Deliverable 2.4: Evaluation and Impact Assessment Framework

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Acronym	Open form
CESSDA	Consortium of European Social Science Data Archives
CS	Citizen Science
EOSC	European Open Science Cloud
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
FAIR	Findable, Accessible, Interoperable, Reusable
KPI	Key Performance Indicator
OECD	Organisation for Economic Co-operation and Development
RI	Research Infrastructure
WP	Work Package

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1. Executive Summary

Research Infrastructures (RIs) are recognised as essential enabling structures for scientific excellence and knowledge production. For RIECS Concept, which is developing a roadmap towards a pan-European Research Infrastructure for Citizen Science, evaluation and impact assessment present particular challenges. The envisioned infrastructure operates at the interface of professional research and public participation and does not fit neatly within conventional RI categories.

This deliverable presents the first version of the RIECS Evaluation and Impact Assessment Framework. The draft framework is grounded in the current state of the art in RI evaluation, most notably the ESFRI lifecycle model and its distinction between the Scientific Case and the Implementation Case, as well as the OECD Reference Framework and the RI-PATHS socio-economic impact pathway toolkit. A review of citizen science evaluation literature further informs the proposed approach, drawing on established frameworks for assessing outcomes across scientific, societal, environmental, and governance domains. This is complemented by initial insights from project work in terms of stakeholder engagement and vision building.

Building on this foundation, the deliverable argues that participation fundamentally changes the object of evaluation. Conventional indicator sets that are centred on publications, citations, user numbers, and cost measures are insufficient to capture the systemic, societal, and community value of a participatory research infrastructure. Accordingly, one of the main contributions of this deliverable is the proposal of a third evaluation case, the **Participation Case**, alongside the existing ESFRI cases. This third case captures forms of value that are essential to citizen science infrastructures but insufficiently covered by conventional RI evaluation frameworks including: the quality and transparency of co-created data and validation workflows; inclusive and accessible research interfaces; community stewardship and trust-building between science and society; policy support through citizen-generated evidence; multilingual and cross-cultural accessibility; participatory and inclusive governance; and capacity development across all stakeholder groups. For each dimension, an initial set of key performance indicators and means of verification is proposed.

The framework was further informed by an internal consortium workshop, in which partners critically reflected on the adaptation of ESFRI dimensions to citizen science and identified the need for qualitative evidence, open science practices, collaboration quality, and ecosystem-level effects alongside conventional output metrics.

To complement the indicator layer, the deliverable articulates six interconnected impact visions for RIECS, covering scientific knowledge production, societal participation and inclusion, policy processes, the citizen science ecosystem, capacity development, and long-term sustainability. These visions are mapped against relevant RI-PATHS impact pathways and extended to incorporate participation-specific dimensions such as

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empowerment, recognition, data justice, and community stewardship. A target group analysis specifies expected benefits and forms of uptake for researchers, citizen scientists, policy-makers, funders, technology providers, educators, private-sector actors, and civil society organisations.

As a first iteration, the framework is intended as an evolving structure. It serves as the basis for further exploration on how RI for citizen science can best be assessed, stressing its participatory qualities. The framework will be further refined, tested, and validated during the second half of the project through participatory activities, stakeholder engagement, and empirical feedback.

2. Introduction

Research Infrastructures (RIs) are now widely recognised as key enabling structures for scientific excellence, innovation, and long term knowledge production. In the European context, they are understood as facilities that provide resources and services for research communities, including equipment, data infrastructures, communication networks, archives, collections, computing systems, and associated human expertise[1]. They are expected to be open to external users and to support excellent research and innovation. Depending on their remit, they may also serve education and public services, and they may take the form of single-sited, virtual, or distributed infrastructures (ESFRI 2024). The literature also suggests that RIs should be understood as socio-technical arrangements that become durable through standards, practices, maintenance work, institutional commitments and forms of access. They are relational rather than merely technical, and their value depends on how they support, shape and sometimes constrain knowledge practices across communities (Star & Ruhleder 1996; Bowker et al. 2010; Karasti et al. 2010).

This broad definition already suggests that RIs cannot be evaluated only in narrow technical terms. They require assessment approaches that capture not only scientific quality, but also organisational robustness, access conditions, sustainability, and wider societal relevance (OECD 2019; ESFRI 2020; Kolar et al. 2023). RI evaluation is therefore concerned with quality, maturity, impact, and sustainability. It serves monitoring and accountability purposes, supports strategic management, provides transparency for funders, and enables mutual learning across infrastructures and service providers. At the same time, evaluation is increasingly expected to account also for long term socio-economic value and the openness of research methods and results (OECD 2019; Kolar et al. 2023).

For RIECS, this discussion is especially relevant because the envisioned infrastructure does not fit neatly into conventional categories. RIECS seeks to broaden and connect the current landscape of RIs supporting participatory approaches in science. While this ambition is both distinctive and challenging, it can build on the extensive experience, resources, and

[1]https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/research-infrastructures_en

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practices developed within existing RIs and will necessarily operate in close interaction with them. At the same time, participatory research and citizen science raise specific methodological, organisational, and societal challenges that are not sufficiently captured by conventional scientific evaluation categories and assessment frameworks. In particular, an evaluation and impact assessment framework for RIECS must account for the perspectives and expectations of multiple stakeholder groups, including researchers, citizens, policy-makers, civil society actors, and other socio-political stakeholders. The impact assessment framework therefore needs to address multiple stakeholder perspectives, including those of scientists, citizens, policy makers, and other socio-political stakeholders.

This document provides a review of existing RI evaluation approaches, identifies evaluation gaps for citizen science infrastructures, and presents the first iteration of the RIECS evaluation and impact assessment framework. The proposed framework, presented in Chapter 5, is grounded in the current state of the art in RI evaluation, as discussed in Chapter 3, and is further informed by the perspectives and expertise gathered from consortium partners and stakeholder consultations, presented in Chapter 4. Building on these foundations, the framework provides an initial structure that complements the scientific and implementation case with the RIECS-specific participation case, stressing the participatory and multi-actor nature of the infrastructure while allowing it to integrate with other RIs.

As RIECS develops further, the framework will be continuously refined and validated through its practical application during the second half of the project, concretely in Task T3.6 of the project workplan. Feedback generated through stakeholder engagement activities, participatory workshops, and ongoing collaboration with external actors will be used to test, adapt, and strengthen the proposed approach. This iterative process is intended to ensure that the framework remains responsive to stakeholder needs and capable of capturing the diverse forms of impact emerging from participatory research and citizen science infrastructures.

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3. State-of-the-Art: How to evaluate a Research Infrastructure

The development of an evaluation and impact assessment framework for RIECS should be grounded in the broader state of the art in RI evaluation practices, since many of the underlying challenges are shared with other collaborative scientific infrastructures and distributed research ecosystems. In the following section, we review existing approaches to the RI evaluation and use these insights as the foundation for proposing an advanced evaluation and impact assessment framework tailored to the specificities of RIECS.

3.1. The current state of RI evaluation

Traditional evaluation of RIs has largely borrowed from project and programme evaluation, often following a linear pipeline logic from inputs and processes to outputs, outcomes, and impact. In response to an over- reliance on publication- and citation-based measures, the use of proxy metrics such as downloads and usage data, alongside growing efforts to standardise attribution for datasets, software, and facilities. Yet the field remains methodologically fragmented, partly because infrastructures are referenced inconsistently and their broader societal value is difficult to capture systematically (Mayernik et al. 2017).

