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Title
DiSSCo Prepare Deliverable D1.4 Report on socioeconomic impact indicators of DiSSCo and DiSSCo-enabled research and research applications

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Abstract
This Deliverable 1.4 report for DiSSCo Prepare Work Package 1 Task 1.4 recommends 29 socio-economic impact indicators to be adopted by DiSSCo. The indicators were selected and adapted for the DiSSCo mission and services, as a result of an extensive review of recent frameworks and studies of socio-economic impact of research infrastructures. The initial review compiled a list of socio-economic impact indicators recommended or used for the assessment of research infrastructures. The report also includes the review of the analysis of impact assessments of research infrastructures and institutions analogous to the goals and domain of activity of DiSSCo. From the analysis of the scope of DiSSCo, the areas of impact, user communities and services, it was possible to identify the relevance of indicators to be adopted by the research infrastructure. Each of the 29 indicators is fully defined and described in the context of DiSSCo's implementation. Although the indicators are all relevant and useful for DiSSCo, it is recommended that future feedback from DiSSCo stakeholders is used to further limit this list to a smaller core of indicators.

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Report on socio-economic impact indicators of DiSSCo and DiSSCo-enabled research and research applications

DiSSCo Prepare WP1 – Deliverable 1.4

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ABSTRACT

This Deliverable 1.4 report for DiSSCo Prepare Work Package 1 Task 1.4 recommends 29 socio-economic impact indicators to be adopted by DiSSCo. The indicators were selected and adapted for the DiSSCo mission and services, as a result of an extensive review of recent frameworks and studies of socio-economic impact of research infrastructures. The initial review compiled a list of socio-economic impact indicators recommended or used for the assessment of research infrastructures. The report also includes the review of the analysis of impact assessments of research infrastructures and institutions analogous to the goals and domain of activity of DiSSCo. From the analysis of the scope of DiSSCo, the areas of impact, user communities and services, it was possible to identify the relevance of indicators to be adopted by the research infrastructure. Each of the 29 indicators is fully defined and described in the context of DiSSCo's implementation. Although the indicators are all relevant and useful for DiSSCo, it is recommended that future feedback from DiSSCo stakeholders is used to further limit this list to a smaller core of indicators.

KEYWORDS

SOCIO-ECONOMIC IMPACT,

RESEARCH INFRASTRUCTURES,

INDICATOR COMPILATION,

KEY PERFORMANCE INDICATORS

INDEX

01 INTRODUCTION

This deliverable report summarises the recommendations from DiSSCo Prepare Task 1.4 of a list of 29 socio-economic impact (SEI) indicators to be implemented with the goal of supporting the future assessment and monitoring of DiSSCo's socio-economic impact to research and society.

The list was prepared after an extensive review, compilation and aggregation of recent frameworks and studies of socio-economic impact of research infrastructures (RI), namely ESFRI (2019), OECD (2019), RI-PATHS (Helman et al.,2020) and ALA (Alluvium, 2016). The result of this compilation was reported in Milestone 1.4 (Figueira et al., 2022).

The report also includes the review of the analysis of impact assessments of RI and institutions analogous to the goals and domain of activity of DiSSCo. An analysis of the scope of DiSSCo, the areas of impact, user communities and services provided guidance to identify the relevance of indicators to be adopted by the research infrastructure. Each of the 29 indicators was fully re-defined and described in the context of DiSSCo's implementation.

This report aims to support the future implementation of SEI indicators by DiSSCo. The following sections of the report include i) the description of the scope of DiSSCo socio-economic impact assessment, including the framework of research infrastructures it integrates, and its domain of knowledge and application; ii) the methodology to develop and define the list of suggested indicators; iii) the review of existing frameworks of SEI for RIs, iv) the review of relevant SEI studies applicable to the domain of biodiversity and natural history collections, v) the identification of the areas of impact, users and services of DiSSCo, vi) the suggested list of SEI indicators and, vii) the identification of next steps towards the implementation of the SEI indicators.

