Evaluating the Socio-economic Impact of Citizen Science: Lessons from 54 European Environmental Initiatives for Urban and Regional Policy

Andrea Sarcina(✉), Claudia Amadei, Franco Corti, Chiara D'Alpaos, and Luciano Greco

University of Padova, Padova, Italy
{andrea.sarcina,claudia.amadei,franco.corti,chiara.dalpaos,luciano.greco}@unipd.it

Abstract. Citizen science (CS) initiatives are increasingly recognised as valuable contributors to environmental monitoring, urban governance, and regional planning. Yet their potential to inform public decision-making is undermined by a persistent evaluation deficit: most projects lack standardised frameworks for assessing their socio-economic impact. This paper presents an empirical analysis of 54 European CS projects drawn from the European Commission's Joint Research Centre inventory of citizen science activities for environmental policies. We examine the extent to which these initiatives adopt socio-economic evaluation methodologies, their documented policy uptake, and their survival beyond initial funding periods. Our findings reveal that half of the analysed projects reported no impact assessment whatsoever, and among those that did, methodological fragmentation (spanning survey-based evaluations, indicator frameworks, and cost-benefit analyses) prevents meaningful cross-project comparison. Despite 65% of projects declaring policy relevance, actual documented policy uptake remains limited. Notably, projects that conducted impact assessments were more likely to continue operating after their initial funding period. These findings have direct implications for urban and regional planning, where the integration of citizen-generated data into decision support systems requires evaluable and comparable evidence. We situate our analysis within recent developments in CS-policy integration and propose directions for standardised evaluation approaches tailored to urban and regional contexts.

Keywords: Citizen science · Impact assessment · Cost-benefit analysis · Urban planning · Environmental policy · Socio-economic evaluation

1 Introduction

Citizen science (CS), the active involvement of non-professional scientists in research activities, has grown substantially over the past two decades, particu-

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2027
O. Gervasi et al. (Eds.): ICCSA 2026 Workshops, LNCS 16762, pp. 533–549, 2027.
https://doi.org/10.1007/978-3-032-30524-4_33

larly in the environmental domain. European initiatives have engaged citizens in monitoring air quality, tracking biodiversity, and assessing flood risk, among other activities, generating datasets that complement and sometimes provide a greater coverage than those produced by institutional monitoring networks. This growth has been accompanied by rising expectations that CS projects will inform public decision-making at urban and regional levels, contributing to sustainable development goals and evidence-based governance [2,18].

Recent evidence confirms that demand for citizen-generated data in policy contexts is increasing. Callaghan et al. [6] analysed over 1,300 environmental impact statements produced under the US National Environmental Policy Act, finding that 40% incorporated CS data in 2022, compared with just 3% in 2012. At the European level, CS data now contributes to approximately 68% of Global Urban Monitoring Framework indicators [17]. In spatial planning specifically, CS has been shown to instigate behavioural change, cultivate trust towards scientific evidence and policies, and enhance the democratic legitimacy of planning decisions [9].

Yet this growing demand encounters a significant supply-side bottleneck. Despite the proliferation of CS initiatives, the majority do not adopt standardised frameworks for evaluating their socio-economic impact. The absence of such evaluation hinders their capacity to continue their operations and attract funding for the production of comparable evidence [24]. For urban and regional planners seeking to integrate CS into decision support systems, this evaluation deficit represents a fundamental obstacle: without reliable, standardised impact assessments, CS projects cannot be meaningfully compared, aggregated, or incorporated into evidence-based planning processes.

This paper addresses this gap through a qualitative analysis of 54 European CS projects selected from the European Commission's Joint Research Centre (JRC) inventory of citizen science activities for environmental policies [15]. We examine: (1) the extent to which these projects adopt socio-economic evaluation methodologies; (2) the nature and comparability of the evaluation approaches employed; (3) the degree of policy uptake achieved; and (4) the relationship between impact assessment practices and project sustainability beyond initial funding. Our analysis contributes to the understanding of how evaluation practices in CS projects relate to their capacity to provide reliable inputs for urban and regional policy-making.

The remainder of this paper is organised as follows. Section 2 reviews the literature on economic evaluation of CS and its relevance to urban and regional planning. Section 3 describes our data and methods. Section 4 presents the findings across four dimensions: project characterisation, evaluation practices, policy uptake, and post-funding survival. Section 5 discusses the implications and Sect. 6 concludes.

2 Theoretical Background

This section reviews the conceptual and methodological literature that frames the analysis, focusing on definitions of citizen science, approaches to socio-

economic evaluation, and the relevance of these debates to urban and regional policy.