RI evaluation therefore still typically relies on standardised, mostly quantitative indicators such as publications, citations, user numbers, training activities, or cost based measures, often complemented by bibliometrics, cost benefit analysis, and case studies. As Zakaria et al. (2021) note, this approach is useful for accountability and comparison, but it tends to treat infrastructures as background inputs rather than as enabling platforms in their own right. As a result, it privileges short-term, easily measurable results over the longer-term and system level contributions of infrastructures (Zakaria et al. 2021).

Against this background, more recent approaches have sought to broaden RI evaluation beyond short-term productivity metrics and linear output models. The OECD Reference Framework is particularly important in this respect, as it shifts attention from performance alone to the scientific and socio-economic impacts of RIs across different phases of their lifecycle. It therefore offers a more differentiated basis for understanding RIs not simply as inputs to research, but as infrastructures that generate multiple, longer-term, and often indirect forms of value (OECD 2019). Similarly, the RI-PATHS project[2] provided a pathway-based framework for assessing the socio-economic impact of RIs. Rather than relying on a single set of metrics, it maps how RI activities generate effects through a series of impact pathways and offers a modular toolkit that can be adapted to different infrastructure types and domains (Catalano 2025). Many of these developments have also been taken up within the ESFRI approach, which has gradually expanded RI evaluation

[2] https://ri-paths-tool.eu/en

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beyond narrow performance measures towards a more multidimensional and lifecycle-sensitive framework. Since ESFRI constitutes the most relevant reference framework for RIECS, it will be outlined in greater detail in the following section.

From a different perspective, Rasmussen et al. (2025) suggest that, in participatory and non-establishment research settings, evaluation must attend not only to outputs but also to infrastructural enabling conditions. These include access to funding, available time, expertise, onboarding, and appropriate organisational structures, since such factors determine whether participation can be sustained and translated into credible research practice (Rasmussen et al. 2025).

In summary, the current state of RI evaluation is characterised by multi-dimensional, hybrid frameworks combining quantitative indicators, economic models, and qualitative analysis. There is no single dominant methodology, but there is strong convergence around international frameworks such as ESFRI, OECD, and RI-PATHS, which are adapted to specific contexts. The literature also points towards continuous, embedded evaluation systems that support strategic decision-making rather than accountability alone. Despite this progress, challenges remain in data collection, impact attribution, and the assessment of long-term societal value (Catalano et al. 2018).

3.2. Relevant approach to RI evaluation: the ESFRI Model

The dominant European reference point for RI evaluation is the ESFRI framework (ESFRI 2024). ESFRI approaches RIs through a lifecycle perspective that differentiates between concept development, design, preparation, implementation, operation, and termination. This lifecycle model provides a structured way to understand how infrastructures have different needs, risks, and targets at different stages of maturity. Evaluation is therefore not a one-off exercise, but a staged process that links planning, implementation, operation, and long term sustainability.

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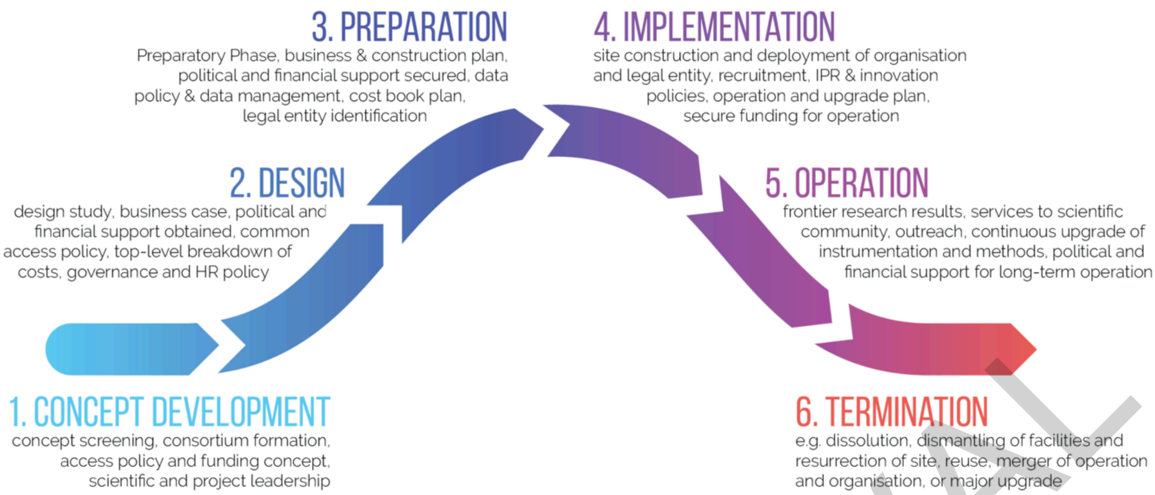

Fig.1: Lifecycle Approach of a Research Infrastructure (Source: https://www.slices-ri.eu/what-is-esfri/)

Within this lifecycle logic, ESFRI distinguishes between the “Scientific Case” and the “Implementation Case”. The evaluation of the Scientific Case assesses whether minimum requirements are met, whether the future scientific plans are convincing, whether the initiative adds strategic value to the European infrastructure landscape, and whether it shows potential for internationalisation, integration with other infrastructures, and alignment with digital and data related priorities such as the FAIR principles and EOSC. Monitoring relies on key performance indicators (KPIs), self assessment, hearings, and peer review. Six dimensions are considered: scientific excellence, pan-European relevance, socio economic impact, user strategy and access policy, e-needs and data, and environmental considerations.

Figure 2 shows how these broad evaluation criteria are operationalised into measurable indicators that demonstrate alignment with mission and maturity level of the infrastructure. For the scientific dimension, typical indicators include publications using RI data and services, citations of RI-enabled research, supported research projects, newly developed methods, and compliance with open science practices. Pan-European relevance is often measured through participating countries, international collaborations, and the infrastructure’s positioning in the European landscape. Socio-economic impact is captured through policy citations, industry collaborations, outreach activities, media visibility, and qualitative case studies. User strategy and access policy are commonly assessed through the number and diversity of users, access requests granted, user satisfaction, and training activities. Data related dimensions include dataset provision, reuse rates, interoperability, service uptime, and FAIR maturity. Environmental dimensions address impacts, mitigation plans, and responsible research practices.

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01 Scientific Excellence	- Publications using RI data/services (number per year) - Publications in high-impact journals - Citations of RI-enabled research - Research projects supported (national + international) - New scientific methods or tools developed via the RI - Open science compliance (licensing, metadata richness, openness of tools
02 Pan-European Relevance	- Countries involved (members/partners) - International collaborations - Positioning in the European RI landscape
03 Socio-Economic Impact	- Contributions cited in policy documents - Industry collaborations - Outreach events & community engagement - Media visibility - Societal impact case studies
04 User Strategy & Access Policy	- Number of users / user diversity - Access requests and granted access - User satisfaction - Training events (number & participants
05 E-Needs & Data	- Number of datasets (incl. FAIR assessment) - Dataset reuse / reuse ratio - FAIR maturity score - Interoperable services / APIs - TRL levels of tools & services - Service uptime & digital reliability
06 Environmental Considerations	- Identification of potential environmental impacts - Environmental action plan - Alignment with responsible research practices

Fig 2: Typical KPIs for RIs: Scientific Case

The Implementation Case complements this perspective by shifting the focus to stakeholder commitment, preparatory work and planning, governance and human resources, finances, and risks. Indicators include representation of stakeholders in governance bodies, completion of design studies, existence of business cases and timelines, secured long term funding, cost estimates, and strategies for managing scientific, political, financial, or security-related risks (see Fig. 3).

