

ESFRI

ASSESSMENT OF IMPACT

OF RIs

Policy Brief

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EXECUTIVE SUMMARY

The impact assessment is an important part of the policy-making process, as it helps in evaluating the potential effects of proposed policies on various stakeholders and making informed decisions about whether to adopt, modify, or reject a proposed policy. It also helps them communicate the benefits of public investment on society. For these reasons, its importance has grown over recent years, and the domain of Research Infrastructure (RI) policy is no exception. Acknowledging the relevance of impact assessment, the ESFRI Strategy working group has organised two conferences on this topic.

Recently, Competitiveness Council have asked “*ESFRI to look into the approaches by Member States, the Commission, international organisations and RIs to assess scientific, societal and economic impacts of investments in RIs, identify good practices, develop a monitoring framework, test it and elaborate recommendations to national and regional RI stakeholders by the end of 2023*”¹. ESFRI has responded to this request by setting up a drafting group² tasked with preparing the report based on information collected from literature and questionnaires to the ESFRI member countries and RIs.

This report highlights the importance of understanding the differences between performance monitoring, which ESFRI started implementing last year, and impact assessment (IA), ex-ante or ex-post, for research infrastructures (RIs) and provides recommendations for stakeholders, policymakers, funders, governments, RIs, ESFRI, and the EC. Key points include the following:

- Acknowledging the differences between RIs and avoiding direct comparisons in impact assessments.
- No one-size-fits-all methodology for impact assessments; a customized approach should be taken.
- Recognizing the primacy of scientific impact while also considering other socio-economic impacts.
- Taking into account the longitudinal nature of impact assessments and the need for data collection over time.
- Ensuring adequate resources for impact assessments and the development of internal expertise.
- Integrating impact analysis frameworks into RI governance systems.

IA methodologies, be it ex-ante or ex-post, addressing running RIs vary significantly. In fact, there is no optimal methodology which could be recommended. They all have their strengths and weakness, and the choice depends on several factors, such as the objectives of the RI and the assessment. Consequently, the report does not develop a one-size-fits-all type of a monitoring framework, as requested by the Council, but proposes an ESFRI approach to impact assessment. This approach stipulates that ESFRI will not undertake IA of RIs itself, and leaves the choice of the method to be determined by the RIs and their stakeholders instead. It also presents recommendation aimed to

¹ Research Infrastructures - Council conclusions, 15429/22

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develop the field further, increase the quality of impact assessments and their role and use in RI policy and management.

General Recommendations

- **Understand the distinction between performance monitoring and impact assessment.** Although interconnected, these processes serve separate functions in ensuring that RIs achieve their objectives. It is crucial to recognize their unique roles for a comprehensive evaluation of RIs.
- **Establish consensus on assessment objectives and impact dimensions³.** Collaborative agreements among stakeholders, including RIs, funding agencies, governments, and relevant RI bodies, are essential for determining the appropriate impact assessment methodology and dimensions. This consensus should be based on clear expectations of the objectives of an RI and the assessment itself.
- **Avoid using impact assessments for direct RI comparisons.** Given the significant variations in objectives, organization, size, and maturity among RIs, impact assessments should not be employed for simplistic comparisons. Instead, focus on clearly defined evaluation criteria, contextual factors, and outcome-focused benchmarking to identify individual RI strengths, weaknesses, and inform decision-making.
- **Adopt a tailored approach to impact assessment methodology.** Methodologies have inherent advantages and disadvantages, necessitating a customized selection process that considers factors such as assessment objectives, available resources, data accessibility, and intended assessment users.
- **Prioritize scientific impact in assessments.** The primary purpose of RIs is to enable or enhance specific research endeavours. Consequently, the contribution of RIs to scientific excellence within a research field should be a crucial and central impact assessment dimension.
- **Consider impacts beyond scientific achievements.** RIs also generate socio-economic impacts, such as increased innovation, economic growth, improved policymaking, or talent development. The extent and nature of these impacts should be determined case-by-case, following a mutually agreed framework between RIs and stakeholders.
- **Recognize the differences between ex-ante and ex-post impact assessments.** While potential impacts during the design phase are inherently theoretical, operational phases allow for more concrete demonstrations of impact.
- **Adopt a long-term perspective for impact assessments.** Impacts may take years to manifest following initial RI investments, necessitating both timing considerations during impact discussions and early initiation of data/information collection for impact assessments.

³ The term "dimensions of impact assessment" refers to the various categories or areas in which the impacts of an RI are assessed. Objectives serve as the basis for defining relevant impact dimensions, and the dimensions help guide the selection and specification of specific criteria for impact assessment. Typical dimensions are scientific, societal, economic, policy-making and talent development impacts.

- **Promote results of RI impact assessments.** RIs, governments, and ESFRI should utilize impact assessments to showcase RI contributions to science, society, and the economy. Comprehensive communication efforts will foster positive development and funding in the RI domain.

Recommendations to policymakers, funders and governments

- **Conduct regular impact assessments for RIs with proper timing considerations.** Periodic evaluations are crucial, but it is essential to recognize that certain types of impacts may not materialize immediately after initial investments. Allow for the adequate time when expecting the manifestation of impacts.
- **Allocate sufficient resources for impact assessments.** Impact assessments can be complex and expensive, as they often involve long-term information collection and significant human and financial resources. Funders should provide adequate funding for the necessary level of impact assessment and align their expectations with available resources.
- **Emphasize a customized approach for each RI.** A single, unified method for impact assessments is unsuitable for applying across all RIs due to varying objectives, scopes, and activities. Although some impact indicators may be shared across RIs, it is essential to adopt a tailored approach that accounts for each RI's unique characteristics and requirements.

Recommendations to Research Infrastructures

- **Define relevant impact dimensions in a proactive way.** RIs are very different and cannot be assessed with a single method or single sets of indicators. However, RIs should reflect at an early stage not only on performance but also in what areas they would create impacts. Showcasing impacts is difficult and requires good information, often over a long period. Therefore, as for monitoring outputs and outcomes through the collection of KPIs, relevant impacts need to be clearly defined and outlined, and the relevant data and information need to be collected.
- **Develop internal expertise for impact assessment.** Analysing the impacts of the RI requires specific expertise, which is important to develop in-house to be able to design the indicators and track them over time, analyse and interpret the collected data as well as adapt the assessment framework over time depending on specific needs. This will also be of significant help also when/if external expertise is employed.
- **A high-quality approach may require internal and external impact assessments.** Both internal assessments, performed by RI's staff and/or stakeholders, and external, employing third-party experts, can be used for impact assessment. They both have advantages and weaknesses, and the choice will often depend on internal capacities and knowledge, resources available, goals of the impact assessment, etc. It may be beneficial to use a combination of both approaches to ensure a comprehensive and balanced assessment of impacts.
- **Integrate an impact analysis framework into the RI governance system.** To follow up the RI's impacts over time in a coherent way, allowing to capture the evolution of these impacts

properly, the assessment needs to become a permanent activity of a RI, with dedicated human and financial resources.

Recommendations to ESFRI

- **Recognize the importance of impact assessment for ESFRI.** Impact assessment is essential for policymakers to evaluate and direct investments. As a key player in shaping the European RI landscape, ESFRI should conduct periodic reviews of RIs' impact assessments to encourage knowledge-sharing and good practices. Additionally, ESFRI can facilitate mutual learning by including impact assessment discussions in workshops and other collaborative events.
- **ESFRI's role should focus on guidance rather than direct assessment.** Although impact assessment is highly relevant for ESFRI, its contribution should be limited to offering guidance and promoting the exchange of experiences. ESFRI should encourage RIs and their stakeholders to perform periodic impact assessments, incorporating the results as supplementary information in regular performance monitoring.
- **Consider conducting an impact assessment of ESFRI itself.** ESFRI may consider initiating an impact assessment of its activities, which extend beyond the selection of European RIs through the ESFRI roadmaps. This evaluation could help demonstrate ESFRI's influence on the European Research Area (ERA).