02 SCOPE OF DiSSCo SOCIO-ECONOMIC IMPACT ASSESSMENT

The need to perform a credible socio-economic impact assessment is justified by the demand for understanding and evaluating the return on investment in these facilities, to support informed decision-making and RIs management with useful information for negotiations with funders (OECD, 2019). In the case of RIs that are part of ESFRI Roadmaps, this is also a requirement as part of their regular assessment of the scientific case (ESFRI, 2021).

For RIs, the scientific output is the most important, but the SEI has a broader scope, by including environmental, cultural, educational, economic and social impacts.The SEI of different RIs should never be compared because of their uniqueness (Hajdinjak, 2019). The SEI assessment faces several challenges that need to be considered (Hajdinjak, 2019; OECD 2019):

- difficult to perform in cutting edge fields
- RI targets multiple stakeholders
- research outcomes uncertain and non-linear
- time lag between research and impact
- difficult to gather data about impacts and to verify them
- impacts can be direct and indirect, intended and unintended, quantitative and qualitative
- changes (endogenous and exogenous) during the lifecycle of the RI
- the relevant types of impact varies depending on RI specific goals
- quantitative and qualitative impact assessment methods are diverse (e.g. experimental and quasi-experimental impact evaluation methods; value-for-money methods like cost benefit analysis) and some require information difficult to obtain like uncertainty data or social discount rate).
- societal impact may be broad and difficult to measure and allocate monetary value.

Furthermore, there might be legal barriers related to non profit status, limitations of commercial activities and profit making depending on the legal forms of the European Research Infrastructure Consortium (ERIC) and the member institutions of the RI.

There are several approaches to measure SEI, but no single method can appropriately meet the information needs for that assessment (Vignetti et al., 2019). Furthermore, many RIs implement monitoring schemas using Key Performance Indicators (KPIs), but fewer collect indicators for impact assessments (Vignetti, 2021). Although connected, impact assessments are not identical to monitoring. The performance monitoring is a continuous process generating data to track the progress of an action, while the impact assessment is a

structured process that takes place at a given point in time, allowing the assessment of the implications (past, future or both) of proposed actions (Vignetti, 2021).

DiSSCo crosses two domains, environment (biodiversity and geodiversity) and digital data, in the scope of museums, particularly natural history collections. Therefore, impacts could result from both domains, possibly synergistically. A SEI study targeted to assess, by a Cost-Benefit Analysis (CBA), the benefits of improving the knowledge about biodiversity in Australia (Deloitte Access Economics, 2020), namely the discovery and documentation of species, indicates that for each dollar spent, benefits range from 4 to 35 dollars. The return results from an increase in biosecurity diagnostics, e.g. reducing the frequency of genuine threats, from biodiscovery for human health, agriculture R&D and biodiversity conservation.

These results can be leveraged by the digitisation of collections, which increases accessibility and usability of data for knowledge production. In another study (Popov et al., 2021), it was found that the full digitisation of the London's Natural History Museum collections would give a return of seven to ten times on the investment, with a benefit of 2 billion pounds over 30 years. This figure resulted from the analysis of the impact of digitisation on five areas: biodiversity conservation, medicines discovery, invasive species, agriculture R&D and mineral exploration.

In addition to these, it is reasonable to expect additional increased impacts where natural history collections already have an important role, like on defining baselines and time-series for key environmental variables, on training and education, and on scientific communication. Several reviews have discussed the use of natural history collections with examples (Brooke, 2000; Suarez and Tsutsui, 2004; Tewksbury et al., 2014; Rocha et al., 2014).

DiSSCo aims to digitally unify all European natural science assets under common access, curation, policies and practices. It will create a unique access point for integrated data analysis and interpretation through a wide array of digital services provided by its community. This sharing and harmonisation of practices and processes will promote capacity transfer between countries and between bigger and smaller institutions, contributing to levelling up their capacity and the accessibility of their collections.

DiSSCo will enable the data to be easily Findable, Accessible, Interoperable and Reusable (FAIR principles). For researchers, this will make access to data instantaneous, and in many cases reduce costs and the negative impacts of travelling. But the digital transformation of museums can also occur in its interaction with the public, which, through the exploration of the Digital Specimen concept and digital technologies, can make passive visitors into active participants. Ruttkay and Bényei (2018) provide examples how digital technologies in museums can promote motivation and engagement, education in different ways, learning by doing, participation, adaptation to different visitors and extension in time and space. Digitisation not only enables access to objects in different ways, but also enriches it with metadata.