The purpose is to determine whether the infrastructure is institutionally and organisationally ready for implementation, and whether targeted support is needed to advance it towards full operation. This shows that standard RI evaluation is not confined to scientific output. It

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also addresses political backing, governance capacity, financial viability, and risk management.

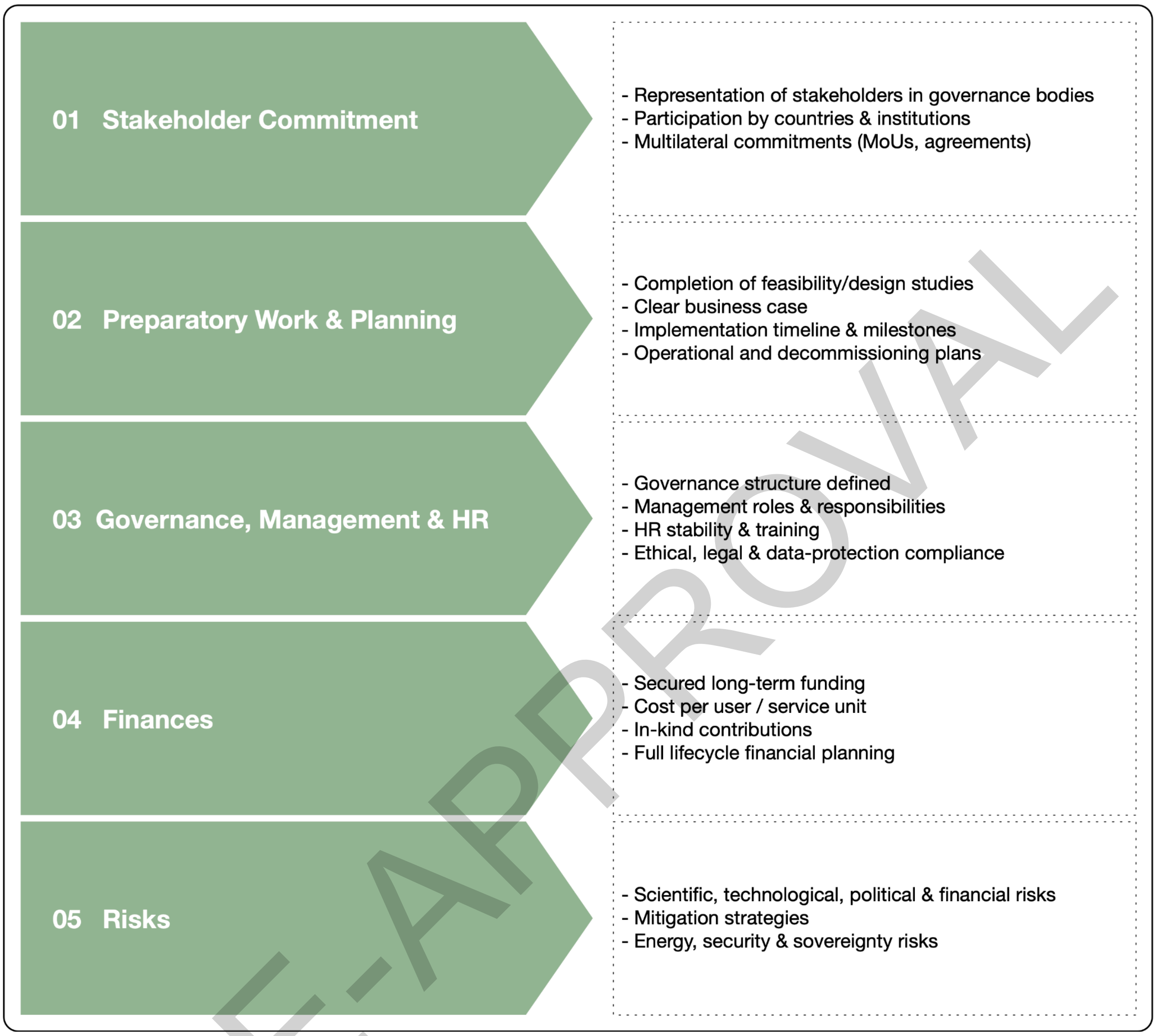

Fig 3: Typical Indicators for RIs: Implementation Case

The ESFRI model is therefore best understood as a multidimensional governance framework for assessing RIs. It translates broad strategic expectations into operational dimensions and minimum requirements. The resulting indicator logic is now well established across RI policy and management. However, what counts as a meaningful indicator depends heavily on the domain, the maturity of the infrastructure, and the nature of its service offer. This becomes particularly clear in the social sciences and humanities, where data infrastructures, language tools, archives, and survey infrastructures occupy different positions in the ESFRI landscape and rely on very different modes of use, user communities, and value creation.

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Domain adaptation in practice: the example of CESSDA

The CESSDA ERIC (Consortium of European Social Science Data Archives) offers an instructive example of how the ESFRI framework can be translated into a social sciences context. Participatory research, such as “interventional research” or “participatory action research”, has a long tradition in social sciences and thus lends itself as a good domain to explore. Also, it includes practices of participatory evaluation (Springett & Wallerstein, 2008), which are relevant in certain citizen sciences contexts.

As a distributed RI for social science data archives and an ESFRI Landmark since 2018, CESSDA focuses on data archiving, reuse, interoperability, FAIR data, training, service provision, and standardisation. This makes it a particularly relevant case for understanding how generic ESFRI criteria can be turned into mission-aligned indicators within the social sciences and humanities (SSH) domain.

CESSDA reported a set of KPIs for the period 2020 to 2022 (CESSDA 2025), combining common and specific indicators. These include e.g., numbers of access to digital objects, publications, projects, lectures and training events. Such indicators are directly tied to the mission of the infrastructure and combine quantitative output measures with broader notions of capacity building, accessibility, and return on investment in social science research.

The significance of the CESSDA case lies not simply in the specific numbers reported, but in the way evaluation criteria are translated into a domain-sensitive indicator set. FAIR datasets, reuse metrics, training, service-provider performance, and technology readiness levels of tools are used to demonstrate how a social science data infrastructure contributes both to scientific excellence and to infrastructural capacity. The case therefore shows that ESFRI criteria are adapted to the service logic, epistemic practices, and user communities of a particular field. CESSDA thus translates the ESFRI logic into a context where scientific and societal goals are more closely intertwined.

But what happens, when participation enters the scene? Evaluating citizen science RIs

Unlike conventional RIs that primarily serve specialised scientific communities, RIs for citizen science operate at the interface of professional research and public participation. They therefore combine methodological and technical support for research with mechanisms that enable broader publics to contribute data, knowledge, interpretation, and sometimes action. It is important to distinguish between citizen science platforms and citizen science RIs. Citizen science RIs are a subset of the broader platform ecology: socio-technical systems that provide sustained resources, services, and organisational arrangements for producing, managing, validating, and mobilising knowledge through citizen participation. Other platforms, such as project directories, training hubs, or

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communication spaces, may play important enabling roles without constituting full RIs in their own right (Soacha-Goday et al. 2025).

What differentiates the evaluation of a citizen science RI from that of a conventional scientific RI is that the evaluative object is more heterogeneous, context dependent, and plural. Citizen science is not a single, unified mode of knowledge production, but a diverse field shaped by different disciplinary traditions, governance models, participation formats, and local contexts (Fraisl et al. 2025). Evaluation therefore cannot rely on one fixed definition or a uniform set of criteria. Instead, it must remain modular and responsive to purpose and setting (Wehn et al. 2021).