Recommendations to the EC

- **The EC is invited to consider further supporting the development of the impact assessment methodology.** In particular, in addition to the methodology and the indicators, case studies would be of significant added value, as they support the demonstration and dissemination of the methodologies and foster their broader uptake.

INTRODUCTION

Research infrastructures (RI) have grown in importance in all fields in the last decades. RIs allow for scientific innovation and advance research in different ways and in different domains. In Europe, infrastructures are long-term collaborative endeavours involving usually many different countries, research institutions and researchers. Given the relatively large and long-term investments, funders and policymakers show increasing interest in the performance of RIs but also in how they impact advancement in science and contribute to solutions to societal and economic challenges beyond.

Within ESFRI the relevance of impact assessment has been acknowledged for some time. The ESFRI Strategy Working Groups organised two conferences dedicated to the topic of research infrastructures in 2018 and 2021 in order to reflect with various stakeholders on conceptual and measurements aspects of impact assessments^{4,5}.

Competitiveness Council, in its recent Conclusions, invited “*ESFRI to look into the approaches by Member States, the Commission, international organisations and RIs to assess scientific, societal and economic impacts of investments in RIs, identify good practices, develop a monitoring framework, test it and elaborate recommendations to national and regional RI stakeholders by the end of 2023*”⁶.

Similarly, in 2018 Competitiveness Council invited ESFRI to develop a common approach for monitoring the performance of research infrastructures⁷, which led to the establishment of the ESFRI Landmark monitoring process in 2022⁸.

Understanding impact is much more difficult than understanding performance. While the reflections and publications on how to define and measure impact have grown over the last years, a unified framework or consensus on how to assess the impact of research infrastructures does not yet exist. A significant step forward was achieved recently by the EC H2020-funded project RI-PATHS⁹ and by the work of OECD¹⁰.

Objectives

Building on recent work within ESFRI¹¹, OECD and RI-PATHS, this report addresses from an ESFRI perspective how to define and assess impacts. It first examines the approaches to assessing scientific

⁴ Stay tuned to the future. Impact of for social sciences and humanities, January 2018

https://www.clarin.eu/sites/default/files/STAY_TUNED_TO_THE_FUTURE.pdf

⁵ Stay tuned to the future. Impact of Research Infrastructures 2.0, September 2021

<https://forscenter.ch/impact-of-research-infrastructure/>

⁶ Research Infrastructures - Council conclusions, 15429/22

⁷ Council conclusions on "Accelerating knowledge circulation in the EU", 9507/18.

⁸ ESFRI Landmark Monitoring Public Guide, 2021

https://www.esfri.eu/sites/default/files/ESFRI_LM-Monitoring_Guide_Public.pdf

⁹ Research Infrastructures' Impact Assessment Toolkit

<https://ri-paths-tool.eu/en>

¹⁰ OECD (2019), "Reference framework for assessing the scientific and socio-economic impact of research infrastructures", OECD Science, Technology and Industry Policy Papers, No. 65, OECD Publishing, Paris

<https://doi.org/10.1787/3ffee43b-en>

¹¹ Two conferences were organised by the ESFRI strategic working groups in 2018 and 2021, and a meta-analysis of impact assessments of RIs is currently conducted.

and socio-economic impacts of investments in RIs by the Member States, the Commission and international organisations. The report then provides examples of impact assessments of RIs. Finally, the report concludes with a proposed approach of ESFRI with guidelines for its further development and future impact assessment (IA) of RIs.

ASSESSING AND MEASURING IMPACT

Performance monitoring and impact assessment

Following the 2018 Competitiveness Council Conclusions¹, ESFRI developed a common approach for monitoring the performance of research infrastructures³ and proceeded with its implementation in 2022. **Performance monitoring** and **impact assessment** are **two distinct but related processes** used to evaluate the effectiveness of activities or institutions (in the following “activities”). While both processes involve collecting data and analysing results, their focus, scope, and objectives differ. The aim of performance monitoring is to regularly collect and analyse data on activities and outputs to assess progress towards achieving predetermined goals and objectives and to identify areas where a programme is succeeding and where it needs improvement. Performance monitoring typically involves tracking key performance indicators (KPIs) such as the number of users served, the amount of funding secured, collaborative engagements etc. In contrast, impact assessment is a process of identifying and assessing the actual changes due to activity. The primary purpose of impact assessment is to determine the extent to which the achieved outcomes brought about changes in the broader ecosystem.

The importance of impact assessment for public policy

Impact assessment helps policymakers and decision-makers to understand the potential scientific, economic, social, and environmental effects of their policies on different stakeholders and society as a whole. It allows them to evaluate the costs and benefits of different policy options, identify potential intended and unintended consequences, and develop more effective and equitable policies. Impact assessments help policymakers make informed decisions based on evidence.

Impact assessment of investments in research is no exception. It reveals the potential or actual impacts of the investments on science, society, the environment, the economy, and other areas. It aims to ensure that research findings are effectively communicated, are used to inform public policy and decision-making and help secure future funding. Impact assessment of research investments is thus an essential step in demonstrating their relevance, effectiveness, and efficiency in addressing societal needs and informing public policy and decision-making.

The increasing importance of impact assessments is also reflected in the domain of RIs, which is results in the growing pressure on science in general in times of limited availability of public funding, to demonstrate the broader benefits that it provides to the economy and society.

The impact assessment is important before and after the implementation of a RI.

- **Ex-ante impact assessment.** It refers to an evaluation that is conducted during the planning stage of a RI investment to demonstrate its potential impacts, anticipate its effects, and support deliberate planning for their achievement. It has been a part of the ESFRI “Proposal Submission Questionnaire” for the Roadmaps since 2016. For the scientific case, proposers had to “*Outline the scientific vision and mission, its short- and long-term impact on the main research field (-s) and its potential impact on other fields – if any – as well as on innovation*” and in addition, they had to outline the socio-economic impact in detail. By definition, such impact assessment has to be conceptual and, to some extent, abstract at this stage since RIs only enter their preparatory phase.
- **Ex-post impact assessment.** Once RIs have been operational for a while, they can show if and how they create impacts. In this phase, ex-post impact assessment is used to determine whether the RI has achieved its intended objectives and to assess the actual effects, both in a quantitative way, using specific indicators, and qualitatively through the presentation of specific cases and narratives of how impact has been created.

Typically, these two types of impact assessments should be connected; however, in reality, the connection might be rather loose – for some pan-European RIs, the consideration of impact has not been a very important dimension in its design phase, at least beyond scientific impacts, so the case for the creation of broader societal impacts has not been clearly made upfront.

Definitions of impacts

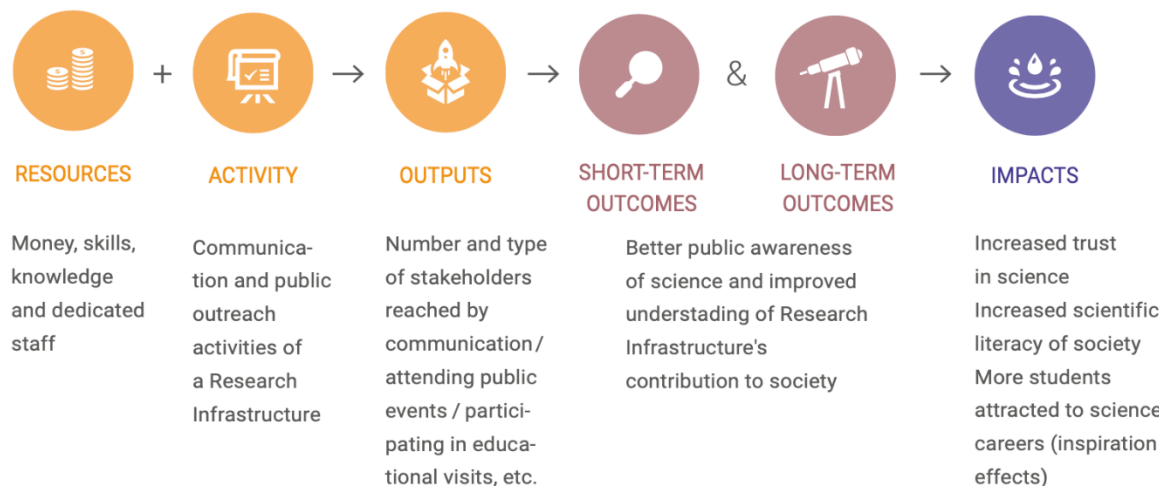
OECD defines impacts as “*the extent to which the intervention has generated or is expected to generate positive or negative, intended or unintended, higher-level effects*”¹². The European Commission states that “*The term impact describes all the changes which are expected to happen due to the implementation and application of a given policy option/intervention [such as investment in a Research Infrastructure and its activities]. Such impacts may occur over different timescales, affect different actors and be relevant at different scales (local, regional, national and EU)*”¹³.