2.1 Citizen Science: Definitions and Impact Dimensions

While no single definition of CS has achieved universal acceptance (Haklay et al. [13] identify over thirty in the academic and policy literature), common features include the participation of non-professional scientists in research activities conducted under the direction of trained researchers, typically involving data collection, analysis, or interpretation. Importantly, not all definitions agree on the voluntary nature of participation, a point with direct consequences for the economic assessment of such projects.

The impacts of CS projects span multiple dimensions. Following Wehn et al. [24], these can be organised into five categories: *environmental* (effects on natural systems), *social* (community building, individual empowerment), *scientific* (knowledge production, data generation), *economic* (financial sustainability, value creation), and *political/governance* (policy influence, civic participation). This multi-dimensionality hinders evaluation, as different impact types require different assessment methodologies and data.

2.2 Economic Evaluation Methodologies

The economic evaluation of CS projects can draw on several established methodologies, each with distinct strengths and limitations [19,21]. *Cost-effectiveness analysis* (CEA) computes the cost per unit of a non-monetary outcome (e.g., cost per data observation), offering comparability within projects using the same indicator but not across projects employing different ones. *Cost-benefit analysis* (CBA), grounded in welfare economics, monetises all costs and benefits, enabling cross-project comparison but requiring extensive data and often contentious monetisation of non-market goods such as health improvements or environmental quality [10]. *Multicriteria analysis* (MCA) accommodates qualitative alongside quantitative dimensions, but produces context-dependent results that resist aggregation [20]. *Return on investment* (ROI), while computationally simple, is limited to projects with identifiable financial returns and lacks time-adjustment [3].

The European Union's CBA guidelines for investment projects [10] provide a standardised framework for cost and benefit identification, discounting, and sensitivity analysis. However, CS projects present specific challenges for CBA: the prevalence of non-market benefits (e.g., increased environmental sensitivity, community cohesion), the difficulty of attributing outcomes causally to project activities rather than confounding factors [12], and the limited availability of data for monetisation. The cost dimension is arguably more tractable, with Alfonso et al. [1] estimating CS data collection costs between €37 and €300 per observation; it is the benefit side that remains largely ad hoc.

The literature proposes several techniques for benefit quantification, including influence in scientific literature [23], environmental attitude measurement [7,16], community monitoring frameworks [8], and data complementarity assessment [1]. Yet these remain fragmented, with researchers often developing bespoke metrics rather than building on existing instruments [22]. The OECD's recent assessment confirms that standardised evaluation guidelines for CS remain absent at the policy level, though six key success factors (funding, legal frameworks, institutional culture, capacity building, infrastructure, and societal dialogue) have been identified as prerequisites for effective integration of CS into research and governance systems [18].

2.3 Citizen Science and Urban/Regional Policy Integration

The relevance of CS to urban and regional planning has been the subject of growing scholarly attention. Beck and Mitkiewicz [2], in a systematic review of 94 studies, identify CS as a tool for fostering sustainable cities and data-driven decision-making, although its integration with policy processes remains an underdeveloped research area. Similarly, Bonhoure et al. [5] highlight the potential of CS to address the complexity of sustainable urban development, while emphasising gaps in the inclusion of underserved communities and in policy integration. Goosse et al. [9], analysing 22 Belgian and Dutch cases, find that CS can strengthen the social relevance and democratic legitimacy of spatial planning decisions, but only when evaluation mechanisms are in place to demonstrate outcomes to decision-makers.

The role of CS in policy can be conceptualised along four dimensions [14]: as a source of information for policymaking, as an object of research policy, as a policy instrument, and as a form of sociotechnical governance. For urban and regional planning, the first dimension is most immediately relevant: CS projects that produce evaluable, comparable evidence can serve as decision support systems for sustainable development, environmental monitoring, and participatory governance. However, the absence of standardised evaluation frameworks fundamentally constrains this potential.

3 Methodology

This section describes the empirical basis of the study and the analytical choices used to examine the selected projects, including the data source, selection criteria, and variables of interest.

3.1 Data Source and Selection Criteria

The empirical basis for this analysis is the European Commission Joint Research Centre's dataset "An inventory of citizen science activities for environmental policies" [15]. The dataset originates from a study developed by Bio Innovation Service (FR) in collaboration with Fundación Ibercivis (ES) and The Natural

Table 1. Variables used for project screening and analysis. Source: authors' elaboration based on the JRC inventory [15].