Rather than assessing only outputs or standard data quality measures, evaluation needs to consider whether the infrastructure supports meaningful and transparent forms of participation, clarifies roles and responsibilities, accommodates different disciplinary standards, enables the co-creation of success criteria and output or impact measures, and supports forms of data and knowledge production that are fit for purpose in a specific contexts.

Citizen science RIs therefore introduce additional layers of hybridity, participation, and co-production that are not sufficiently captured by conventional categories: Is the infrastructure mainly for academic users, for citizen participation, or for both? What is the hybrid value proposition? Are contributors also users? Are data co-produced? Who should have access to data and workflows? What validation and feedback processes are required? Should governance be participatory? Which ethical and justice dimensions become central?

These questions point to an important shift in the understanding of infrastructure. In a conventional RI, users are often imagined as researchers who access services, tools, or data. In a participatory science infrastructure, by contrast, central actors may also be contributors, co-producers, community representatives, or publics affected by the research. This alters the meaning of access, service provision, governance, and impact. Participation is not merely an add-on; it can also shape the design of data flows, validation practices, interfaces, ownership arrangements, and evaluation criteria. Participants are active contributors to agenda setting, data collection, interpretation, validation, and, in some cases, governance. For RIs, this means that the infrastructure is no longer only a technical and organisational support system for science. It can also become a civic and societal arrangement that enables co-production between science and society. In that sense, participation changes the object of evaluation.

3.3. ESFRI approach to RI impact assessment

The ESFRI policy brief (Kolar et al. 2023) clearly distinguishes impact assessment from performance monitoring and stresses that they serve different functions in the assessment of RIs. Impact assessment should not be treated as a one-size-fits-all indicator exercise.

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Instead, it requires a customised, longitudinal and strategically embedded approach that takes into account the specific mission, context and stakeholder environment of each RI. While scientific impact is a core aspect of any RI, the ESFRI policy also emphasises the need to consider wider socio-economic impacts.

The ESFRI policy brief identifies several impact dimensions that are relevant for RIs. These dimensions are taken up in Section 5, where they are expanded to reflect the specific characteristics of an RI for citizen science, which include:

- ***Contributing to the creation and preservation of scientific knowledge*** *is at the core of every RI. RIs support this in many different ways, including by collecting, preserving and providing access to data and information, as well as broader services and tools. These may include access to physical facilities and data, curation and provision of samples, enabling analytical experiments, development of standards and software, and general support to researchers throughout the research process. Such activities advance scientific knowledge by enabling innovative research, expanding the frontiers of understanding, and generating new insights and discoveries. Increasingly, the impact of RIs is also linked to data management and preservation, the establishment of standards and protocols for data curation, metadata documentation, and data sharing. These activities support data re-use, allowing researchers to validate, replicate, and build upon previous work.*
- ***Contributing to addressing societal challenges*** *has been an increasingly important focus of RIs in recent years. Such impacts may range from contributions to the UN Sustainable Development Goals, the European Green Deal, and broader public understanding and perception of science.*
- ***Contributing to innovation and economic development*** *is also an important dimension of RI impact. RIs require significant financial investment, and it is therefore important to demonstrate how they contribute to innovation and economic development, including employment, economic growth, and competitiveness at local, regional, national, and EU levels. Large-scale RIs, in particular, employ substantial numbers of personnel and make significant investments in construction, services, and the supply of high-value-added components.*
- ***Contributing to policy-making*** *is another important pathway. Research enabled by infrastructures can support informed and evidence-based policy-making across different thematic domains, as well as policy and funding decisions at European and national levels.*
- ***Contributing to talent development*** *is also central to many RIs. Training and education are often explicit objectives, and significant resources may be allocated to them. As hubs of excellence, RIs are well-placed to nurture talent and train young scientists. They may also have significant impacts on users and their careers by increasing scientific excellence and productivity, supporting networking, and providing training opportunities.*

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While all of these ESFRI dimensions are relevant for a citizen science RI, they need to be adapted to the specific characteristics of participation. For example, in relation to capacity building, training and education should not be directed only towards researchers, but should also include other actors, such as experienced scientists, civil society organizations, policy actors, and the wider public. The adaptations needed to make these impact dimensions suitable for citizen science are explored further in section 5.

3.4. Evaluation and Impact Assessment in Citizen Science

Evaluation and impact assessment have become central concerns in citizen science, as participatory research approaches increasingly seek to demonstrate their value for science, society, and socio-ecological systems. Citizen science is commonly framed as generating impacts across multiple domains, including science and technology, society, the environment, the economy, and governance (Schaefer et al. 2021; Wehn et al. 2021). Impact assessment therefore extends beyond project-internal goals to wider contributions to sustainability, such as the United Nations Sustainable Development Goals (SDGs), public participation, political impacts, and structural change in the science-society relationship (Liu et al. 2023; Turrini et al. 2018). Within citizen science, evaluation is also increasingly understood as a learning process that supports self-reflection, adaptive management, and the iterative improvement of participatory research practices (Davis et al. 2022).

Over the past decade, a growing body of work has proposed frameworks, principles, and tools to support the systematic evaluation of citizen science processes and outcomes. Several influential frameworks now shape the field (Kieslinger et al. 2018; Passani et al. 2020; Wehn et al. 2021), while more recent contributions have extended this conceptual work by translating frameworks and principles into operational tools and infrastructures (Ceccaroni et al. 2022). In parallel, institutional-level initiatives foreground evaluation as part of broader organisational change processes. Rather than focusing exclusively on project-level outcomes, these approaches emphasise evaluation capacities within research-performing organisations, including governance structures, incentive systems, and support mechanisms (Schaefer et al. 2023). This marks an important expansion of evaluation beyond individual projects towards the conditions under which citizen science can be sustained and scaled.

Scientific outcomes of citizen science activities have been among the most frequently assessed dimensions to date. Traditional metrics such as data quality, publications, and contributions to research agendas, are increasingly complemented by broader scientific impacts, including methodological innovation, increased openness of research processes, and changing relationships between science and society (Bonn et al., 2018; Kasperowski et al., 2017). Citizen science is also increasingly studied as an object of research in its own right, with methodological and epistemological questions becoming a growing area of scholarly attention (Schaefer et al., 2021).

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Amongst participant-level outcomes, learning outcomes are the most frequently evaluated. Reviews consistently show that gains in content knowledge are the most commonly reported effects of participation, while more complex outcomes, such as changes in attitudes, behaviour, self-efficacy, are assessed less frequently and less systematically (Aristeidou & Herodotou, 2020; Peter et al., 2019). To address this gap, Somerwill and Wehn (2022) reviewed state-of-the-art scales and identified five validated approaches for evaluating changes in environmental attitudes, behaviour and knowledge that can be directly adopted in citizen science.

The evaluation of impacts on socio-ecological systems and governance structures remains comparatively underdeveloped, but has gained renewed attention through links to sustainability agendas and the SDGs. Recent analyses suggest that citizen science can contribute to monitoring a substantial proportion of SDG indicators, particularly where community-generated data complement official statistics (Fraisl et al., 2025). Liu et al. (2023) investigated how urban citizen science contributes to the SDGs and highlighted the need to align citizen science indicators with SDG metrics in order to mainstream citizen science contributions.