Both definitions are aligned in terms of covering all possible impacts, with OECD calling them “effects”, whereas the European Commission refers to “changes”. In simple terms, it means that all the activities carried out at a RI will generate some impact, whether positive or negative, regardless of whether it was planned or not, and will be seen if not in the short-term then after several years.

¹² <https://www.oecd.org/dac/evaluation/revised-evaluation-criteria-dec-2019.pdf>

¹³ <https://ec.europa.eu/info/sites/default/files/better-regulation-guidelines-impact-assessment.pdf>

Figure 1. An example of impacts coming out from the communication and outreach activities.



Source: RI-PATHS project

Outcomes, while outside the direct control of the RI's team, remain at arm's length and the RIs may seek to influence them, while impacts cover general scientific progress as well as lasting and structural changes manifesting in the economy and society and are outside the direct control of the RIs⁵.

It is also important to keep in mind that impact pathways are not linear. One activity can lead to various impacts, creating a web of causes and effects that grow over time.

Defining the scope of the Impact assessments

Impact assessment is based on expectations and assumptions about what a RI should deliver. ESFRI's working group on Monitoring of Research Infrastructures Performance has identified nine objectives of greatest relevance for RIs in general¹⁴, which largely relate to the following broad impact categories:

Contributing to the *creation and preservation of scientific knowledge* is at the core of every research infrastructure. RIs do this in many different ways, through collecting and preserving data and information, but also through services and tools in a broader sense, such as the provision of access to physical facilities, curation and provision of samples, enabling analytical experiments, producing standards, software, and general support to researchers which are all relevant for a research process and scientific discoveries.

Contributing to *addressing societal challenges* has been an increasingly important focus of RIs in recent years. The impact may range from the contribution to the UN Sustainable Development Goals and the European Green Deal, to public perception of science.

Contributing to *innovation and economic development*. RIs require significant financial investments, and it is, therefore, important to highlight how they contribute to innovation and economic development, such as employment, economic growth or competitiveness, especially at the local,

¹⁴ Monitoring of Research Infrastructures Performance, ESFRI Working Group Report, 2019
https://www.esfri.eu/sites/default/files/ESFRI_WG_Monitoring_Report.pdf

regional and national levels. Large-scale RIs, in particular, employ substantial number of personnel and, in some cases, make significant investments requiring construction and the supply of high-value-added components. In addition, RIs may also have a beneficial indirect impact on the social and economic development of a region by expanding the human capital, providing training and acting as innovation hubs more generally, especially in combination with higher education institutions and business incubators.

Contributing to *policymaking*. Research enabled by infrastructures can contribute to informed and evidence-based policymaking in different thematic domains and also for related policy and funding bodies at European and/or national levels.

Contributing to *talent development*. Many of the RIs have among their objectives training and education, to which significant resources may be allocated. As hubs of excellence, they are also well-placed to nourish talents and train young scientists.

The list is not exhaustive, and other policy priorities, such as contribution to reducing R&I gap in Europe, science diplomacy, development of the European Research Area, digital transition, and similar, might be found among the objectives of RIs.

Not all objectives are equally important for all RIs, and how the objectives are defined for each of them varies widely. Impact assessment, therefore, needs at the beginning a clarification of the overall objectives and expectations of a RI. The different objectives are also not at the same level. Creating scientific knowledge and provision of research services and data are always the core of a RI. The other objectives are rather a consequence of the scientific activities of a RI and are usually not a primary objective in itself. This does not mean that the contribution to addressing societal challenges or to economic development is less important, but it has to be understood that this needs to happen through realising the scientific objectives of a RI.

Some objectives can be a by-product of core activity, and their impacts are sometimes only noticeable once a RI is fully operational. Objectives may also change over time. For example, societal or economic objectives have grown in importance in recent years for RIs; they were often not at the centre when RIs were established in earlier times.

The issue is further complicated by the different expectations and interests of stakeholders in various types of impact – while researchers mainly expect that RIs facilitate their research, RI management and staff have to deal with the day-to-day management of resources, organisation of the processes and the work of the RI, funders might want to see a return on investments, policymakers might also want to see how the data provided by RIs have impacted evidence-based policies, while governments might be interested in the strategic positioning of their country as part of the European or global science competition.

The different objectives of the actors around RIs have to be taken into account when designing impact assessments.

Given the multitude of objectives and their varying relevance for different stakeholder groups, it is not feasible to have a single approach for impact assessment for all of RIs.

Impact assessment, therefore, needs at the beginning a proper clarification and development of a joint understanding of the overall objectives and expectations of an RI. To frame the scope of such assessment the RIs, with the relevant involvement of their stakeholders, have to:

- Agree on the objectives of RIs and of their impact assessment. Given that objectives and possible impacts of RIs are multi-dimensional and different stakeholders have different interests, it is important that each impact assessment starts with a process of mutual agreement on which impact dimension matters for an RI against its objectives.
- Identify relevant dimensions of impact assessments. Based on objectives, it is then possible to clarify what dimensions of impact – scientific, societal, economic, and policymaking – are most relevant and also, within impact dimensions, the more specific criteria can be further specified.

It is important to keep in mind that the objectives and activities of RIs may change over time, and as a consequence, relevant impact dimensions may also change with time. In addition, RI activities may generate unintended impacts not linked to the RI objectives, or even negative impacts (e.g. environmental), that should also be identified and taken into account.

Frameworks and methods for assessing and measuring impact

The RI-PATHS project's team conducted a comprehensive literature review¹⁵ of methodologies to assess and measure the *ex-post* socio-economic impacts of RIs. The team grouped relevant contributions from the literature in six main approaches:

- Socioeconomic assessment based on impact multipliers: This approach assesses the socioeconomic impact of a particular policy or project by quantifying the ripple effects on various sectors of the economy. The assessment is based on impact multipliers, which are used to estimate the indirect effects of the policy or project on the economy. In this approach, impacts are expressed regarding effects on aggregated macroeconomic variables, such as GDP, gross value added, or employment.

Its main advantage is reliability to produce replicable and comparable results over projects, as the methodology is based on well-established theory and uses the input/output analysis tool, which is often used in socio-economic impact assessments of RIs. Its issue is in limited validity, as the approach often can't reliably measure non-monetary impacts (e.g. cultural, societal, and environmental impacts). An example of an impact assessment using this approach is the Socio-economic Assessment of SKA (Square Kilometre Array) Phase 1 in South Africa¹⁶.

- Methodologies applying the knowledge production function: This approach focuses on the impact of research and development activities on the economy. The knowledge production function method is used to quantify the relationship between investment in research and development, and economic

¹⁵ State of play - literature review of methods to assess socio-economic impact of research infrastructures
https://www.researchgate.net/publication/327645719_State_of_play_-_literature_review_of_methods_to_assess_socio-economic_impact_of_research_infrastructures

¹⁶ Atkinson, D. (2017). Socio-economic Assessment of SKA Phase 1 in South Africa.
<https://www.sarao.ac.za/wp-content/uploads/2019/03/SocioEconomic-Assessment.pdf>

growth. The approach only focuses on a small share of expected socio-economic impacts of RIs. An example using this approach is the study of Fraunhofer Gesellschaft Impact (Comin (2019))¹⁷.