Variable	Description	Source
Geographical extent	Projects classified as at least "macro-regional".	JRC inventory
Start year	Projects starting in 2007 or later.	JRC inventory
Documentation availability	Excluded inactive, undocumented, or non-English cases.	Authors' screening
Project objectives/thematic focus	Used to define the substantive scope of each initiative.	Project documentation
Stakeholder involvement	Main actor groups engaged in project activities.	Project documentation
Policy uptake/involvement of public actors	Evidence of public authority participation, policy outputs, or documented uptake.	Project documentation
Post-funding survival	Continuation, partial continuation, or no evidence/not ascertainable.	Websites and follow-up traces
Impact assessment methodology	None, survey-based, indicator-based, cost-benefit analysis, or mixed.	Deliverables, reports, and articles

History Museum (UK), and documents 503 CS projects of relevance to environmental policy and the United Nations Sustainable Development Goals, providing descriptive information on project topics, dates, geographical extent, countries of implementation, policy aims, and SDG contributions.

To select projects comparable in scale and scope, we applied two screening criteria. First, geographical extent was restricted to at least "macro-regional", ensuring sufficient scale for policy relevance. Second, a start year of 2007 was set as a baseline to ensure comparability of technological solutions. These criteria reduced the sample to 126 projects. A further restriction based on the availability of relevant documentation (excluding projects with inactive websites, unavailable deliverables, or non-English documentation) yielded a final sample of 54 projects. The substantial attrition from 126 to 54 is itself a noteworthy finding, suggesting either poor survival rates or limited attention to documenting impact.

3.2 Variables of Interest and Analytical Approach

For each selected project, a documentary analysis of public deliverables, scientific articles, and project websites was conducted to identify the variables reported in Table 1.

These variables were chosen to capture multiple dimensions of CS project impact relevant to urban and regional policy: the objective defines the scope for evaluation; stakeholder involvement indicates the breadth of engagement;

policy uptake signals relevance to governance; post-funding survival indicates long-term viability; and evaluation methodology reflects the project's capacity to produce comparable evidence. The analysis is limited by its reliance on publicly available documentation; projects may have conducted evaluations that were not published or accessible.

4 Results

This section presents the findings of the analysis, moving from the overall characterisation of the selected projects to their evaluation practices, policy uptake, and post-funding sustainability.

4.1 Characterisation of Selected Projects

The 54 selected projects display heterogeneity across several dimensions. Table 2 presents the full list of analysed projects, reporting duration, whether a publicly available impact assessment was identified (IA), the continuation status after the initial funding period (Cont.), and thematic domain. Projects marked with an asterisk are the illustrative cases discussed more explicitly in the text and were selected through a maximum variation sampling strategy [25] to ensure representation across three key dimensions: (i) impact assessment status (projects with and without documented evaluation), (ii) post-funding continuation outcomes (full continuation, partial continuation, and cessation), and (iii) thematic domains (spanning water management, air quality, biodiversity, road sustainability, humanitarian mapping, and others).

Regarding policy relevance, out of the 54 projects, 43% held relevance in the field of policy monitoring or implementation, 33% in problem definition, 15% in early warning, and 9% in policy evaluation. This distribution suggests that CS projects predominantly serve as input providers to existing or emerging policies, rather than contributing to the formulation of new ones, a finding with direct implications for their role in urban and regional planning cycles, where the demand is precisely for evidence that can support monitoring, assessment, and iterative adjustment of planning decisions.

The temporal distribution reveals a pronounced spike in 2016, with 20 of the 54 projects starting that year, likely linked to the implementation of the Horizon 2020 programme and its dedicated actions on societal challenges, green development, and citizen engagement. The publication of the Green Paper Citizen Science Strategy 2020 for Germany in the same year further illustrates the growing institutional recognition of CS during this period. The most common type of project initiator is academia (52%), followed by consortia of both public and private entities (22%), governmental organisations (13%), non-governmental organisations (7%), and private organisations (6%). The dominance of academic initiators is relevant to the evaluation question: academic-led projects might be expected to have greater potential for rigorous assessment, yet even within this group, evaluation practices were inconsistent.

Table 2. Complete list of 54 CS projects analysed. Projects marked with an asterisk are the illustrative cases discussed more explicitly in the text. IA = Impact Assessment (Y/P/N); Cont. = Continuation (Y/P/N/A). Source: authors' elaboration based on JRC inventory [15].