Similar to ESFRI and the RI-PATHS framework (Griniece et al. 2020), the citizen science evaluation and impact assessment framework defined by Kieslinger et al. (2018), as well as other frameworks such as Passani et al. (2020, propose a logic model approach for evaluating citizen science processes and impacts.

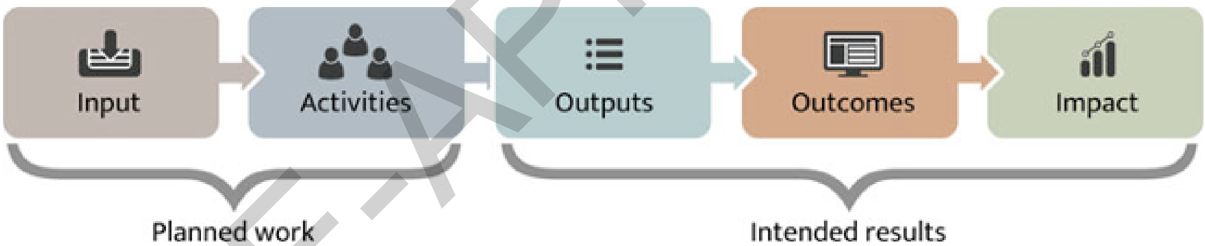

Fig 4: Logic model for evaluation and impact assessment (from Schaefer et al. 2021)

In section 5.3, we elaborate on how the logic model can be used to shape an impact vision for RIECS.

4. Particularities of Evaluation and Impact Assessment in RIECS

4.1. What difference does participation make?

Participation changes the evaluation of RIs in several important ways. First, it broadens the range of stakeholders whose values, experiences, and expectations matter for evaluation.

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Second, it expands the notion of impact beyond academic outputs and service efficiency to include empowerment, trust-building, local problem-solving, and public value. Third, it introduces new quality dimensions, including the quality of co-created data, the transparency of validation workflows, the inclusiveness of interfaces, and the fairness of governance processes. Fourth, it raises ethical and political questions around recognition, consent, data rights, accessibility, and power asymmetries. These dimensions are not external to evaluation; they become constitutive of what a successful participatory infrastructure is.

RIECS will therefore require a careful adaptation of ESFRI dimensions to the specific context of citizen science. Scientific excellence, for example, remains important, but needs to be interpreted in relation to the quality of co-created data, the transparency of validation workflows, and reflexivity regarding bias. Pan European relevance should include multilingualism, accessibility across contexts, and the ability to support cross border participation. Societal impact needs to capture community empowerment, trust-building, and local problem-solving. Access and services should move beyond user numbers to include onboarding, retention, accessibility, and community support. Governance needs to include community representation, participatory decision-making, ethical protocols, and data justice. Sustainability should include not only platform maintenance, but also long-term support for communities, coordinators, and engagement work.

Table 1 summarises the core ESFRI evaluation dimensions and indicates how they need to be adapted to meet the requirements of participation in citizen science. These suggested adaptations are based on the literature discussed above, including Wehn et al. (2021), Fraisl et al. (2025), and are aligned with Ten Principles of Citizen Science defined by the European Citizen Science Association (ECSA 2015).

Table 1: Adapting ESFRI Evaluation Dimensions to Citizen Science

ESFRI Dimensions	Citizen Science
Scientific excellence	● quality of co-created data ● transparent validation workflows ● reflexivity on biases
Pan-European relevance	● cross-border participation ● multilingual interfaces ● accessibility across contexts
Societal impact	● empowerment of communities ● local problem-solving ● trust-building between science & society

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Access & services	• participant onboarding • retention • inclusive and accessible tools • community support
Governance	• community representation • participatory decision-making • ethical protocols • data justice
Sustainability	• long-term support for communities and coordinators • resourcing of engagement work, not only platform maintenance

It should be noted that this first translation into ESFRI dimensions of citizen science dimensions is based on a literature review. In the following section, it is compared with inputs collected during an internal consortium workshop, as well as with initial insights from RIECS deliverables and the analysis of the stakeholder engagements. For example, Deliverable D2.1 identified several current challenges for a unified European citizen science infrastructure. These include limited interoperability among citizen science systems, due to varying data formats, metadata standards, and validation methods; scalability issues, including difficulties in handling increasing data volumes growing numbers of users; the short project-based lifespan of many platforms; uneven geographic and disciplinary coverage; and the integration of artificial intelligence (AI) and big data techniques into citizen science projects, which introduces new ethical, legal, and privacy considerations. Based on the identified challenges, the deliverable also suggests potential solutions to be addressed by RIECS. We investigated these solutions and structured them according to the ESFRI evaluation dimensions, so that they can be taken into account when designing the RIECS evaluation framework.

4.2. Internal Workshop

To align the RIECS evaluation and impact assessment framework with the views and experiences of the consortium, an online workshop was held on 27. November 2026. The workshop was attended by approximately 20 representatives from the consortium partners and lasted for 2 hours. Following a general introduction to RI evaluation, the ESFRI model, and its evaluation dimensions, consortium members were invited to reflect on how the ESFRI dimensions could be adapted to the specific case of a citizen science RI. This resulted in a first collection of individual comments on an interactive board shown in Figure 5 (Miro: https://miro.com/app/board/uXjVIqIZ2Fs=/?share_link_id=114729307427)

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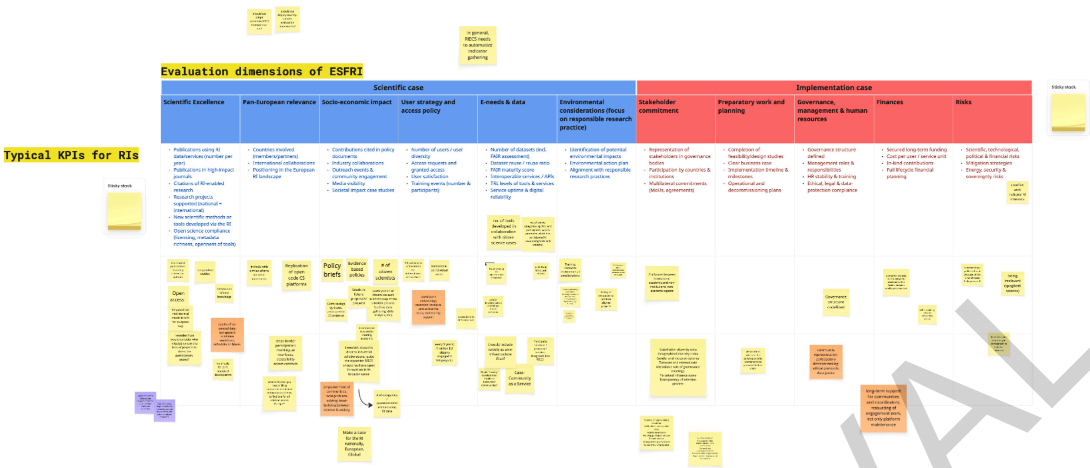

Fig.5: Miro Board screenshot

Following the ESFRI model, the board structured evaluation along two main dimensions: the Scientific Case and Implementation Case. It collected comments on typical KPIs for RIs, as well as additional sticky notes suggesting refinements, gaps, and critiques. Alongside quantitative KPIs, consortium partners stressed the need for qualitative, systemic, and societal impact dimensions, since the current indicators were seen as insufficient to capture the real value of a citizen science RI.

Scientific Case

The comments from the Scientific Cases are listed in Tables 2. They represent the original statements collected from the consortium partners during the workshop.