- Cost-benefit analysis: This approach compares the costs and benefits of a policy or project to determine whether the benefits outweigh the costs. The analysis considers both quantitative and qualitative factors to make an informed decision. All benefits and costs are expressed in monetary terms, even if the effects are not only financial. The approach is often used by governments and economists to evaluate the impact of various investment projects. It is reliable for comparison of positive and negative impacts and has the potential to capture many effects of RIs. The approach, however, can be costly and time-consuming. There is also a limited explanation of causality, and it can be challenging to capture all costs. An example of a cost-benefit analysis done among RIs is the assessment of the Large Hadron Collider at CERN¹⁸.

- Approaches based on multi-methods, multiple partial indicators: This approach combines multiple methods and indicators to assess the impact of a policy or project. The methods may include surveys, focus groups, and statistical analysis, and the indicators may include economic, social, and environmental factors. An example of such an approach is the OECD framework for socioeconomic impact, which included lists of 25 core impact indicators and further 58 standard indicators. The approach is more reliable when connected to theory on how to define and measure impacts.

- Theory-based approaches: These approaches are based on established economic or social theories to assess the impact of a policy or project. The approach relies on theoretical models and empirical evidence to make predictions about the impact. A typical example is a “logical framework/model”, which is based on a logical sequence of steps, from inputs to impacts. Theory-based approaches typically share common features, for example, accounting for wider context and external factors that may influence performance, and they define “impact pathways”. The impact pathways approach was further developed in the RI-PATHS project¹⁹, exploring more details than the logical framework and providing more of a narrative vision with more information on causes and effects.

- Case studies: This approach involves an in-depth analysis of a particular case to understand the impact of a policy or project. The analysis focuses on the specific context, identifying the factors contributing to success or failure and drawing lessons for future policies and projects. When used in impact assessments, case studies are used to reflect the uniqueness and complexity of RIs better. Sometimes they show success stories, although this can lead to optimism bias. Other cons are lower reliability and issues with reproducing results. Case studies are part of many existing impact assessments; one example is the OECD study of CERN.²⁰

¹⁷ Comin, D. et al. (2019). Do Companies Benefit from Public Research Organizations? The Impact of the Fraunhofer Society in Germany

<http://dx.doi.org/10.2139/ssrn.3354365>

¹⁸ Florio, M., Forte, S., Sirtori, E. (2016). Forecasting the socio-economic impact of the Large Hadron Collider: A cost-benefit analysis to 2025 and beyond

<https://www.sciencedirect.com/science/article/pii/S0040162516000731>

¹⁹ Concrete examples of assessments within the RI-PATHS projects were pilot studies of RIs ALBA, DESY, EATRIS, ELIXIR, etc.

²⁰ OECD (2014). The impacts of Large Research Infrastructures on Economic Innovation and on Society: Case studies at CERN. <https://www.oecd.org/sti/inno/CERN-case-studies.pdf>

After a systematic assessment based on reliability, validity, accuracy, cost/time needed, relevance for policymakers, and relevance for RI managers, the review highlights that there is not a single methodological approach that can appropriately answer all the questions that an assessment addresses. Rather, a smart and rigorous combination of approaches can add value compared to existing methods.

Based on this observation and the stakeholder analysis performed in the project, the RI-PATHS Impact Assessment Toolkit was co-developed together with the RI community. Notably, some approaches are more suited to assess economic impact rather than societal or scientific impact, or vice-versa. In general, these approaches can complement each other – some are more quantitative, e.g. macroeconomic modelling or Cost-Benefit Analysis (CBA), and some are more qualitative (narratives, case studies).

For ex-ante impact assessment, only a limited number of those methodologies are available. Logically ex-ante impact assessment cannot claim the actual impact of any kind since an RI has not been established yet. However, it is still possible to make a case in which areas RIs can potentially create an impact. Such impact assessments are, in those cases, theory-based, or they can rely on experience of RIs with a similar scope.

Internal vs External impact assessment

Both external and internal assessments can be for evaluating the impact of RIs, each with distinct advantages and disadvantages. External assessments entail utilizing independent third-party entities to evaluate an institution's impact. This approach provides an objective and unbiased evaluation since external assessors are not affiliated with the institution being assessed and are less likely to be influenced by internal biases or vested interests. Moreover, external assessments can provide novel perspectives and insights that may not be readily available to internal assessors. However, external assessments are often costly and time-consuming, and may not always account for the unique contextual nuances and priorities of the institution being evaluated.

Conversely, internal assessments rely on the institution's own staff or stakeholders to evaluate its impact. This approach is more cost effective and efficient since internal assessors are already familiar with the institution and its operations. Internal assessments might also consider better contexts and priorities of the institution and can be more adaptable to changes in the RI's objectives and goals. However, internal assessments may be subject to internal biases and conflicts of interest and may lack the objectivity and independence of external assessments. Moreover, internal assessors may be limited by their own knowledge and expertise, which may restrict their capacity to provide novel insights and perspectives.

The choice between external and internal assessments will often depend on internal capacities and knowledge, resources available, goals of the impact assessment, etc. It may be beneficial to use a combination of both approaches to ensure a comprehensive and balanced assessment of impacts.

Indicators

Impact indicators are essential for many impact assessment methods because they provide a measurable and objective way to assess the impacts of a RI. It is important to keep in mind that they differ from typical performance indicators, although some might be used for impact assessment. Several lists of impact indicators have been proposed in recent years:

- OECD¹⁰. It prepared a list of Core impact indicators (CII) and a more exhaustive list of »standard indicators« (overall 58). The Core indicators were sorted by five impact categories (scientific, technological, training and education, economic, and social and societal impact), and seven strategic objectives:
 - be a national or world scientific leading RI and an enabling facility to support science;
 - be an enabling facility to support innovation;
 - become integrated into a regional cluster/in regional strategies/be the hub to facilitate regional collaborations;
 - promote education, outreach and knowledge dissemination;
 - provide scientific support to public policies;
 - provide high-quality scientific data and associated services;
 - social responsibility).
- RI-PATHS²¹. It built on the earlier work^{10, 22} and sorted indicators by impact areas (human resources, economy & innovation, society, policy), and types of indicators (activity, outcome, impact).

The two lists differ in the dimensions (e.g. OECD includes scientific impact) and the type of indicators. While RI-PATHS distinguishes between activity, output and impact indicators, this is not the case in the OECD framework. The latter, however, indicate the source of data.

The two documents, and the recent report by ERIC Forum²³, are relevant sources of information when preparing for or undertaking impact assessments. Nevertheless, additional work focusing on the definition and description of indicators would be useful. Elaboration of impact indicators by ESFRI, as was done for the performance monitoring indicators, is beyond the scope of this paper but remains relevant for future work by ESFRI as well as RIs. In particular, ERICs, in their forthcoming “ERIC Observatory” may consider developing the indicators further.

²¹ RI-paths indicators

<https://ri-paths-tool.eu/en/indicators>

²² A. Reid, E. Grinieca, J. Angelis (2015). Evaluating and Monitoring the Socio-Economic Impact of Investment in Research Infrastructures, 2015. DOI: 10.13140/RG.2.1.2406.3525/1

https://www.researchgate.net/publication/275037404_Evaluating_and_Monitoring_the_Socio-Economic_Impact_of_Investment_in_Research_Infrastructures

²³ ERIC Forum Policy Brief, Assessing the Socio-Economic Impact of ERICs, October 2022.

APPROACHES TO IMPACT ASSESSMENTS

Approaches by ESFRI Countries

ESFRI survey about impact assessments of RIs in member states was conducted in April and May 2023. By the deadline in May 19th 2023, we received responses from 18 different countries²⁴. More than half of them (10, 56%) reported that their country either performs impact assessments or requires RIs to perform impact assessments. Out of these 10, four are mostly ad hoc, while 3 answered that impact assessments are either regular assessments or split between regular and ad hoc exercises.

In the following, some of the approaches used by the countries are presented.