Project	Duration	IA	Cont.	Domain
AirSensEUR	2016–19	N	P	Air quality
∗ BEWATER	2014–17	Y	Y	Water
∗ BigPicnic	2017–	Y	P	Food security/RRI
BioVill	2016–	Y	P	Sustainable consumption
∗ BlueSCities	2017–	N	P	Water/waste integration
CAPSELLA	2016–	Y	P	Biodiversity
CAPTOR	2016–	Y	P	Air quality
CASI	2014–17	P	P	Climate
∗ CITCLOPS	2014–	Y	P	Coastal monitoring
∗ CITI-SENSE	2012–	Y	P	Environmental sensing
∗ Cities at Night	2014–	N	Y	Light pollution mapping
∗ COBWEB	2012–	Y	Y	Crowdsourcing platform
COST Action Citizen Sensor	2012–	N	P	Land monitoring
∗ Crowd4Roads	2016–	Y	Y	Road sustainability
D-NOSES	2018–	N	P	Air quality
Decarbonet	2013–16	Y	P	Sustainable consumption
ENABLE.EU	2016–	Y	P	Sustainable consumption
EU BON	2012–	N	P	Biodiversity
EuroBirdPortal	2016–	Y	P	Biodiversity
FoodSmartphone	2017–	N	P	Resource efficiency
∗ GAP2	2011–15	Y	P	Fisheries governance
Greenmapper	2016–	N	P	Land monitoring
Ground Truth 2.0	2016–	Y	P	Biodiversity
∗ GROW	2016–	N	Y	Soil/water monitoring
∗ hackAIR	2015–	Y	Y	Air quality platform
Hercules Landscapes	2013–	N	P	Biodiversity
∗ Humanitarian OSM	2010–	N	Y	Humanitarian mapping
I-REACT	2016–	Y	P	Cross-cutting
ICARUS	2016–	N	P	Air quality
InSPIRES	2017–	Y	P	Environmental health
INTAROS	2017–	N	P	Sustainable consumption
∗ INTERACT	2010–16	N	Y	Arctic monitoring
ISABEL	2015–	N	P	Resource efficiency
iSCAPE	2016–	Y	P	Air quality

(*continued*)

Table 2. (*continued*)

Project	Duration	IA	Cont.	Domain
∗ iSpot	2008–	N	Y	Biodiversity observation
Landsense	2016–	N	P	Land monitoring
LIFE AskREACH	2017–	N	N/A	Environmental health
LIFE EUROLARGECARNIVORES	2017–	Y	N/A	Biodiversity
NETLAKE	2012–16	N	P	Water
∗ Noise Tube	2008–	Y	Y	Noise monitoring
Omniscientis	2012–14	N	P	Air quality
PERARES	2010–14	Y	P	Cross-cutting
PERSEUS	2011–	P	P	Sustainable consumption
∗ POWER	2015–	Y	Y	Water awareness
PROSO	2016–18	N	P	Sustainable consumption
SAF21	2015–	N	P	Sustainable consumption
Scent	2016–	N	P	Land monitoring
SeaChange	2015–	Y	P	Biodiversity
∗ STARS4ALL	2016–	N	Y	Dark sky preservation
Vespa Velutina	2016–	Y	Y	Biodiversity
Waste4Think	2016–	Y	P	Waste management
Water Shrew Survey	2017–	N	Y	Biodiversity
∗ WeObserve	2017–	Y	Y	CS mainstreaming
Women for Water Partnership	2016–	Y	Y	Sustainable consumption

4.2 Impact Assessment Practices

The most striking finding is that half of the analysed projects did not report any impact assessment or, if conducted, did not publicly share results. This finding is consistent with the barriers identified in the literature, including the mismatch between project durations and the longer-term nature of impact materialisation, limited resources for evaluation, and the absence of standardised methodologies [24]. For urban and regional planning, this means that roughly half of the potential CS evidence base is entirely invisible to decision-making processes.

Among the remaining 27 projects, three main evaluation approaches were identified, along with one mixed methodology case. The distribution of these approaches (expressed below as percentages of the total 54 projects to convey the scale of each category relative to the full sample) is itself revealing of the methodological fragmentation that characterises the field.

Survey-Based Evaluation. Approximately 19% of the sampled projects (10 initiatives) relied on questionnaires administered to end users, project partners, or external experts. These surveys typically assessed progress towards project

objectives, strengths and weaknesses of developed solutions, and user acceptance. Evaluation forms were dispensed on various occasions, including thematic events and workshops, and were sometimes complemented by structured and semi-structured interviews.

Two distinct orientations were observed. First, evaluation forms have been administered to project partners, advisory board members, or external experts, aimed at assessing progress towards objectives, sometimes at different implementation stages, yielding recommendations and good practices. Second, forms have been administered to end users, aimed at evaluating the acceptance of solutions developed during pilot implementation, including feedback on perceived environmental, social, and economic impacts.

Survey-based evaluation yields project-specific results that are difficult to compare across projects. In anonymised project #1, CS was combined with collaborative learning and environmental grassroots activism through a generic questionnaire tailored to each pilot's specific needs. The resulting data captured perceptions of CO_2 reduction, awareness of cultivation methodologies, and economic impacts such as agricultural income and job creation, but the format remained unique to that project.

Impact Indicator Evaluation. Another 19% of the sample (10 projects) employed quantitative and qualitative indicators to assess multi-dimensional impact. Two sub-approaches were observed within this category.