The digitisation and FAIRification (see Glossary) of Natural History Collections will create large volumes and diversity of data (*big data*). This will support existing scientific and knowledge creation activities, in environment, biodiversity, and related domains mentioned earlier. It is, additionally, a possible source? forum? for new data-driven innovation (OECD,

2015) resulting from machine learning and artificial intelligence applications. The DiSSCo RI may well turn out to be a data infrastructure in the sense defined by OECD (2015), with potential for value creation based on the following properties of data: *i) the non-rivalrous nature of their consumption, ii) their non-excludability, and iii) the economics of scale and scope in the creation and use of data*. In fact, data aggregation and access through DiSSCo can be seen as an infrastructure resource, meaning a non depletable capital good and with a theoretical unlimited range of purposes, even outside the domains of its origin. It is necessary, nevertheless, that data are under a governance framework (non-excludable and non-rivalrous are characteristics of the public goods) for better data access, sharing and interoperability, a component of the DiSSCo RI construction and implementation.

03 METHODOLOGY

The methodology applied to the definition of a list of recommended SEI indicators for DiSSCo followed the workflow described in Figure 1.

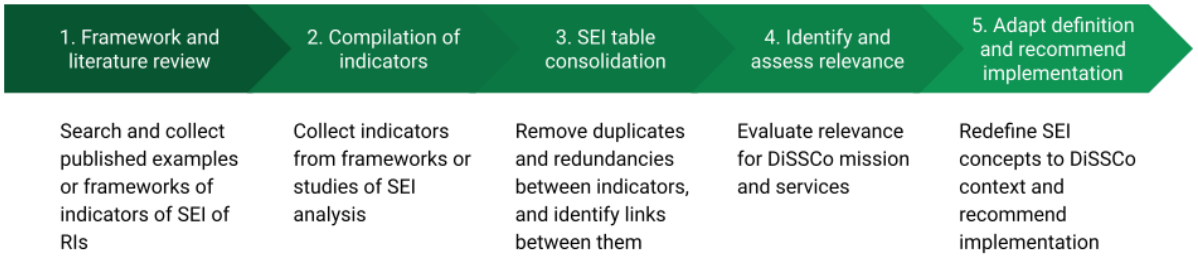

Figure 1. Workflow of the compilation, adaptation and recommendation of the SEI indicators for DiSSCo.

Steps 1 to 3 were reported in detail in DPP Milestone 1.4 (Figueira et al., 2022). These included the identification of existing frameworks for RI impact assessment, in particular those applied to ESFRI projects or landmarks, and an extensive bibliographic review on SEI exercises practised in other types of organisations or institutions and initiatives, with a special focus to the domain of environment, including biodiversity.

The compilation of indicators included the transcription of the original source, and, in some cases, a disaggregation, as in the case of indicators for the RI Atlas of Living Australia (Alluvium, 2016), to ensure the indicator to be equivalent in scope to the indicators of other frameworks. The objectives and impact areas of the different frameworks were interpreted in order to classify all compiled indicators, to enable further analysis to identify and select the most relevant indicators for DiSSCo.

Finally, a consolidation step was necessary to remove duplicates of indicators between frameworks, as well as redundancies between similar indicators. Nevertheless, these duplications were documented in an auxiliary table for future reference. The consolidated table retains 24 columns for the description of the indicators.

The full file of compiled indicators is available in Figueira et al., (2022), and contains the following sheets:

- **metadata**: description of the tables and columns included in the file;
- **list_indicators**: List of all indicators found in the four frameworks consulted (ESFRI, 2019; OECD, 2019; RI-PATHS in Helman et al., 2020; and Alluvium, 2016);
- **list_consolidated**: Consolidated list of indicators, obtained after removing duplications and redundancies between indicators of different frameworks. Only

columns with meaningful information at this stage are kept in this consolidation. The columns of this table have the same meaning as in list_indicators;
- **related_indicators**: links between duplicated or redundant indicators of different frameworks;
- **references**: reference list of the consulted frameworks.