Czechia

Impact assessments of RIs are regular exercises aimed at a detailed monitoring and evaluation of socioeconomic benefits stemming from public investments in RIs. They focus on identifying and measuring impacts in the areas of science, technology and innovation, human resources development, economy, and society. Following the pilot exercise carried out in 2021, it is foreseen to implement them every five years, with the next round scheduled for 2026. Assessment of socioeconomic impacts of public investments in RIs is a specific input into regular international peer-review assessments of RIs, based on a comprehensive portfolio of indicators and conducted already in 2014, 2017 and 2021, with the next round scheduled for 2026.

Cyprus

Cyprus require RIs to perform the impact assessment on a regular basis for some RIs, and ad hoc in case of others. The main objectives of the exercises are the optimal utilization of the RI capacities of the country, the identification of synergies and/or overlaps and gaps, and to streamline of RIs mission with national and EU priorities for the benefit of society and the economy. The approach consists of RIs preparing a multi-annual Strategic Plan for a period of 3-5 years. The government is conducting assessments on an annual basis regarding the utilization of public funding as well the implementation of the multi-annual Strategy of the RI. Scientific evaluation is conducted on an ad-hoc basis.

Germany

The country requires RIs to perform impact assessments on a regular basis. The majority of RIs are set up, financed and monitored within the framework of the German Pact on Research and Innovation (PFI IV)²⁵. The main objectives of their impact assessment are derived from the overall objectives set out in the German Pact on Research and Innovation IV (PFI IV): fostering the dynamic development of the research system, transfer from research into economic activity and society, improving networks, attracting best minds and strengthening research infrastructures. The impact of RIs is assessed through

²⁴ AM, BG, CZ, CY, DE, ES, FO, GR, HU, IS, IE, IT, NL, PL, PT, SK, SI, UEA

²⁵ <https://www.gwk-bonn.de/themen/foerderung-von-ausseruniversitaeren-wissenschaftseinrichtungen/pakt-fuer-forschung-und-innovation>

impact parameters aggregated for all RIs of a given research (Pact) organization. Assigning existing and new indicators to so-called transfer paths helps to make the impact of the Pact organizations easier for the public to understand.

Greece

The country performs impact assessments of RIs on an ad hoc basis, but plans to establish more regular assessment cycles. Recently an impact assessment of 28 RIs funded during the period 2014-2020 was performed with the support of the European Commission and the Policy Support Facility. The objective was to provide policy recommendations to increase the contribution of the national RIs to the Greek R&I ecosystem with a view to:

- Enhancing socio-economic impacts, innovation potential exploitation, technology transfer, access policy efficiency and business collaboration,
- Reinforcing international value chains and European networks and facilitating effective internationalisation policies,
- Boosting the scientific and technological excellence of the RIs

The PSF panel has not conducted a fully-fledged evaluation of the 28 national RIs nor has it carried out a peer review of the scientific excellence of the research carried out within these infrastructures. Both these types of analysis are beyond the scope and remit of the current exercise. However, the panel's work has built on a substantive evidence base including:

- A survey sent to all 28 national RIs and completed by 27 of them between December 2021 and January 2022;
- A background report prepared by two national experts in the spring of 2022 that reviewed the policy framework and available evidence on the NRIs' selection and implementation, which summarised and drew conclusions from the NRI survey results²⁵;
- A series of interviews with Greek national stakeholders, the NRI coordinators and selected users (researchers, businesses, public-sector organisations) during the first-panel mission to Greece at the end of March 2022;
- Working sessions with thematic groups of NRI coordinators as part of the second mission in June 2022 during which the panel's initial conclusions were discussed. This evidence base enabled a thorough review of the progress of each national RI in terms of their development of a governance framework, operational procedures and access policies for users as well as initial results and impact to innovation.

The main bottlenecks perceived by GR are gaps in funding, fragmentation of investment and effort, a universal lack of well-accepted meaningful metrics of derivative impact assessment, e.g., on the economy, health, industry, etc.

The Netherlands²⁶

Impact assessments of the RIs are regular exercises aimed at monitoring the development and (non)academic use of the large RIs. The main aim is to assess the academic impact. In COVID-times, some large RIs showed an immediate unplanned societal impact.

The provisions for impact assessments are included in the standard NWO regulations and practices. For assessing the impact of large RIs some adaptations were made, as the general approach mainly focuses on research projects. The exercise consists of annual progress reports, a midterm monitoring report (after 5 years) and a final report (after 10 years). In addition, for large RIs, annual monitoring meetings with the funded consortia are organised to maximise the success of the project and also of scientific and societal impact. These meetings focus on specific objectives, scope and activities of the large RIs.

NWO is presently formulating a portfolio strategy for international RI membership that will include an impact assessment approach for these memberships.

Approaches by the European Commission and OECD (to be added)

Approaches by RIs

Given a lack of consensus on a unified framework or guidelines for assessing impact, it is unsurprising that approaches to impact assessments of RIs have varied, relying on many different methodologies or theoretical frameworks. Moreover, at least until very recently, there have been relatively few impact assessments made among RIs. Publicly available material reveals that only a minority of ESFRI RIs have already performed an impact assessment. This is also supported by findings of the ESFRI survey conducted in March 2023²⁷. Around 40 % of the responding 40 RIs or RI projects expressed that they have already performed an impact assessment, with most of the remaining (47 % (22)) reporting that they plan to undertake one in the future. This demonstrates that RIs are largely aware of the importance of impact assessment. The percentage of ESFRI Landmarks who expressed that they have done an impact assessment is very similar (41 % (9 of f 22))

Three respondents to the survey answered that their impact assessment was built into the regular RI management with defined intervals. Others noted that their assessment was a “one-off”, or provided another explanation, e.g. that it’s an ongoing process or that these assessments represent a too significant amount of work to be carried out regularly.

Among available impact assessment reports, we can see that some RIs have utilised external experts, e.g. consulting companies/agencies. Some others were taking part in the Horizon2020 projects (RI-PATHS, ACCELERATE) – in some cases as pilot studies. Several cases cannot be viewed as impact assessments as we understand them, even if they were flagged as such by the RIs themselves. Some of these reports or exercises come closer to the definition of performance monitoring, while some are

²⁶ <https://www.nwo.nl/en/impact-outlook-approach>

²⁷ By April 1st 2023, there were 38 respondents to the survey. 18 of those were ESFRI landmarks, and 12 were ESFRI projects. Other 8 were not ESFRI RIs (for example a non-ESFRI ERIC, synchrotrons, research centres).

lists of impacts of RIs without the appropriate methodology with which this information could be reliably measured.

Regarding the methodology for assessing impact, the results from the impact assessment survey reveal that most RIs use (or are planning to use) a combination of different methods (53% of the 40 RIs who answered the questions). Among the most commonly mentioned methods are impact pathway, case studies, while some RIs also use cost-benefit analysis.

Most respondents (93%, or 43 out of 46 who answered the question) are interested in measuring the scientific impact of their RI. 78% also measure (or “would” measure, if the impact assessment was not performed yet) societal impact, 70% of RIs measure talent development, and the same number economic impact. Fewer RIs (43%) are interested in measuring impacts on policy. Among other answers were environmental impact and technological impact.

Responding RIs noted several challenges related to impact assessment. For example, several RIs noted the challenge of identifying a suitable method or framework, or finding appropriate indicators. Others noted the extent of the resources needed and the timeframe needed to evaluate the impacts of their infrastructure properly. In general, some RIs are worried that impacts may not be correctly detected. This is similar to the “traceability” issue that the ERIC Forum has also mentioned – there is uncertainty on how to link activities of RIs or data that are generated within RIs, to its later use. One RI noted that measuring innovation or societal impacts could take several decades.

It is important to note that some challenges may be specific (or more common) to a type of RI or the thematic areas that it covers.

An overview of the impact assessments reported is provided in the Annex. It includes information regarding the type and domain of RIs, who conducted their IA, and brief overview of the methodology, if there is one provided or discernible from the report. Selected cases are presented in more detail in the following sub-chapter as examples of good practices.

Some examples of impact assessments performed by RIs

This chapter aims to present the variety of approaches used by the RIs, the impacts and some methodological challenges observed.