Projects in the first sub-category defined ad hoc key performance indicators (KPIs) aligned with their specific objectives. This tailor-made approach produces indicators highly specific to the project's activities but lacking in comparability and replicability. Examples include the availability of project deliverables, the number of conferences organised, and the capacity of citizens to influence policies on project-specific topics.

Projects in the second sub-category drew on established frameworks, most notably the Impact Assessment for Social Innovation (IA4SI) methodology [4], developed within the Collective Awareness Platforms for Sustainability (CAPS) domain. Three of the ten projects in this category adopted the IA4SI framework, selecting from its vertical indices those that aligned with their foreseen impact areas. Table 3 presents a representative set of indicators from one anonymised project, illustrating the range of measurable dimensions across social, environmental, economic, and political areas.

The anonymised project #2, focused on air quality awareness and forest fire probability, combined IA4SI-derived indices with project-specific indicators and behavioural change experiments. The most prominent behavioural impacts were recorded in terms of citizen empowerment in local policy definition, perceived and actual knowledge of air pollution, and soft mobility behaviour. While this approach offers greater structure than pure survey-based evaluation, the selective adoption of framework elements still limits full comparability across projects.

Cost-Benefit Analysis. Only six projects (approximately 11%) adopted formal CBA frameworks. This low uptake is significant given that CBA is the methodology most suited to inform allocation decisions and enable cross-project comparison of socio-economic returns, precisely the evidence that urban and regional planners require.

The projects that did employ CBA shared a common feature: clear-cut definitions of expected impact areas and identifiable benefits, including health improvements from better environmental conditions and avoided costs from reduced disaster risk. Project implementation costs were generally tractable through accounting records and internal investigations with partners, covering both investment costs (capital expenditure for solution development) and estimated running costs (maintenance, based on partner expectations).

Benefit estimation, by contrast, required substantially greater methodological effort. Benefits were typically framed either as positive gains (e.g., health improvements from better air quality) or as avoided costs (e.g., reduced life risks, averted infrastructure damage from flooding). The anonymised project #3, focused on emergency management and flood risk, defined a CBA case at the national level of one pilot country, collecting information through interviews, working sessions, and stakeholder consultations to define costs (CapEx, OpEx, disaster damages) and benefits (social benefits, avoided costs from system adoption).

The difficulty of monetising non-market benefits (such as increased environmental sensitivity, community cohesion, or civic participation) remains the principal barrier to wider CBA adoption in CS [11]. This challenge is compounded by the externality problem: many CS benefits operate outside market mechanisms, requiring estimation techniques (stated-preference surveys, revealed-preference methods, value transfer) that add complexity and cost to the evaluation process [10].

Mixed Methodology. One project adopted a distinctive approach, combining multiple evaluation strands tailored to different solution types. For passive environmental control systems and behavioural change interventions, economic methods from the literature (hedonic pricing, meta-analysis) were deployed to estimate health-related benefits from air quality improvements. For policy-related interventions, living labs, and CS activities, MCA-based indicators were used to capture predominantly social impacts on quality of life. This modular approach, while sophisticated, further illustrates the field's tendency towards bespoke solutions that resist standardisation.

4.3 Policy Uptake

Thirty-five of the 54 projects either mention policy aims in their documentation, issue recommendations or policy briefs, or involve public authorities in project activities. While a third of the initiatives reported not having a declared policy aim, all projects were nonetheless classified as having some form of policy

relevance in the JRC inventory, distributed as noted in Sect. 4.1. This seems to ascribe to CS projects a role limited to providing inputs to already existing or emerging policies, rather than contributing to the formulation of new ones.

However, the actual documented uptake of results by local or regional authorities is very limited, despite these stated ambitions. Three principal barriers were identified from the project documentation:

First, *limited trust in citizen-provided data* on the part of public authorities. Several projects reported resistance from decision-makers who perceived citizen-generated data as less reliable than data from established institutional monitoring networks. This trust deficit is particularly relevant for urban planning contexts, where data quality requirements for regulatory decisions are stringent.

Table 3. Representative impact indicators from an anonymised project, based on the IA4SI framework [4].

Impact Area	Dimension	Indicator Examples
Social	Community building	Number of platform users (start vs. end); degree of communication
	Information access	Perceived improvement in information access; influence on information asymmetries
	Behavioural change	Number of engagement participants; change in opinion and awareness
Environmental	Environmental behaviour	Compensation activities since engagement
	Sensitivity	Capacity to increase users' sensitivity towards pollution
Economic	Empowerment	Impact on entrepreneurship and access to finance
Political	Civic participation	Increase in grassroots organisations; participation in campaigns

Second, *institutional reticence to depart from traditional paradigms*. Public authorities were recorded as reluctant to adopt systems perceived as less mature and "experimental", preferring established data collection methods even when CS alternatives offered broader spatial or temporal coverage.