To determine the relevance of the indicators for DiSSCo, Step 4 analysed the indicators in relation to the scope of DiSSCo and the expected services to be implemented. This assessment conducted by three task members led to a reduced list of 30 indicators. In addition, the list was evaluated by participants at the All-Hands Meeting 2 workshop Task 1.4., through an on-line survey. Participants were asked to rate, in a 5-point Likert scale, the relevance of each of the indicators, which are arranged in four impact areas: users, economy and innovation, policy and society.

The final step works the original definition, description and calculation requirement of indicators to adapt them to the specific scope of DiSSCo mission and services. This was done through an indicator reference sheet, which includes the terms listed in Table 1.

Table 1. Indicator sheet terms used to describe SEI indicators.

Term	Description	Reference
Indicator Name	name of the indicator	ESFRI (2019)
Definition	definition of the indicator	ESFRI (2019)
Rationale	reason or objective for using the indicator	ESFRI (2019)
Assumptions	assumptions or limitations that need to be considered when using the indicator	ESFRI (2019)
DataInformation needs and Resources	data requirements to measure the indicator	ESFRI (2019)
Who provides information	name of the source of the indicator	ESFRI (2019)
Indicator Calculation	mode of calculation of the indicator	
Breakdown categories	suggested disaggregation of data, broken down by detailed subcategories	
Nature of indicator	nature of the indicator: numeric, binary, categoric, narrative	
Estimated Cost Data Collection	direct costs to collect information to obtain the indicator	ESFRI (2019)
Level reporting burden	indication of the effort needed to report the indicator	ESFRI (2019)
Frequency of measurement	frequency of reporting of indicator	ESFRI (2019)

Term	Description	Reference
Objective	identifies the objective of the RI that this indicator helps to monitor. This field is based on the ESFRI framework, and it was interpreted for the indicators of the other frameworks. Uses the following categories: Enabling Scientific Excellence, Delivery of education and training, Enhancing transnational collaboration in Europe, Facilitating economic activities, Outreach to the public, Optimising data use, Provision of scientific advice, Facilitating international cooperation, Optimising management, Enhancing Collaboration in Europe	ESFRI (2019)
Impact area	area of impact, according to Ri-PATHS framework. Assumes one of the following values: Human Resources, Economy and Innovation, Society, Policy	https://ri-paths-tool.eu/en/glossary, Helman et al. (2020)
Category of Socio Economic Impact (SEI)	category of socio-economic impact measured by the indicator, according to the OECD framework. Uses a controlled vocabulary: scientific, training and education, economic, social and societal, technological	OECD (2019)
Type of indicator	type of indicator, according to Ri-PATHS framework. Assumes one of the following values: activity, outcome, impact	https://ri-paths-tool.eu/en/glossary, Helman et al. (2020)
Additional Issues Observations	additional Issues or Observations	ESFRI (2019)
ID source	unique ID, with indication of the source of the indicator. If the source has IDs for the indicators, these are used. A prefix of the source framework is added.	

04 SOCIO-ECONOMIC IMPACT FRAMEWORKS

Three frameworks on the socio-economic impact assessment of RIs were recently published (ESFRI, 2019; OECD, 2019; Helman et al., 2020). In addition to an extended review, these frameworks resulted also from consultations with RIs through surveys, workshops or pilot studies. These prompted a useful and comprehensive list of methods and indicators that serve as a basis for the DiSSCo SEI development. We provide here a summary of the three frameworks from which indicators were compiled for this milestone. In addition to these frameworks, some other frameworks (Hajdinjak, 2019) or SEI exercises performed by RIs (e.g. ACTRIS) were also consulted, not adding, however, additional indicators to the list.