Table 2: Summary of comments for the Scientific Case

Dimension	Comments & Reflections
Scientific Excellence	Critical reflections: Over-reliance on traditional metrics (publications, impact factors) Need to better capture: Open science contributions, Reuse of data/tools, Real scientific collaboration impact
Pan-European Relevance	Emerging insight: Importance of cross-border accessibility and inclusivity; Need to move beyond counting partners → towards quality of collaboration
Socio-economic Impact	Key additions from notes: Policy briefs and evidence-based policymaking, Community engagement and societal value, Case studies instead of abstract

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	metrics 👉 Strong push to measure real-world impact, not just outputs.
User Strategy & Access	Key critique: Metrics are too quantitative; Inclusiveness, Accessibility across communities, and Quality of engagement are missing
E-needs & Data	Important additions: APIs and service ecosystems, Trust in data quality, Data reuse as key metric 👉 Shift from "data volume" → data usability and integration
Environmental Considerations	Notes highlight: Link to responsible research practices, Need for measurable sustainability indicators

Implementation Case

The comments from the Implementation Cases are listed in Tables 3. They represent the original statements collected from the consortium partners during the workshop.

Table 3: Summary of comments for the Implementation Case

Dimension	Comments & Reflections
Stakeholder Commitment	Insights: Importance of diversity and inclusiveness, Need for transparent selection processes, Real engagement vs symbolic participation
Preparatory Work & Planning	Observed gap: Lack of clarity on operational readiness and long-term sustainability planning
Governance & Human Resources	Key concerns are that governance often exists "on paper" but not in practice and there is a need for: ethical frameworks, data protection compliance, skills development
Finances	Critical notes: Sustainability of funding models is unclear; Over-reliance on short-term funding cycles
Risks	Additional concerns: Energy security, Sovereignty risks, National vs EU-level conflicts

Cross-Cutting Insights

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In addition to the case-specific comments, the workshop generated several broader cross-cutting insights:

- The current KPIs are too quantitative and too output-focused; they are not capturing the systemic impact, the community value, and the long-term transformation.
- RIECS needs to place greater emphasis on the policy impact (e.g. through policy briefs), citizen engagement, community benefits, open science practices, such as open access, open data reuse, open-source tools/platforms, as well as collaboration quality and trust and legitimacy.
- Open Science needs to be seen as a core evaluation dimension, not a side metric.
- More focus should be placed on ecosystem impact, including cross-border participation, multi-level accessibility, and integration into broader innovation systems.

Some tensions were also identified, namely:

- National vs European priorities
- Scientific excellence vs societal relevance
- Quantitative vs qualitative evaluation
- Infrastructure vs community value.

5. RIECS evaluation and impact framework

Based on ESFRI framework assessment, insights gained from the co-creation process with consortium members, stakeholder interactions, and the user stories collected during the first half of the project, we present a first version of the RIECS evaluation and impact assessment framework.

5.1. RIECS evaluation framework: the Participation Case

In line with the ESFRI framework, and in order to connect with other RIs, we build on the existing ESFRI evaluation approach and expand it with a dedicated **Participation Case. This Participation Case captures** the core dimensions required for evaluating a citizen science RI. We see these three cases (the Scientific Case, the Implementation Case and the Participation Case) as closely interconnected in the RIECS evaluation approach (Fig. 6). The Participation Case adds dimensions that are relevant to both the Scientific Case and the Implementation Case, while foregrounding the specific value that RIECS adds to participatory research processes.

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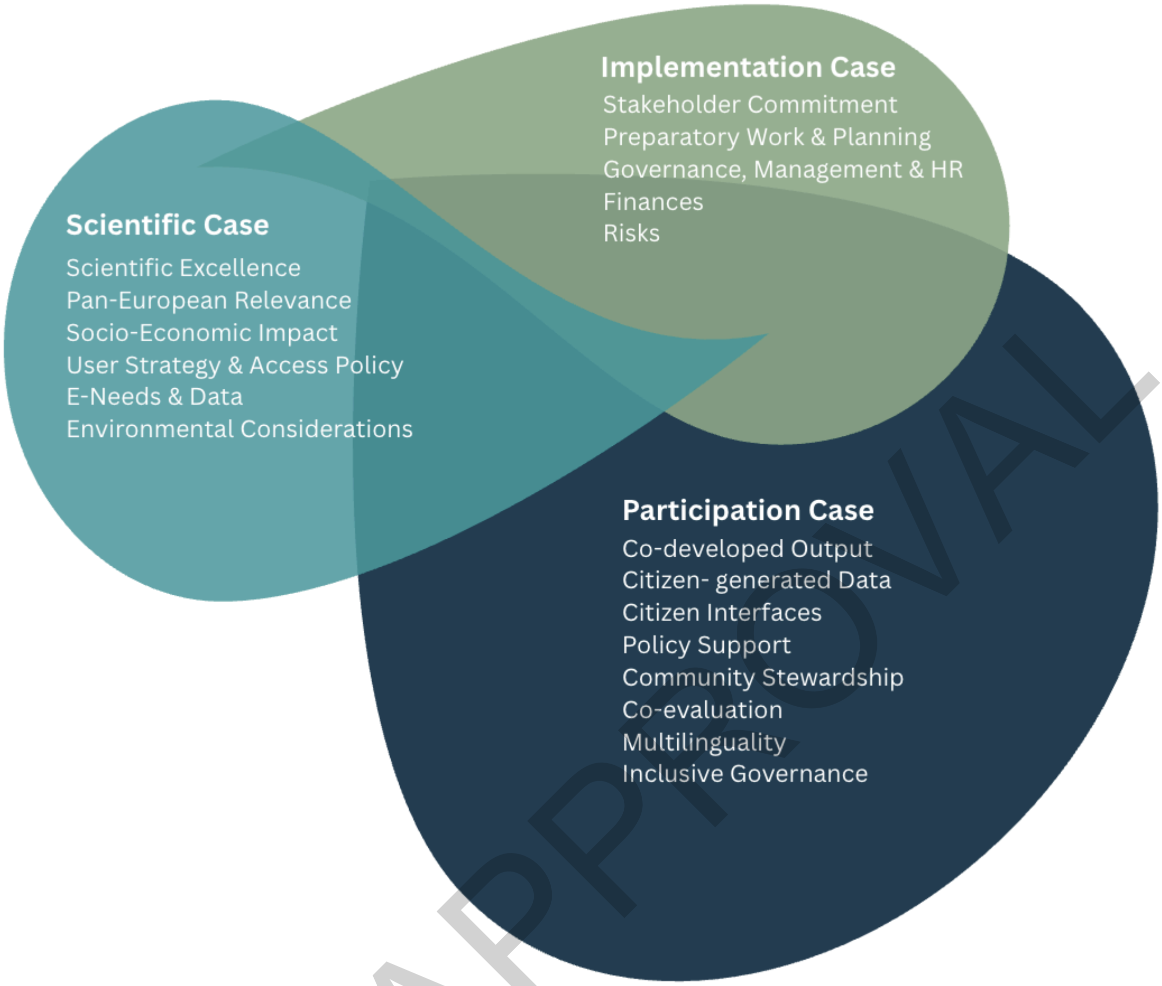

Fig.6: RIECS evaluation approach

Although we propose the Participation Case as an additional case alongside the Scientific Case and the Implementation Case, the suggested dimensions are not separate from the existing ESFRI dimensions. Rather, they are aligned with them and feed into them. For example, in relation to stakeholder commitment and governance, the Participation Case extends the Implementation Case by introducing a more explicitly participatory perspective. Similarly, in relation to scientific excellence, it adds attention to the quality of co-created data, transparent validation workflows, and the role of citizens and communities in knowledge production.