Third, *insufficient project duration* to document actual policy influence. The timeline of most projects (typically two to four years) does not align with the longer cycles of urban and regional policy development, making it difficult to trace the pathway from project outputs to policy adoption.

The most notable exception involved a project that successfully influenced new legislation and licensing activities, directly attributable to the systematic involvement of local authorities in all phases of its demonstrators. While collaboration with public authorities is beneficial, as it shapes project activities to align

with public needs, this does not automatically imply policy translation. The lesson for urban and regional planning is that CS-policy integration requires deliberate institutional design, embedding public authorities as co-creators rather than passive recipients of project outputs.

It is also worth noting the role that CS projects can play in the policy cycle beyond direct adoption. Following the typology proposed by Haklay [14], CS may function as a source of information for policymaking, as a policy instrument, or as a form of sociotechnical governance. Our data suggest that most projects in the sample operate in the first mode, generating data and knowledge, but few succeed in transitioning to the second or third modes, where CS actively shapes or constitutes governance processes.

4.4 Post-funding Sustainability

Out of 54 projects, 16 (30%) reported some form of continuation beyond the initial funding period, through mechanisms such as the creation of foundations, the persistence of user communities, or the generation of successor projects. Conversely, nearly half (24 projects) either lacked an active website or showed no evidence of recent updates. The remainder had developed business plans or commercialisation strategies without documented evidence of actual continuation.

A particularly noteworthy finding is that more than half (9 of 16) of the projects that reported continuation had also conducted an impact assessment, a proportion modestly above the sample-wide base rate of 50% (27 of 54). While this correlation does not establish causality, it suggests that the practice of evaluating socio-economic impact may be associated with the development of evidence that supports funding decisions and institutional support for project continuation, a dynamic directly relevant to the long-term integration of CS into urban governance structures.

5 Discussion

Our analysis reveals four interconnected findings with implications for the integration of CS into urban and regional planning.

A Systematic Evaluation Deficit. Half of the analysed CS projects reported no impact assessment. This is not merely an academic gap; it represents a fundamental barrier to the use of CS outputs in evidence-based urban and regional planning. Decision support systems require evaluable inputs; without standardised assessment, CS projects produce data that may be scientifically valuable but remains invisible to planning processes that demand quantified, comparable evidence of costs and benefits.

Methodological Fragmentation. Among the projects that did conduct evaluations, the diversity of approaches (from ad hoc surveys to IA4SI indicators to

formal CBA) prevents meaningful cross-project comparison. This fragmentation echoes the broader finding that CS impact assessment lacks standardised guidelines [18,24]. For urban and regional planners, this means that even when evaluation evidence exists, it cannot be aggregated across projects to inform portfolio-level decisions about CS investment.

A Disconnect Between Policy Ambition and Policy Uptake. While 65% of projects declared policy relevance, actual documented uptake was limited. The barriers identified (institutional distrust, perceived immaturity, short project durations) align with the broader literature on CS-policy integration challenges [2,5]. The contrast with Callaghan et al.'s [6] finding of rapidly growing CS incorporation in environmental impact statements suggests that the bottleneck lies primarily on the supply side: projects are not producing the evaluable evidence that policy processes demand.

Evaluation and Sustainability. The correlation between impact assessment and post-funding survival, while not causally established, suggests that evaluation practices may contribute to project sustainability. Projects that quantify their impact are better positioned to justify continued funding, attract institutional support, and demonstrate value to urban and regional authorities. This is consistent with the OECD's [18] identification of funding and institutional culture as key success factors for CS.

These patterns are not distributed uniformly across project contexts. Projects operating at broader territorial scales and led by academic or multi-actor consortia more often produce formal documentation and declare policy relevance, but this does not automatically translate into documented uptake by public authorities. By contrast, the few cases showing clearer policy influence appear to be those with stronger institutional anchoring and more direct involvement of public actors in project activities. Likewise, post-funding continuation seems more plausible where project outputs remain embedded in an identifiable organisational or territorial setting, rather than depending solely on the lifespan of the original grant.

These findings suggest that the development of standardised, yet flexible, evaluation frameworks for CS, tailored to the specific needs of urban and regional planning contexts, would address multiple gaps simultaneously. We propose that such frameworks should satisfy five requirements:

Multi-dimensionality. The framework must accommodate the environmental, social, scientific, economic, and political dimensions of CS impact, as these are rarely reducible to a single metric. The IA4SI framework [4] offers a useful starting point, but requires extension to incorporate the cost-benefit dimension that European guidelines [10] require and that planning practitioners need to justify resource allocation decisions.