4.1. ESFRI RI performance monitoring

In an attempt to develop a common approach to measure the performance of RIs, ESFRI adopted a Working Group report published in 2019 (ESFRI, 2019) that proposed 21 key performance indicators (KPIs). These can be voluntarily adopted by a RI, and although being formulated as KPIs to measure performance, they can also be used as a proxy to measure impact. The adoption can be decided if they are aligned or adapted to the objectives and activities of the infrastructure, and follow the RACER criteria (European Commission, 2015):

- **Relevant** – i.e. closely linked to the objectives of the RI over a particular period of time.
- **Accepted** by the RI (at all levels) and stakeholders otherwise there will be limited implementation.
- **Credible** for non-experts, unambiguous and easy to interpret.
- **Easy to monitor** – e.g. data collection should be possible at low cost.
- **Robust** – e.g. against manipulation

The list of KPIs proposed are organised by nine objectives that reflect several aspects relevant to RIs. This relevance varies depending on the type and scope of the RI and phase of its life cycle. It is worth noting that the ESFRI WG proposal is targeted to the assessment of operational (landmark) RI. Its application to early phases implies adaptation. Table 2 includes a list of those objectives and their relevance to DiSSCo.

Table 2. Objectives of an RI identified by the ESFRI report and their preliminary relevance to DiSSCo.

Objective	Relevance	Phase of life cycle
Enabling scientific excellence	high	all
Delivery of education and training	high	all
Enhancing transnational collaboration in Europe	high	all
Facilitating economic activity	medium	operation
Outreach to the public	high	all
Optimising data use	high	all
Provision of scientific advice	medium	construction, operation
Facilitating International co-operation	high	all
Optimising management	medium	preparation, construction

The set of 21 KPIs proposed are all quantitative, e.g., number of users served, number of publications, number of publicly available datasets. For each indicator, a data sheet details the relevant information about its definition and description (Table 3).

Table 3. Attributes defined for each ESFRI indicator datasheet.

Indicator (name)
Definition(s)
Rationale
Assumptions
Data/information needs and resources
Who is providing this information
Detailed methodology for indicator calculation
Unit of measure
Frequency of measurement
Assessment of indicator quality and comparability
Estimated cost of data collection (including access to external databases)
Level of reporting burden
Additional issues or Observations

The structure of the datasheet is useful and will be adopted for the description of the indicators to be used by DiSSCo. Nevertheless, the report includes in the Annex 4 other possible indicators by objective, which are of narrative or boolean type. Some of these can be more appropriate when valuing impact.

4.2. OECD reference framework

The reference framework was developed in the scope of the OECD organisation (OECD, 2019), by an Expert Group of the Global Science Forum. It aims to provide funders, decision-makers and RI managers with a tool to evaluate the achievement of scientific and socio-economic objectives, in order to facilitate communication and reporting between RI stakeholders. The tool proposes a set of 25 core impact indicators that can be adopted regardless of the activity area of the RI or its life cycle phase. The list is drawn from a larger set of 58 standard indicators referred by the RI surveyed in support of the study.

The analysis provided by the report identifies the different interested stakeholders and their main interest in an RI impact assessment exercise. These stakeholders and interests include:

- **Funders** (national and/or regional authorities, other funders) - justify the investment and value for money
- **Implementers** (creators, managers or hosts of the RI) - demonstrate value of the RI and impact
- **Scientific community** - foster scientific knowledge
- **Civil society** - value for money and new scientific knowledge

In alignment to the ESFRI framework, the OECD report also identifies several strategic goals of the RI, not limited to the scientific output, but which includes cultural, educational, economic and social impact, revealing the broader scope of the RI. However, the practice of the SEI assessment needs to be connected to strategic objectives: useful, reliable, meaningful, practical and recognised (for economic indicators).

The proposed framework is based on a logic model, adapted from the theory of change, set as a pathway that includes the following steps:

- **Inputs**: the resources mobilised by the RI to perform its activities. Resources may come from multiple sources and in-kind support can be an important input.
- **Activities**: what RIs do - supporting science and technology, targeting economic and social activities and developing the skills and competencies of human resources.
- **Outputs**: the results of RI activities: scientific, educational, collaborative and economic.
- **Impacts**: intended and unintended effects of the RI's activities and outputs over their lifecycle. Activities and outputs can lead to long terms impacts on different aspects of society and the economy.