5.2. RIECS Participation Case Typical Indicators

For each of the Participation Case dimensions, we define a set of indicators or KPIs (Figure 7) to translate the dimension criteria into measurable elements. These indicators provide evidence of the performance and relevance of RIECS and contribute to assigning the maturity level of the RI.

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At the same time, we recognize that these indicators cannot be applied as a "one-size-fits-all" framework. RIECS aims to span across multiple disciplines and domains, while citizen science itself is a transdisciplinary concept. The framework will therefore need to be implemented with a certain degree of flexibility, and context- and domain-specific adaptation will be essential.

More fundamentally, RIECS has the opportunity to conceptualise impact assessment itself as a participatory process. If this is achieved, evaluation will become part of infrastructure-making rather than an external exercise. It will no longer be only a managerial instrument for measuring performance after the fact, but a mechanism for jointly defining what counts as value, relevance, and success. This is particularly important for infrastructures with hybrid scientific, societal, and civic objectives.

Fig.7: Typical KPIs for Participation Case

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This represents a first attempt to define (quantitative and qualitative) indicators and KPIs for the Participation Case. Table 4 illustrates how the suggested KPIs can be measured and verified. The indicators do not exhaustively cover all adaptations listed in Table 1, but translate selected participation-specific dimensions into an initial operational framework. Further refinement will be needed to incorporate additional aspects, such as bias reflexivity, ethical protocols, data justice, participant retention, and the long-term resourcing of engagement work.

Table 4: Indicators for the Participation Case

Participation Dimension	KPI	Means of verification
Co-developed output	Tools	Repository records, publication lists, project documentation, co-authorship or contribution records
	Publications	Publication records
Citizen-generated data	Quality of citizen-generated data	Data quality protocols, validation workflows, metadata records, reuse cases, expert and community review
Citizen-interfaces	Research interfaces for citizens	Interface audits, usability testing, accessibility checks, user feedback
	# of citizens as non-professional users	Registration data, user surveys
	User diversity index	Diversity monitoring where ethically appropriate
Policy support	Uptake of citizen science data in official monitoring	Policy briefs, consultation submissions, advisory roles, citations in policy documents
	Contributions to regulatory and policy development	Consultation submissions
	SDG contributions	SDG monitoring
Community stewardship	Support for stewardship and empowerment	Capacity building activities (empowerment on different levels, local, regional, national, academic…), structured reflection reports
	Trust-building	Policy briefs (support), eg. public libraries

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	between science & society	partnerships, or NGOs…. (local governance structures), feedback surveys, partnership documentation
	Facilitation of multi-stakeholder engagement	Workshops and events
Co-evaluation	Participatory feedback	Workshop documentation, feedback forms, structured reflection reports
	Participatory evaluation processes/ structures	Evaluation protocols, advisory group records, documented stakeholder involvement in indicator refinement
Multilinguality	# of languages supported	Metadata, documentation, service specifications, translation records
	Accessibility across cultural contexts	Accessibility reviews, local adaptation cases, stakeholder feedback from different countries or communities
Inclusive governance	Governance structure co-defined	Variety of actors represented in governance structures definition
	Community representation in governance	Variety of actors represented in governance structures
	Diversity in leadership	Variety of actors represented in leadership positions
Talent and capacity building	Training and learning opportunities for researchers, citizen scientists and coordinators in participatory dimensions of science	Training records, learning materials, participation numbers, feedback surveys and learning outcomes
	Career and competence development effects	User feedback, career narratives, certification, mentoring formats and uptake of training resources

These indicators/KPIs serve as measurable elements that can provide evidence of performance and relevance of RIECS and contribute to defining the maturity level of the RI. Hence, they should be understood as a first operationalisation of the Participation Case. As stated above, flexibility needs to be part of its qualities in order to allow contextual and domain-specific adaptations. Beyond this, RIECS should conceive of impact assessment

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itself as a participatory process by making evaluation part of infrastructure-building rather than a retrospective managerial instrument. It would offer a mechanism for collectively defining what counts as value, relevance and success in an infrastructure with hybrid scientific, societal and civic objectives. Building on this operational layer, the following section shifts from evaluation indicators to impact pathways and asks how a future Citizen Science RI could generate longer term scientific, societal, policy and ecosystem level value.

5.3 From Participation Case indicators to impact visions

As discussed in Section 3, evaluation and impact assessment in citizen science cannot be reduced to output measurement alone. Citizen science frameworks increasingly understand evaluation as a learning process that supports reflection, adaptive management, and the iterative improvement of participatory research practices. They also point to impacts across several domains, including science and technology, society, the environment, the economy and governance.

For RIECS, this means that the Participation Case indicators outlined in Table 4 should be understood not only as performance measures, but also as entry points for articulating broader impact visions for a future Citizen Science Research Infrastructure. This is in alignment with the ESFRI policy brief (Kolar et al. 2023), which states that impact assessment should be distinguished from performance monitoring and should not be treated as a one-size-fits-all indicator exercise. Instead, it requires a customised, longitudinal and strategically embedded approach that takes into account the specific mission, context and stakeholder environment of each RI. In the case of RIECS, this implies a strategic, longitudinal, and stakeholder-based theory of change.

This broader perspective is also supported by the RIECS specific findings discussed in section 4. The adaptation of ESFRI dimensions to citizen science showed that participation changes the object of evaluation itself: scientific excellence, access, governance, sustainability, and societal impact all need to be interpreted in relation to co-created data, inclusive interfaces, community support, participatory decision-making, ethical protocols and long term stewardship.

The internal workshop further confirmed that conventional KPIs alone are insufficient to capture the systemic, societal and community value of a citizen science RI. Consortium reflections pointed to the need for qualitative evidence, policy relevance, trust-building, collaboration quality, open science practices and ecosystem effects. They also identified tensions between scientific excellence and societal relevance, quantitative and qualitative assessment, infrastructure value and community value, and national and European priorities.

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RIECS impact visions

The RIECS impact visions build on the ESFRI understanding of research infrastructure impact, especially the contributions of RIs to scientific knowledge, societal challenges, innovation and economic development, policy-making and talent development. At the same time, RIECS adapts these dimensions to the specific conditions of citizen science (Table 5). Participation changes what impact means: it includes not only the production and reuse of knowledge, but also recognition, accessibility, empowerment, community stewardship, trust-building, and changes in the relationship between science, society, and policy.

The impact visions are structured around six interconnected areas that reflect the main domains in which a citizen science RI could create value: scientific knowledge production, societal participation and inclusion, policy processes, the wider citizen science ecosystem, capacity development across stakeholder groups, and the long-term sustainability of citizen science practices and infrastructures.

In defining these areas, RIECS draws on the RI-PATHS toolset as a useful guiding repertoire for describing how RIs generate socio-economic effects across different domains (Grieniece et al. 2020). Several RI-PATHS pathways are particularly relevant for RIECS, including addressing societal and public-sector challenges, providing curated or edited data, changing the fundamentals of research practice, creating and shaping scientific networks and communities, and promoting engagement between science, society, and policy. Further relevant pathways include publication, citation and recognition; technology transfer and licensing, especially through open licences that enable community uptake; learning and training through the joint development and use of tools and services; higher education cooperation; and communication and outreach.