Comparability. Outputs should be structured to enable meaningful comparison across projects, regions, and temporal periods. This requires a core set of

common indicators, complemented by domain-specific modules that capture the particularities of different CS applications (e.g., air quality monitoring versus biodiversity mapping).

Resource Efficiency. Given the inherent funding and staffing constraints of CS projects, evaluation methods must be deployable without disproportionate cost. The finding that CBA (while most informative) was adopted by only 11% of projects reflects the heavy data requirements that deter its use. Simplified CBA approaches or cost-effectiveness proxies may offer more practical alternatives for routine evaluation.

Accessibility. Evaluation tools should be usable by non-specialists, reflecting the diverse composition of CS project teams that include academics, community organisations, and citizen volunteers [22]. Template-based approaches, with built-in guidance on data collection and analysis, could lower the entry barrier.

Policy Legibility. Outputs must be formatted and communicated in ways that are interpretable by urban and regional planners, municipal decision-makers, and funding bodies. This means translating multi-dimensional assessments into summaries that can inform portfolio-level decisions about CS investment, for example through composite indices or standardised reporting templates aligned with established planning frameworks such as the Global Urban Monitoring Framework [17].

A further consideration concerns the timing of evaluation. Our analysis reveals that most projects that conduct assessments do so ex post, typically at or near the end of the funding period. Yet the European CBA guidelines [10] emphasise the value of ex ante evaluation for allocation decisions. An integrated approach, combining ex ante assessment at the planning stage with ex post evaluation for accountability and learning, would better serve the needs of urban and regional governance, where both prospective planning and retrospective accountability are required.

6 Conclusions

This paper has presented an empirical analysis of socio-economic evaluation practices across 54 European citizen science initiatives in the environmental domain. Our findings reveal a persistent evaluation deficit that constrains the integration of CS into urban and regional policy-making: half of the projects lacked any reported impact assessment; those that did conduct evaluations employed heterogeneous and non-comparable methodologies, and the gap between declared policy ambitions and documented policy uptake remains substantial.

The contribution of this work is threefold. First, it provides systematic empirical evidence on the state of evaluation practices across a substantial sample of European CS projects, confirming and extending findings from the recent literature [2,24]. Second, it identifies the correlation between impact assessment

and post-funding sustainability, offering a pragmatic argument for evaluation investment. Third, it frames the evaluation deficit specifically in terms of its consequences for urban and regional planning, where the demand for citizen-generated data is growing [6,17] but the supply of evaluable evidence remains inadequate.

A further result is that the implications of citizen science are not uniform across territorial and institutional contexts. Projects operating at broader scales or within structured multi-actor consortia more often produce formal documentation and declare policy relevance, whereas clearer examples of policy uptake tend to emerge in place-based initiatives where public authorities are involved more directly in project activities. Likewise, post-funding continuation appears more plausible when project outputs remain embedded in a specific organisational or territorial setting. This contextual variation helps explain why the same evaluation deficit generates uneven consequences across urban and regional governance contexts.

Our study is subject to limitations. The analysis relies on publicly available documentation and English-language sources, potentially underestimating the evaluation efforts of projects that publish in other languages or do not make their assessments publicly available. The JRC inventory, while comprehensive, reflects a particular point in time (2018) and the CS landscape continues to evolve. The anonymisation of detailed case studies, while necessary, limits the specificity of the methodological examples.

Future work should develop standardised evaluation toolkits for CS projects operating in urban and regional contexts. These toolkits could build on frameworks such as IA4SI [4] while incorporating the cost-benefit dimension called for by the OECD [18] and European guidelines [10]. A further extension of this research would be an exploratory cluster analysis based on variables such as territorial scale, policy relevance, evaluation methodology, stakeholder configuration, and post-funding continuity, in order to identify recurring profiles of citizen science initiatives across different governance contexts. Longitudinal studies tracking the evolution of CS-policy integration, particularly in the context of smart city initiatives and participatory urban governance, would further illuminate the pathways through which citizen-generated evidence enters planning processes.