The reference framework includes 25 Core Impact Indicators (CII), which with the additional 33 indicators comprise 58 standard indicators. The former provide a general picture of the SEI of the RI at a certain time, while the full set of 58 indicators reflects the diversity of indicators used regularly by the infrastructures surveyed for the study. The CII are organised around the following sets of impact and strategic objectives categories:

Impact categories

- Scientific impact
- Technological impact

- Economic impact
- Training and education impact
- Social and societal impact

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 in a regional cluster/in regional strategies / be a hub to facilitate regional collaborations
- Promote education outreach and knowledge transfer
- Provide scientific support to public policies
- Provide high quality scientific data and associated services
- Assume social responsibility towards society

The report provides, for each indicator, the category of impact and strategic objective it belongs to, a detailed explanation of the indicator and the data needed with possible sources of information.

4.3. RI-PATHS Impact assessment framework

The Ri-Paths framework was developed in the scope of the European project with the same acronym (Helman et al., 2020). The framework proposes the impact assessment around several components. The first and most important are the impact pathways, which can be defined as *simplified causal chains of events that connect the activities carried out on a Research Infrastructure to identifiable effects on the economy and wider society*. Thirteen impact pathways are identified in the framework (Table 4), distributed around three main strategic objectives, namely, enabling science, problem solving and science and society.

Table 4. Pathways defined in the RI-PATHS framework to enable RI impact assessments.

Enabling science
Publication-citation-recognition
Employment, operations & standardised procurement
Technology transfer and licensing
Learning and training through joint development of instruments and tools
Learning and training by using RI facilities and services
Training and higher education cooperation
Problem-solving
Interactive problem-solving for the private sector (industry)
Addressing societal and public-sector challenges
Provision of specifically curated/edited data
Science and society

	Changing fundamentals of research practice
	Creating and shaping scientific networks and communities
	Promoting engagement between science, society and policy
	Communication and outreach

Not all pathways apply to all RIs, the identification of the appropriate ones should be done by the RI, in accordance with its mission and type of RI - virtual or physical facilities, single-site or distributed. The Ri-PATHS project developed an online toolkit, available at https://ri-paths-tool.eu, to guide RIs on developing their assessment exercise. In the tool, the details of each pathway indicate relevant stakeholders and a long and comprehensive list of indicators that can be considered for the specific path, which are arranged in four impact areas (Table 5).

Table 5. Impact areas considered in the RI-PATHS toolkit.

Impact area	Dimensions considered	Number of indicators
Human Resources	Research jobs and career development; Skills development for non-scientific staff and users; Relationship capital and international collaboration; Better working conditions; Wider effects	31
Economy and Innovation	Business and industry; Labour market and productivity; Technology transfer and innovation; Impact on the local and regional economy	36
Society	New solutions, technologies, open access data and software for societal use; Knowledge benefits for society in different domains; Public awareness and engagement; Cultural impact; Social inclusion; Environmental impact	17
Policy	Policy, regulations, standards and institutions; Science diplomacy; Co-funding and sustainability; Ethics and trust in science	18

The various indicators, which are quantitative or qualitative, measure (or are a proxy for) different levels of the RI impact. An indicator can measure an activity, an outcome or an impact, which, in the scope of this framework, are defined as:

Activity – Initiatives and endeavours undertaken using the resources of a Research Infrastructure or work performed by Research Infrastructure staff.

Activity indicator - Indicators that capture the scale and nature of a Research Infrastructure's activities; a measure that should form part of internal reporting. The indicators of this type can be considered KPIs, as in the case of the ESFRI framework.

Impact – Intended and unintended long-term effects of activities using the resources of a Research Infrastructure or work performed by Research Infrastructure staff.

Impact indicator - An indicator that reflects the extent and nature of generated effects in the economy and wider society; with few exceptions, impact indicators are estimations.

Outcome – Longer-term effects that stem from the stakeholder uptake of or interaction with Research Infrastructure outputs.

Outcome indicator - Indicators that document the result of the first productive interactions; collecting data by reaching out to involved stakeholders, e.g. via a survey, interview, external reporting or other data-gathering means.