At the same time, the RI-PATHS framework needs to be adapted for a citizen science RI, since it does not fully capture dimensions that are constitutive of participatory research. RIECS therefore expands this repertoire by foregrounding empowerment, recognition and participatory agency; justice, inclusion and accessibility; and community stewardship and the long-term sustainability of engagement work.

Taken together, these visions provide a forward-looking perspective on how RIECS could strengthen the conditions for citizen science in Europe, support collaboration across sectors and communities, and contribute to more open, participatory and socially responsive research and innovation systems.

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Table 5: RIECS impact visions

Impact vision	Core contribution of RIECS	Related RI PATHS orientation	Participatory extension
Scientific knowledge production	Supports the creation, curation, validation and reuse of citizen science data, tools and methods; strengthens methodological transparency and recognition of citizen science as a credible mode of knowledge production.	Publication, citation and recognition; provision of curated or edited data; changing fundamentals of research practice.	Recognition of citizen-generated knowledge; transparency of validation workflows; co-produced criteria of research quality.
Societal participation and inclusion	Improves the conditions under which citizens, communities and civil society actors can contribute to research in meaningful and accessible ways.	Addressing societal and public-sector challenges; promoting engagement between science, society and policy; communication and outreach.	Empowerment, participatory agency, justice, inclusion, accessibility and feedback to contributors.
Policy processes	Makes citizen science knowledge more visible, usable and trustworthy for public decision-making, monitoring and regulatory development.	Addressing societal and public-sector challenges; promoting engagement between science, society and policy.	Community-generated evidence, transparent validation, trust-building and stronger links between local knowledge and policy uptake.

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Citizen science ecosystem	Strengthens connections between existing platforms, RIs, communities and institutions through shared standards, interoperability, visibility and collaboration.	Creating and shaping scientific networks and communities; changing fundamentals of research practice.	Community stewardship, ecosystem care, respect for diversity across disciplines, countries and participation formats.
Capacity development and develop talent	Supports learning, training and peer exchange for researchers, citizen scientists, communities, policy actors and infrastructure providers.	Learning and training through joint development of instruments and tools; learning and training by using RI facilities and services; training and higher education cooperation.	Mutual learning, co-development of tools, participatory data literacy and capacity to engage across roles and sectors.
Long-term sustainability and institutionalisation	Helps stabilise citizen science practices, services and governance arrangements beyond short-term project cycles.	Technology transfer and licensing; communication and outreach; selected aspects of operations and procurement where relevant.	Long-term stewardship of engagement work, institutional recognition, open licensing for community uptake and sustainable support structures.

Potential risks

The expected impacts of a future citizen science RI depend on a set of implementation and sustainability conditions that are widely discussed in the RI literature. These include stable long-term funding, effective governance, stakeholder commitment, reliable operations, access arrangements, user uptake, international coordination, and the capacity to sustain services beyond initial project phases. ESFRI treats risks as part of the Implementation Case, while OECD work on international RIs highlights governance, funding, access,

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operation and lifecycle sustainability as recurring challenges for funders, managers and operators (ESFRI, 2024; OECD, 2017).

For RIECS, these general RI risks are compounded by participation-specific risks, including uneven inclusion across countries and communities, insufficient recognition of engagement work, fragile community infrastructures, and lack of trust in citizen-generated data (Resnik et al. 2019, Paleco 2021, Ponti & Craglia 2020). During the second half of the project we expect to develop a clearer understanding of the most critical risks and challenges for RIECS, particularly through the feedback mechanisms involving the different target groups and potential beneficiaries of the future RIECS infrastructure.

Target groups and beneficiaries

The impact visions outlined in Table 5 concern different stakeholder groups in different ways. For this reason, the expected benefits of a future citizen science RI should be specified not only in relation to general impact areas, but also in relation to concrete forms of uptake by target groups. Table 6 provides a first overview of key beneficiaries, expected benefits and possible forms of uptake.

Table 6: RIECS target group uptake

Target group	Expected benefit	Expected form of uptake
Citizen science researchers	Better tools, data access, standards and support	Use of RIECS services, methods and guidelines in research projects
Citizen scientists and communities	Better recognition, feedback, accessibility and governance voice	Participation in projects, evaluation and governance
Existing networks, platforms and RIs	Interoperability, visibility, shared standards	Alignment with RIECS service architecture, metadata standards, interfaces and governance models
Policy-makers	Access to validated citizen science knowledge	Use in monitoring, policy design, public administration and evidence-informed decisions
Funders and institutions	Better basis for supporting citizen science infrastructures	Use of framework in assessment and funding decisions, institutional

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		strategies and support structures
Technology and service providers	Clearer requirements for interoperable, open, accessible and trustworthy citizen science services.	Development or alignment of tools, APIs, platforms, repositories and service components with RIECS standards and governance expectations.
Education and training actors, students	Access to materials, infrastructures and examples for citizen science teaching, skills development and talent development.	Use of RIECS resources in curricula, training programmes, higher education cooperation, professional development and public learning formats.
Private-sector actors	Opportunities to contribute to, or responsibly reuse, open citizen science tools, standards and data infrastructures where aligned with public-interest goals.	Uptake of open standards, open licences, responsible service provision, and participation in innovation activities that support rather than extract from the citizen science ecosystem.
Civil society actors	Stronger channels for knowledge contribution	Engagement in co-creation and stewardship processes, advocacy, local problem-solving and societal uptake

The target group perspective provides an important basis for monitoring the impact of RIECS. For each group, impact can be traced by assessing whether the expected benefits are realised and whether the anticipated forms of uptake actually occur. This requires combining different types of evidence, including usage data, stakeholder feedback, case studies, policy references, training records and documentation of governance participation. Monitoring should therefore not only count users or services, but also assess whether different groups experience RIECS as useful, accessible, trustworthy and relevant to their specific practices. In this way, the target group table can support a more differentiated and participatory assessment of impact over time.

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6. Conclusions & Outlook

This deliverable presents the first version of the RIECS evaluation and impact assessment framework. Building on the current state of the art in RI evaluation and informed by consortium and stakeholder input, the framework introduces a novel approach tailored to the specific characteristics of citizen science and participatory RIs. In addition to the established Scientific and Implementation Cases of the ESFRI framework, we propose a dedicated Participation Case that recognises participation as a core structural dimension of RIECS. For this Participation Case, an initial set of key indicators has been defined in order to capture the distinct forms of value, engagement, and impact generated through participatory research processes.

The proposed framework recognises that RIECS does not fit neatly within conventional RI categories and therefore requires an evaluation approach capable of addressing a broad range of stakeholder perspectives, including those of researchers, citizens, policy-makers, civil society actors, and other socio-political stakeholders. Consequently, the framework adopts an explicitly multi-perspective and participatory approach to evaluation and impact assessment. In this sense, the RIECS approach moves beyond conventional monitoring and evaluation practices by embedding evaluation directly into participatory governance and stakeholder engagement processes.

As a first iteration, the framework should be understood as an evolving structure that will be further developed and validated during the next phases of the project. The proposed indicators and assessment processes will be tested in practice and systematically revised on the basis of empirical findings and stakeholder feedback gathered through participatory activities. This iterative process with moderated feedback loops will allow the framework to mature into a robust yet adaptable instrument capable of capturing the complex scientific, societal, and institutional impacts of participatory RIs. In doing so, RIECS also contributes to broader discussions on how future RIs can integrate participation, inclusiveness, and societal responsiveness into their core evaluation and governance models.

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