systemic change in urban areas, in: Towards a European Green Deal with Cities. The urban dimension of the EU's sustainable growth strategy. Eds. H. Abdullah, et al. Monografia CIDOB nº 80.

BUTLER, C.W., Hamli, I., Richardson, M., Lowe, M., Fox, R. (2024). Connection for conservation: The impact of counting butterflies on nature connectedness and wellbeing in citizen scientists. Biological Conservation, 110497. In Press, Corrected Proof. https://doi.org/10.1016/j.biocon.2024.110497

COLLABORATIVE ENVIRONMENT (2025). Available online: https://greengage-project.github.io/Documentation/tools/collaborativeEnvironment/

COMMONPLACE 2025. Available online: https://www.commonplace.is/

DING Y., Xiong L., Ji F., Lu J., Zhu X., Huang H. (2022). Using citizen science data to improve regional bird species list: A case study in Shaanxi, China. Avian Research, 13, 100045. https://doi.org/10.1016/j.avrs.2022.100045

FIETSERSBOND 2025. Available online: https://www.fietsersbond.nl/

GREENGAGE 2025. Available online: https://www.greengage-project.eu/

GREENGAGE app 2025. Available online: https://play.google.com/store/apps/details?id=com.greengage.project

GREENGAGE Documentation 2025. Available online: https://greengage-project.github.io/Documentation/

HAKLAY, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., and Vohland, K. (2021). What is citizen science? The challenges of definition, in: The science of citizen science. Eds. K. Vohland, et al. (Cham, Switzerland: Springer), 13–34. https://doi.org/10.1007/978-3-030-58278-4

HÖLSCHER, K., Frantzeskaki, N., McPhearson, T., Loorbach, D. (2019). Capacities for urban transformations governance and the case of New York City. Cities, 94, 186-199. https://doi.org/10.1016/j.cities.2019.05.037

KESERU, I., Wuytens, N., & Macharis, C. (2019). Citizen observatory for mobility: A conceptual framework. Transport Reviews, 39(4), 485–510. https://doi.org/10.1080/01441647.2018.1536089

LIU, HY., Grossberndt, S., Kobernus, M. (2017). Citizen Science and Citizens' Observatories: Trends, Roles, Challenges and Development Needs for Science and Environmental Governance. In: Foody, G., See, L., Fritz, S., Mooney, P., Olteanu-Raimond, AM., Fonte, CC., Antoniou, V. (eds.). Mapping and the Citizen Sensor, pp. 351–376. London: Ubiquity Press. https://doi.org/10.5334/bbf.o

MAHAJAN, S., Chung, MK., Martinez, J., Olaya, Y., Helbing, D., Chen, LJ. (2022). Translating citizen-generated air quality data into evidence for shaping policy. Humanities and Social Science Communication, 9, 122. https://doi.org/10.1057/s41599-022-01135-2

MINDEARTH app 2025. Available online: https://play.google.com/store/apps/details?id=ch.mindearth.mindviewgreengage

MINISTERIE VAN KONINKSRIJKRELATIES (2024). Available online: https://wetten.overheid.nl/BWBR0037885/2024-01-01

MODE Software Library 2025. Available online: https://www.ait.ac.at/en/solutions/sensing-travel-behavior/mode

NPRR (2024). Available online: https://www.governo.it/en/approfondimenti/italia-domani-national-recovery-and-resilience-plan

O'GRADY, M., O'Hare, G., Ties, S., Williams, J. (2021). The Citizen Observatory: Enabling Next Generation Citizen Science. Business Systems Research Journal, 12(2), 221-235. https://doi.org/10.2478/bsrj-2021-0029

PAPPERS, J., Keserü, L., & De Wilde, L. (2022). Evaluating citizen science data: A citizen observatory to measure cyclists' waiting times. Transportation Research Interdisciplinary Perspectives, 14, 100624. https://doi.org/10.1016/j.trip.2022.100624

PETER, M., Diekötter, T., Höffler, T., Kremer, K. (2021). Biodiversity citizen science: Outcomes for the participating citizens. People and Nature, 3(2), 294-311. https://doi.org/10.1002/pan3.10193

RATHNAYAKE, C., Joshi, S., & Cerratto-Pargman, T. (2020). Mapping the current landscape of citizen-driven environmental monitoring: a systematic literature review. Sustainability: Science, Practice and Policy, 16(1), 326–334. https://doi.org/10.1080/15487733.2020.1829845

ROCHA MENOCAL, A., Power, G., Kaye, O. (2019). Promoting Inclusive Governance More Effectively: Lessons From the Dialogue for Stability Programme. Journal of Peacebuilding & Development, 14(1), 84-89. https://doi.org/10.1177/1542316619835121

SUPERSET 2025 (for GREENGAGE). Available online: https://superset.greengage-project.eu

TONNE C, Adair L, Adlakha D, Anguelovski I, Belesova K, Berger M, Brelsford C, Dadvand P, Dimitrova A, Giles-Corti B, Heinz A, Mehran N, Nieuwenhuijsen M, Pelletier F, Ranzani O, Rodenstein M, Rybski D, Samavati S, Satterthwaite D, Schöndorf J, Schreckenberg D, Stollmann J, Taubenböck H, Tiwari G, van Wee B, Adli M. Defining pathways to healthy sustainable urban development. Environ Int. 2021 Jan;146:106236. doi: 10.1016/j.envint.2020.106236. Epub 2020 Nov 5. PMID: 33161201.

YEVENES, M. A., Pereira, H., Bermudez, R. (2022). Citizen Science as a Co-Creative Measure to Water Quality: Chemical Data and Local Participation in a Rural Territory. Frontiers in Environmental Science, 10, 940778. https://doi.org/10.3389/fenvs.2022.940778

VAUGHN, L. M., & Jacquez, F. (2020). Participatory research methods – choice points in the research process. Journal of participatory research methods, 1(1). https:// / doi.org/ 10.35844/ 001c.13244