The framework also provides a list of possible sources of information to support indicator calculation. This includes internal or external tracking of several parameters related to staff, users, visitors, costs, publications, citations, appearance in media and social media, events, etc, or performing surveys. The approaches for data analysis include assessment based on impact multipliers, cost-benefit analysis (CBA), approaches based on multiple criteria, theory-based approaches, case studies and narratives, input-output models and methodologies grounded in the knowledge production-function approach. These methodologies, if they are to be adopted to evaluate the impacts, also need specific information to be applied. For example, the data collection must include monetary information for costs and benefits in the case of CBA or ways to convert information into monetary units.

Cost-benefit analysis (CBA) is used to test whether a project or policy is socially profitable. It is often used to compare alternatives when it is expected that the projects or policies have social impact. To apply the methodology the social costs and the social benefits need to be quantified, usually in monetary units. The costs and the benefits can be tradable or not in the market and, consequently, there are direct pecuniary costs and benefits and also non-pecuniary effects. These non-pecuniary costs and benefits are also referred to as negative and positive externalities of the project. Examples of non-market costs of projects (promoted by private or public entities) are environmental impacts like pollution or disturbance of wildlife. In the case of digitising natural history collections, examples of non-market benefits are preservation of the physical specimens in archive (lower frequency of handling) and reductions in travelling time for the researchers. The CBA is frequently applied to support decisions about subsidising projects with expected social impact. When the social benefits exceed the social costs this can justify the attribution of a public subsidy if the project is not privately profitable or even when it is privately profitable. One challenge of the application of this method is the use of the social discount rate (SDR) reflecting the perception of society about benefits and costs over time in order to convert the future values into present values. There are different ways to compute the SDR (e.g. the social time-preference rate or the social opportunity cost rate.

Multi-criteria analysis (MCA) is applied to select alternatives adopting a set of different criteria each with a weight. This MCA contrasts with CBA because the objectives are not aggregated in a single objective. The MCA considers *m* alternatives to be assessed based on *n* attributes. One possible way to implement the MCA is (European Commission 2008, p.66; Johansson & Kristrom, 2016, pp. 202-204; Greco, Ehrgott, & Figueira, 2016): i) quantified objectives are defined (not redundant but could be alternatives); ii) a weight is

allocated to each objective (for example the relative importance given by research policy); iii) definition of appraisal criteria (e.g. based priorities by the stakeholders); iv) impact analysis which indicates an effect for each criterion (e.g. environmental protection); v) a forecast of the effects of the policy on each criterion allocating a score; vi) the associated preference function (weight) is evaluated for each criterion within each stakeholders group; vii) the project (or policy) impact is aggregated based on the sum (or other method non-linear calculation). Table 6 illustrates the methodology in a case of digitisation of the collections of a given museum.

Table 6. Methodology in a case of digitisation of the collections of a given museum.

Criterion*	Score**	Weight	Impact
Biodiversity Conservation	2	0.6	1.2
Medicines Discovery	1	0.2	0.2
Improve Mineral Exploration	4	0.2	0.8
Total		1.0	2.2

* Criteria associated with the key areas, for example. Other criteria: Equity in the access to collections; improve publication, etc.

** Score: 0=none; 1=Scarce; 2=Moderate; 3=High; 4; Very High.

In this example, the project value aggregated is 2.2. This can be compared with another project using the same approach. Another project with more than 2.2 will be preferred to this one. However, as this very simple example shows, the results and the selection are very sensitive to the ranges of the score (in this case 0-4) and the weights.

05 OTHER SEI ANALYSIS RELEVANT TO DiSSCo

Some of the assessment exercises of RIs or organisations related to or associated with the activity of DiSSCo might provide a good example of the approach and type of indicators relevant to determine the infrastructure SEI. In this particular case, the impact of digitisation and data infrastructure is particularly adequate, as are the cases of Atlas of Living Australia (Alluvium, 2016) and the Natural History Museum, London (Popov et al., 2021). Another area of pertinent importance is biodiversity discovery and related activities, for which a cost-benefit analysis was performed for Australia's species (Deloitte Access Economics, 2020). We will briefly review these studies, starting with the latter.