Acknowledgments. This work was supported by the SOCIO-BEE project, funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101037648. The authors wish to thank the project consortium partners for their contributions to the data collection and analysis.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Alfonso, L., Gharesifard, M., Wehn, U.: Analysing the value of environmental citizen-generated data: complementarity and cost per observation. J. Environ. Manage. **303**, 114157 (2022). https://doi.org/10.1016/j.jenvman.2021.114157
2. Beck, D., Mitkiewicz, J.: A systematic literature review of citizen science in urban studies and regional urban planning: policy, practical, and research implications. Urban Ecosyst. **28**(2), 85 (2025). https://doi.org/10.1007/s11252-025-01693-8
3. Boardman, A.E., Greenberg, D.H., Vining, A.R., Weimer, D.L.: Cost-Benefit Analysis: Concepts and Practice, 5th edn. Cambridge University Press, Cambridge (2018). https://doi.org/10.1017/9781108235594
4. Bellini, F., Passani, A., Klitsi, M., Vanobberghen, W. (eds.): Exploring Impacts of Collective Awareness Platforms for Sustainability and Social Innovation. Eurokleis Press, Rome (2016)
5. Bonhoure, I., Guba, B., Peer, C., Labastida, I., Perelló, J.: Citizen science contributions to sustainable urban transformation, urban sustainability and urban planning: a systematic literature review. Cities **174**, 107056 (2026). https://doi.org/10.1016/j.cities.2026.107056
6. Callaghan, C.T., Winnebald, C., Smith, B., Mason, B.M., López-Hoffman, L.: Citizen science as a valuable tool for environmental review. Front. Ecol. Environ. **23**(1), e2808 (2025). https://doi.org/10.1002/fee.2808
7. Chao, S.-H., Jiang, J.-Z., Wei, K.-C., et al.: Understanding pro-environmental behaviour of citizen science: an exploratory study. Sustainability **13**(9), 5126 (2021)
8. Conrad, C.T., Daoust, T.: Community-based monitoring frameworks: increasing the effectiveness of environmental stewardship. Environ. Manage. **41**(3), 358–366 (2008)
9. Goosse, T., Lamker, C., Devos, T.: The potential benefits of citizen science for spatial planning: an exploratory analysis of 22 Belgian and Dutch cases. Eur. Plan. Stud. **33**(10), 1864–1882 (2025). https://doi.org/10.1080/09654313.2025.2530754
10. European Community: Guide to Cost-Benefit Analysis of Investment Projects: Economic Appraisal Tool for Cohesion Policy 2014–2020. European Union (2015)
11. Ferri, M., Wehn, U., See, L., Monego, M., Fritz, S.: The value of citizen science for flood risk reduction: cost-benefit analysis of a citizen observatory. Hydrol. Earth Syst. Sci. **24**(12), 5781–5798 (2020)
12. Gertler, P.J., Martinez, S., Premand, P., Rawlings, L.B., Vermeersch, C.M.J.: Impact Evaluation in Practice, 2nd edn. World Bank, Washington, DC (2016)
13. Haklay, M., Dörler, D., Heigl, F., et al.: What is citizen science? The challenges of definition. In: Vohland, K., et al. (eds.) The Science of Citizen Science, pp. 13–33. Springer, Cham (2021)
14. Haklay, M.: Citizen science and policy. In: Vohland, K., et al. (eds.) The Science of Citizen Science, pp. 365–381. Springer, Cham (2021)
15. European Commission, Joint Research Centre (JRC): An inventory of citizen science activities for environmental policies. European Commission, Joint Research Centre (JRC) [Dataset] (2018). PID: http://data.europa.eu/89h/jrc-citsci-10004
16. Milfont, T.L., Duckitt, J.: The environmental attitudes inventory: a valid and reliable measure. J. Environ. Psychol. **30**(1), 80–94 (2010)
17. Moorthy, I., Fraisl, D., See, L., Hager, G., Mwaniki, D., Ndugwa, R.P.: Opportunities for citizen science within the global urban monitoring framework. NPJ Urban Sustain. **6**, 2 (2026). https://doi.org/10.1038/s42949-025-00305-w

18. OECD: Embedding citizen science into research policy. OECD Science, Technology and Industry Policy Papers, No. 175. OECD Publishing, Paris (2025). https://doi.org/10.1787/a1cfb1a8-en
19. Philippe, A., Blaney, R., Pocock, M., Jones, G.: Citizen Science and Environmental Monitoring—Final Report. UKEOF (2016)
20. Roy, B.: Decision-aid and decision-making. Eur. J. Oper. Res. **45**(2), 324–331 (1990)
21. Rudmik, L., Drummond, M.: Health economic evaluation: important principles and methodology. Laryngoscope **123**(6), 1341–1347 (2013)
22. Somerwill, L., Wehn, U.: How to measure the impact of citizen science on environmental attitudes, behaviour and knowledge? A review. Environ. Sci. Eur. **34**(1), 18 (2022)
23. Tulloch, A.I.T., Possingham, H.P., Joseph, L.N., Szabo, J., Martin, T.G.: Realising the full potential of citizen science monitoring programs. Biol. Conserv. **165**, 128–138 (2013)
24. Wehn, U., et al.: Impact assessment of citizen science: state of the art and guiding principles for a consolidated approach. Sustain. Sci. **16**(5), 1683–1699 (2021). https://doi.org/10.1007/s11625-021-00959-2
25. Patton, M.Q.: Qualitative Research & Evaluation Methods, 4th edn. Sage, Thousand Oaks (2014)