Integrated Carbon Observation System (ICOS)²⁸

The ICOS (Integrated Carbon Observation System) is a pan-European research infrastructure for quantifying and understanding the carbon cycle and greenhouse gas fluxes and concentrations. The impact assessment report, published by Technopolis group in 2018, aimed to evaluate the scientific, societal, and economic impacts of ICOS and its contribution to addressing key societal challenges.

The study used a mixed-methods approach, including surveys, interviews, case studies, bibliometric analyses, and a social return on investment analysis. The authors evaluated the impact of ICOS based

²⁸ https://www.icos-cp.eu/sites/default/files/2018-10/ICOS_Impact_Assessment_2018.pdf

on its strategic objectives and in five key areas: observations, science, climate action support, innovation and (global) cooperation.

The impact of collected data was measured with the help of 17 impact indicators which corresponded to the ICOS' strategic objectives. The most important impact of ICOS regarding observations was that it transferred many observational stations that were already existing into a stable highly-standardised infrastructure and with that secured long-term data sets which are of highest importance in climate science.

The innovation objective was further defined as 'promoting technical developments'. To measure impact, two corresponding indicators were used, one to measure downstream economic effect of ICOS, the other to measure upstream economic effects (investments mobilised by ICOS). Collection of data for these indicators were done through document analysis and interviews with commercial partners, as well as survey filled out by scientists, ICOS employees and private sector parties related to ICOS. The data showed the contributions of ICOS to technological development in its field, as well as a positive effect on the employment of related institutions. ICOS also mobilised a capital value creation of €108 M, the largest part of which came through investments in the hardware and the construction work of the ecosystem stations.

In general, the study found that ICOS has made significant contributions to scientific research and technological development related to the monitoring and understanding of greenhouse gas emissions and uptake. Additionally, ICOS has contributed to addressing key societal challenges, such as climate change mitigation and adaptation, by providing reliable and relevant data to policymakers and the public. The economic impact of ICOS was estimated to be around €21 million in 2016, with potential for growth in the future. Finally, ICOS was found to have positive environmental impacts, such as contributing to the development of more sustainable agricultural practices.

However, the study also identified some methodological challenges in measuring the impact of ICOS, such as difficulties in establishing causal relationships between ICOS and its impacts, limited data availability in some areas, and the complexity of quantifying the societal and environmental impacts of ICOS. The latter included a missing concept on how to quantify preserved assets that would be lost without climate mitigation action.

Despite these challenges, the study concludes that the impact of ICOS is significant and positive, and the infrastructure plays an important role in addressing key societal challenges related to climate change.

European Social Survey (ESS)²⁹

ESS monitors the number of users who register to access its data and documentation. As of May 2023, that number stood at just over 217,000 since data was first provided in 2003. The most recent publication monitoring found almost 6000 publications that have used its data.

In addition to the core monitoring undertaken by the RI, the ESS has commissioned Technopolis to undertake two impact studies to assess the reach and influence of the survey on academia, policy, and

²⁹ Technopolis (2022). SUSTAIN-2: Impact study of the European Social Survey. <https://www.europeansocialsurvey.org/docs/findings/ESS-Impact-Study-2.pdf>

public discourse²⁵. The most recent study, published in June 2021, used a mixed-methods approach that included bibliometric analysis, case studies, and document analysis.

The most recent study found that comparing June 2021 to the start of the earlier impact study in June 2016, the number of registered ESS users has almost doubled. The ESS user base has grown consistently by around 14-15% in each of the last five years before June 2021, and its composition has largely stabilised to around two-thirds of students, one-quarter of academics and just under 10% other (typically non-academic) user types. Whilst there is substantial movement in the overall user numbers, there is also evidence of much repeat-use. Of the roughly 50,000 non-student ESS users registered by 2020, 7,712 had logged in and downloaded data within the calendar year. The impact study authors estimated that around 3,500 of these were repeat-users, who registered in a previous year and have since returned.

The ESS is also widely used in teaching. In 2016, there were 18 institutions with more than 500 confirmed users (including four with over 1,000 users). By the start of 2021, this increased to 42 (including 15 institutions with over 1,000 confirmed users).

Bibliometric analysis was conducted to examine the ESS's contribution to scientific output by analysing the number of citations and co-citations of ESS data in scholarly publications. The citation impact of the 2,448 ESS-based items listed on Web of Science, is well above average, being about 70% more highly cited than average, with 21% of all ESS publications belonging to the top 10%. The journals in which work is being published have a citation impact of 40% above the world average.

Case studies were conducted to explore the ESS's impact on policy and social science research in greater depth. Country-level research yielded many examples of non-academic impacts of different types and across different domains. These take many different shapes, including general intelligence and insight for NGOs or government ministries, agencies or advisory bodies; agenda setting by using ESS data to highlight a particular problem or challenge, triggering various types of policy action; influence on public debate or highlighting certain issues to the general public through presentation of ESS data or ESS-based findings in the news media; and monitoring, i.e. using ESS data as indicators to track certain aspects of societal programme.

Most recently ESS has focused on monitoring and improving use of ESS data and findings at the EC level. ESS has commissioned a study to map current use and suggest additional pathways for the future. Results will be available later in 2023.

ELIXIR³⁰

The article describes an assessment of the public value created by ELIXIR, a research infrastructure for life science data. The authors used a framework based on three pillars of public value - economy, social, and political - to evaluate ELIXIR's impact on society. The study used a mixed-methods approach, including a survey of ELIXIR's stakeholders, case studies, and bibliometric analysis. The results indicated that ELIXIR had created significant public value by contributing to scientific discovery, enabling

³⁰ Corinne S. Martin et al. (2021). Demonstrating public value to funders and other stakeholders – the journey of ELIXIR, a virtual and distributed research infrastructure for life science data
<https://onlinelibrary.wiley.com/doi/10.1111/apce.12328>

innovation and industry development, and enhancing the capacity for scientific research across Europe. The following types of impacts were identified:

- ELIXIR's support in accelerating the pace of research in life sciences and enabling more efficient and effective collaboration between researchers.
- The development of new tools and resources that have led to new discoveries and publications in high-impact journals.
- The generation of new economic benefits through the creation of start-ups and the development of new products and services.
- The improvement of healthcare and patient outcomes by enabling better analysis and sharing of clinical data.
- The enhancement of research training and career development opportunities for researchers in the life sciences.
- The provision of a more coordinated approach to research data management, which has led to increased efficiency and reduced costs.
- The strengthening of relationships between ELIXIR and other research infrastructures, which has resulted in increased collaboration and sharing of resources.

The authors also identified some methodological challenges, such as the difficulties in attributing causality and the limited availability of data on some aspects of impact, particularly in the social and political domains. The study demonstrates the importance of assessing the public value created by research infrastructures to inform decision-making and secure continued funding and support.

Diamond Light Source³¹

The assessment of Diamond Light Source, the national synchrotron facility of the United Kingdom, was conducted by the Technopolis Group in collaboration with Diamond staff, and the final report was released in May 2021. The study aimed to explore the facility's impact in scientific, technological, societal, and economic areas and evaluated the data using key indicators for each stage of activities, outputs, outcomes, and impacts.

To collect data, the study used an online survey of users and suppliers, interviews with stakeholders, and analysed Diamond's event logs, databases and website. To assess the facility's impact, the study used case studies, user estimates of value, and desk-based research.

To determine impact, the study attempted to monetise the value of outputs and outcomes in each of the four impact areas. For example, the monetisation of the scientific impact of Diamond was based on the facility's contribution to knowledge creation, industry income, and benefits to users.

Overall, the study found that Diamond had a cumulative monetised impact of at least 1.8 billion GBP since beginning operation in 2007, which compares favourably with the investment in the facility. The report notes that the estimated impact might be conservative, as some benefits that were monetized

³¹ Technopolis (2021). Diamond Light Source: Socio-Economic Impact study report.
<https://www.technopolis-group.com/wp-content/uploads/2021/06/Socio-Economic-Study-Report-Diamond.pdf>

through the study were based on fewer data points and were not incorporated in the cumulative impact e.g. benefit to Diamond's suppliers each year, contributions to the value of patents each year by proprietary users of Diamond, etc. Furthermore, the study noted that some benefits, particularly societal ones, were deemed not possible to monetise. This includes visitors who were reached through a programme of engagement at the heart of the facility and widespread awareness of the value and relevance of STEM subjects to everyday lives.

The authors noted that the industrial or commercial case studies, which were chosen to attempt to quantify the economic impact, had issues with the willingness or ability of those consulted to quantify impacts or attribute some part of these to Diamond. Some were unwilling to share information due to commercial confidentiality.

CONCLUSIONS

The impact assessment is an important part of the policy-making process, as it helps in evaluating the potential effects of proposed policies on various stakeholders and making informed decisions about whether to adopt, modify, or reject a proposed policy. It also helps them communicate the benefits of public investment on society. For these reasons, its importance has grown over recent years, and the domain of Research Infrastructure (RI) policy is no exception. Acknowledging the relevance of impact assessment, the ESFRI Strategy working group has organised two conferences on this topic.

Recently, Competitiveness Council have asked "ESFRI to look into the approaches by Member States, the Commission, international organisations and RIs to assess scientific, societal and economic impacts of investments in RIs, identify good practices, develop a monitoring framework, test it and elaborate recommendations to national and regional RI stakeholders by the end of 2023". ESFRI has responded to this request by setting up a drafting group tasked with preparing the report based on information collected from literature and questionnaires to the ESFRI member countries and RIs.

This report highlights the importance of understanding the differences between performance monitoring, which ESFRI started implementing last year, and impact assessment (IA), ex-ante or ex-post, for research infrastructures (RIs) and provides recommendations for stakeholders, policymakers, funders, governments, RIs, ESFRI, and the EC. Key points include the following:

- Acknowledging the differences between RIs and avoiding direct comparisons in impact assessments.
- No one-size-fits-all methodology for impact assessments; a customized approach should be taken.
- Recognizing the primacy of scientific impact while also considering other socio-economic impacts.
- Taking into account the longitudinal nature of impact assessments and the need for data collection over time.
- Ensuring adequate resources for impact assessments and the development of internal expertise.

- Integrating impact analysis frameworks into RI governance systems.

IA methodologies, be it ex-ante or ex-post, addressing running RIs vary significantly. In fact, there is no optimal methodology which could be recommended. They all have their strengths and weakness, and the choice depends on several factors, such as the objectives of the RI and the assessment. Consequently, the report does not develop a one-size-fits-all type of a monitoring framework, as requested by the Council, but proposes an ESFRI approach to impact assessment. This approach stipulates that ESFRI will not undertake IA of RIs itself, and leaves the choice of the method to be determined by the RIs and their stakeholders instead. It also presents recommendation aimed to develop the field further, increase the quality of impact assessments and their role and use in RI policy and management.

General recommendations

- Understand the distinction between performance monitoring and impact assessment. Although interconnected, these processes serve separate functions in ensuring that RIs achieve their objectives. It is crucial to recognize their unique roles for a comprehensive evaluation of RIs.
- Establish consensus on assessment objectives and impact dimensions. Collaborative agreements among stakeholders, including RIs, funding agencies, governments, and relevant RI bodies, are essential for determining the appropriate impact assessment methodology and dimensions. This consensus should be based on clear expectations of the objectives of an RI and the assessment itself.
- Avoid using impact assessments for direct RI comparisons. Given the significant variations in objectives, organization, size, and maturity among RIs, impact assessments should not be employed for simplistic comparisons. Instead, focus on clearly defined evaluation criteria, contextual factors, and outcome-focused benchmarking to identify individual RI strengths, weaknesses, and inform decision-making.
- Adopt a tailored approach to impact assessment methodology. Methodologies have inherent advantages and disadvantages, necessitating a customized selection process that considers factors such as assessment objectives, available resources, data accessibility, and intended assessment users.
- Prioritize scientific impact in assessments. The primary purpose of RIs is to enable or enhance specific research endeavours. Consequently, the contribution of RIs to scientific excellence within a research field should be a crucial and central impact assessment dimension.
- Consider impacts beyond scientific achievements. RIs also generate socio-economic impacts, such as increased innovation, economic growth, improved policymaking, or talent development. The extent and nature of these impacts should be determined case-by-case, following a mutually agreed framework between RIs and stakeholders.

- Recognize the differences between ex-ante and ex-post impact assessments. While potential impacts during the design phase are inherently theoretical, operational phases allow for more concrete demonstrations of impact.
- Adopt a long-term perspective for impact assessments. Impacts may take years to manifest following initial RI investments, necessitating both timing considerations during impact discussions and early initiation of data/information collection for impact assessments.
- Promote results of RI impact assessments. RIs, governments, and ESFRI should utilize impact assessments to showcase RI contributions to science, society, and the economy. Comprehensive communication efforts will foster positive development and funding in the RI domain.

Recommendations to policymakers, funders and governments

- Conduct regular impact assessments for RIs with proper timing considerations. Periodic evaluations are crucial, but it is essential to recognize that certain types of impacts may not materialize immediately after initial investments. Allow for the adequate time when expecting the manifestation of impacts.
- Allocate sufficient resources for impact assessments. Impact assessments can be complex and expensive, as they often involve long-term information collection and significant human and financial resources. Funders should provide adequate funding for the necessary level of impact assessment and align their expectations with available resources.
- Emphasize a customized approach for each RI. A single, unified method for impact assessments is unsuitable for applying across all RIs due to varying objectives, scopes, and activities. Although some impact indicators may be shared across RIs, it is essential to adopt a tailored approach that accounts for each RI's unique characteristics and requirements.

Recommendations to Research Infrastructures

- Define relevant impact dimensions in a proactive way. RIs are very different and cannot be assessed with a single method or single sets of indicators. However, RIs should reflect at an early stage not only on performance but also in what areas they would create impacts. Showcasing impacts is difficult and requires good information, often over a long period. Therefore, as for monitoring outputs and outcomes through the collection of KPIs, relevant impacts need to be clearly defined and outlined, and the relevant data and information need to be collected.
- Develop internal expertise for impact assessment. Analysing the impacts of the RI requires specific expertise, which is important to develop in-house to be able to design the indicators and track them over time, analyse and interpret the collected data as well as adapt the assessment framework over time depending on specific needs. This will also be of significant help also when/if external expertise is employed.
- A high-quality approach may require internal and external impact assessments. Both internal assessments, performed by RI's staff and/or stakeholders, and external, employing third-party

experts, can be used for impact assessment. They both have advantages and weaknesses, and the choice will often depend on internal capacities and knowledge, resources available, goals of the impact assessment, etc. It may be beneficial to use a combination of both approaches to ensure a comprehensive and balanced assessment of impacts.

- Integrate an impact analysis framework into the RI governance system. To follow up the RI's impacts over time in a coherent way, allowing to capture the evolution of these impacts properly, the assessment needs to become a permanent activity of a RI, with dedicated human and financial resources.

Recommendations to ESFRI

- Recognize the importance of impact assessment for ESFRI. Impact assessment is essential for policymakers to evaluate and direct investments. As a key player in shaping the European RI landscape, ESFRI should conduct periodic reviews of RIs' impact assessments to encourage knowledge-sharing and good practices. Additionally, ESFRI can facilitate mutual learning by including impact assessment discussions in workshops and other collaborative events.
- ESFRI's role should focus on guidance rather than direct assessment. Although impact assessment is highly relevant for ESFRI, its contribution should be limited to offering guidance and promoting the exchange of experiences. ESFRI should encourage RIs and their stakeholders to perform periodic impact assessments, incorporating the results as supplementary information in regular performance monitoring.
- Consider conducting an impact assessment of ESFRI itself. ESFRI may consider initiating an impact assessment of its activities, which extend beyond the selection of European RIs through the ESFRI roadmaps. This evaluation could help demonstrate ESFRI's influence on the European Research Area (ERA).

Recommendations to the EC

- The EC is invited to consider further supporting the development of the impact assessment methodology. In particular, in addition to the methodology and the indicators, case studies would be of significant added value, as they support the demonstration and dissemination of the methodologies and foster their broader uptake.

ANNEX

Table 1: Impact assessments conducted at ESFRI RIs.

Note: Data was collected through publicly available material or via a dedicated survey. Some IA reports may be missing.

ESFRI RI/project	Type	Domain	Conducted by	Methodology / theoretical approach
ACTRIS (Aerosol, Clouds, and Trace Gases Research Infrastructure)	Distributed Landmark	Environment	ENVECO “Environmental Economics Consultancy”	Pre-study which followed the Step by step procedure; broadly following Florio & Sirtori suggestions on how to identify benefits of a research infrastructure. Focus on identifying as many impacts as possible as a first step before a full CBA Methods of data collection: questionnaire survey case studies: studies of specific ACTRIS contribution
E-RIHS (European Research Infrastructure for Heritage Science) ³²	Distributed Project	Social & Cultural Innovation	Lead author: CSIL (Silvia Vignetti et al.); within context of E-RIHS PP (Preparatory Phase)	Combines cost-benefit analysis (for quantifying direct impacts through the estimation of willingness to pay of potential users) and qualitative discussion of wider long-term impacts and their pathways.
EATRIS (European Advanced ³³ Translational Research Infrastructure)	Distributed Landmark ERIC	Health & Food	RI-PATHS pilot	Pilot study (no formal IA yet) – exploration of various methodologies within RI-PATHS project. e.g., User feedback surveys, bilateral interviews, case studies
ELIXIR	Distributed Landmark	Health & Food	RI-PATHS pilot Separate study focused on economic impact carried out by Beagrie Ltd.	Co-designed by IA experts + RIs themselves modular - modules specific to distributed RIs and to life sciences quantitative (e.g. macroeconomics ; or specific performance indicators) qualitative (e.g. users' narratives of ELIXIR impact on their work + societal impact;) internally, focus groups

³² <https://www.e-rihs.eu/wp-content/uploads/2020/02/D6.1-E-RIHS-impact-assessment-document.pdf>

³³ https://www.eric-forum.eu/wp-content/uploads/ERIC-Forum-Policy-Report_October-2022.pdf

EMBL-EBI	Intergovernmental org.; involved in ESFRI RIs ELIXIR and Euro- Bioimaging	Health & Food	2015-16 and 20-21: Charles Beagrie Ltd. 2021: Technopolis	Beagrie: 2 studies to develop a framework + evidence base for demonstrating economic value + impact of open data resources Methods: cost/benefit, input/output analysis, case studies, »Perpetual inventory method«. Method of collecting data: internal data/reports, user surveys and interviews Technopolis: surveys + analysis of external (non-EMBL) users of EMBL, and case studies
ESS (European Spallation Source) ³⁴	Single-sited Landmark ERIC	Physical sciences & engineering	Centre for Technology Department Entrepreneurs hip of the Technical University of Denmark in collaboration with ESS ERIC within the framework of BrightnESS project OTHER: work within ACCELERATE project	Self-monitoring Survey with suppliers to ESS Survey with ESS In-Kind Partners
ESS (European Social Survey)	Distributed Landmark ERIC	Social & Cultural Innovation	2 studies: 2016-2017 conducted by Technopolis and a follow- up in 2021- 2022, within SUSTAIN-2 project	mix of quantitative and qualitative methods. 4 core components: -user data update -country-level research -social media analysis -bibliometric analysis
ESRF-EBS (European Synchrotron) ³⁵	Single-sited Landmark	Physical sciences & engineering	Self- monitoring	No methods listed in the report. Reported impact (self-monitoring) in following areas: -international collaboration -training -innovation, economic growth -sustainable future

³⁴ https://www.eric-forum.eu/wp-content/uploads/ERIC-Forum-Policy-Report_October-2022.pdf
https://europeanspallationsource.se/sites/default/files/files/document/2020-12/20201202_ESS%20SEI%20brochure_FINAL.pdf

³⁵ <https://www.esrf.fr/files/live/sites/www/files/about/upgrade/documentation/21%20EBRO%20IMPACT%20BAT%204%20BD.pdf>

EST (European Solar Telescope) ³⁶	Single-sited Project	Physical sciences & engineering	Instituto de Astrofísica de Canarias "Report on technical, financial, and socio-economic aspects of EST"	Input-output model (for economic returns)
ET (Einstein Telescope)	Single-sited Project	Physical sciences & engineering	Research group of University of Sassari	Ex-ante assessment of potential socio-economic impact in Sardinia. Qualitative + quantitative approach to evaluate economic, social, environmental impact Methods: Input-output method, impact multipliers, cost-benefit analysis
European Southern Observatory (ESO) /Extremely Large Telescope (ELT)	Single-sited Landmark	Physical sciences & engineering		No methods listed in the report. Reported impact in following areas: -science & engineering -economy & innovation -talent development -education and outreach -international collaboration and policy
FAIR GmbH	Single-sited Landmark	Physical sciences & engineering	Not impact assessment, external reviews on demand of shareholders; e.g.: <i>Committee for first-science and staging review of the project</i>	Investigation of the science case of FAIR (re: progress of construction, requested budget) + suggested options to proceed
GGP (Generations and Gender programme)	Distributed Project	Social & Cultural Innovation	Self-reported	No formal impact assessments; self-reported impacts In survey they note: Case studies, policy impact, use of performance indicators
HL-LHC (Large Hadron Collider) at CERN ³⁷	Single-sited Landmark	Physical sciences & engineering	Application of the Cost-benefit analysis	CBA

³⁶ https://est-east.eu/images/media/pdf/EST_socio-economic_web_version.pdf

³⁷ <https://www.sciencedirect.com/science/article/pii/S0040162516000731>

https://deliverypdf.ssrn.com/delivery.php?ID=90711708102501412410102200106512507202603204600906507810812310806712712307008700002503205209612603901500111802702008800409611704205706400805210208208201119007073003058041083069082071066021073083091121003079110028028086026115112086118012072088085074&EXT=pdf&IN_DEX=TRUE

			framework (developed by Florio & Sirtori (2015); Florio et al. (2016)). University of Milan & Centre for Industrial Studies (Milan, Italy)	
ICOS (Integrated Carbon Observation System) ERIC ³⁸	Distributed Landmark ERIC	Physical sciences & engineering	Technopolis	Data-driven methods: Funding grants & financial flows, Project participations & partners, ICOS Carbon Portal usage, (social) media appearance, website usage, bibliometric data Qualitative methods: Literature analysis, impact mapping workshop, case studies, interviews
IFMIF-DONES	Single-sited Project	Energy	MDPI; authors: Fernández-Pérez, V.; Peña-García, A. The Contribution of Peripheral Large Scientific Infrastructures to Sustainable Development from a Global and Territorial Perspective: The Case of IFMIF-DONES ³⁹	As a case study on contribution of large scientific infrastructures to sustainable development. Analysing impact on environmental, social, and economic system; using socio-economic indicators and sustainable development goals
ILL (Institute Laue Langevin)	Single-sited Landmark ERIC	Physical sciences & engineering	n/a	Impact pathways + case studies
JHR – Jules Horowitz reactor	Single-sited Landmark	Energy	n/a	
METROFOOD-RI	Distributed Project	Health & Food	Within METROFOOD-RI preparatory phase project	Case studies + cost benefit analysis Taking account 7 impact areas (scientific, political, environmental, societal, economic, human resources, technological & innovation)

³⁸ <https://www.icos-cp.eu/sites/default/files/cm/icos%20Impact%20Assessment%20Report%202018.pdf>

³⁹ <https://www.mdpi.com/2071-1050/13/2/454>

SHARE (Survey of Health, Ageing and Retirement) ⁴⁰	Distributed Landmark ERIC	Social & Cultural Innovation	Self- monitoring (presented yearly in activity report in the chapter about SHARE's policy impact)	Qualitative and quantitative methods Use of performance indicators
Square Kilometre Array	Single-sited Landmark	Physical sciences & engineering	n/a (ongoing)	(ongoing process)

⁴⁰ https://www.eric-forum.eu/wp-content/uploads/ERIC-Forum-Policy-Report_October-2022.pdf