5.1. Cost benefit analysis of a mission to discover and document Australia's species

The Australian Academy of Science launched a 25-year mission called Taxonomy Australia in 2021, with the goal to discover all remaining Australian species in a generation. To support this strategic plan, a CBA found that each AUD $1 invested in discovering all remaining Australian species would bring up to $35 of economic benefits (Deloitte Access Economics, 2020). The rapid analysis estimated that a total cost of 824 million AUD over a period of 25 years would result in benefits of 3.7 to 28.9 billion AUD. To define scenarios, the study considered three levels of change for their calculations: a high, a base and a low.

For the analysis, the benefits of four major areas were estimated:

- **Biosecurity**: this sector considers threats by exotic invasive species that threaten Australia's biosecurity, native species and environment. It also considers non-genuine threats corresponding to suspected detections that are later confirmed to pose no or low risk. The benefit would result from the early detections and avoidance of misidentifications, which reduces delays for reaching taxonomic certainty and diagnosis. In the case of genuine threats, the rate of successful detection would result in a threat every 5 years (base scenario), one every 10 years (low change scenario) and one every 15 years (high change scenario). For non-genuine threats, the impact would result in avoiding them to one every 5 years (base scenario), one every 10 years (low change) and one every 15 years (high change);
- **Biodiscovery**: the benefits of more cost-effective and strategic testing of samples for drug discovery, in the research, pre-commercial phase, and of subsequent health benefits. There will be an increase of the biodiscovery value chain, resulting from agreements and contracts between researchers and pharmaceutical companies. At the stage of development, the increase in benefits results from the increase of

successful commercialization and sales, due to a larger pool of base species, and a more targeted species sampling. Finally, additional benefits result from avoided deaths attributed to prescription of natural product-based drugs and medicines;

- **Agricultural R&D**: the benefits of agricultural R&D would result at several levels, including increased knowledge of soil bacteria species that enhance crop management, soil fertility, and harmful organisms such as nematodes, or use of non-agricultural species in the transition to non-farm production of protein and carbohydrates; knowledge about crop wild relatives resulting in better resistance of crops to threats or trait benefits;
- **Biodiversity conservation**: the benefits of improved conservation outcomes with better informed decision-making, through a better understanding of species and their role within a given ecosystem. This includes promoting species resilience and strengthening ecosystems against environmental stressors. Furthermore, the goal of preventing extinctions is well understood by the public.

In addition to these areas, the report mentions other aspects of potential benefits of taxonomic discovery which were not considered including tourism, human and animal health, biomimicry, environmental monitoring and other sectors.

5.2. Atlas of Living Australia's Impact and Value

The report of the assessment of the Atlas of Living Australia's Impact and Value was performed in 2016 (Alluvium, 2016). The Atlas of Living Australia (ALA) is a RI supported by NCRIS, an Australian Government initiative, with the mission to provide free, online access to a vast repository of information about Australia's biodiversity. The RI targets a major barrier resulting from the fragmentation and inaccessibility of biodiversity related data, generated and housed in museums, herbaria, collections, universities, research organisations, and government departments and agencies. ALA implemented a collaborative, digital and open infrastructure that aggregates biodiversity data from multiple sources, and focuses on making biodiversity information accessible and usable.

The evaluation exercise includes:

- an assessment of the key impact areas of the ALA such as influence on cultural change, new products and services, productivity and efficiency gains and applications and derivatives.
- initial and contemporary estimate of the benefit-cost ratio for investment in ALA and contextualising this in the organisation's overall value.

The analysis considers information as an economic asset, which results in benefit by holding or using it. In the case of information as an economic asset, in relation to other assets, the following specifics apply (according to Moody and Walsh, 1999):

- information is infinitely shareable, reusable and repurposable;
- the value of information increases with use;
- information is perishable;
- the value of information increases with accuracy;
- the value of information increases when combined with other information;

- more is not necessarily better;
- information is not depletable.

The Theory of Change approach was used as methodology for the analysis, as depicted in Figure 2, extracted from the report (Alluvium, 2016).

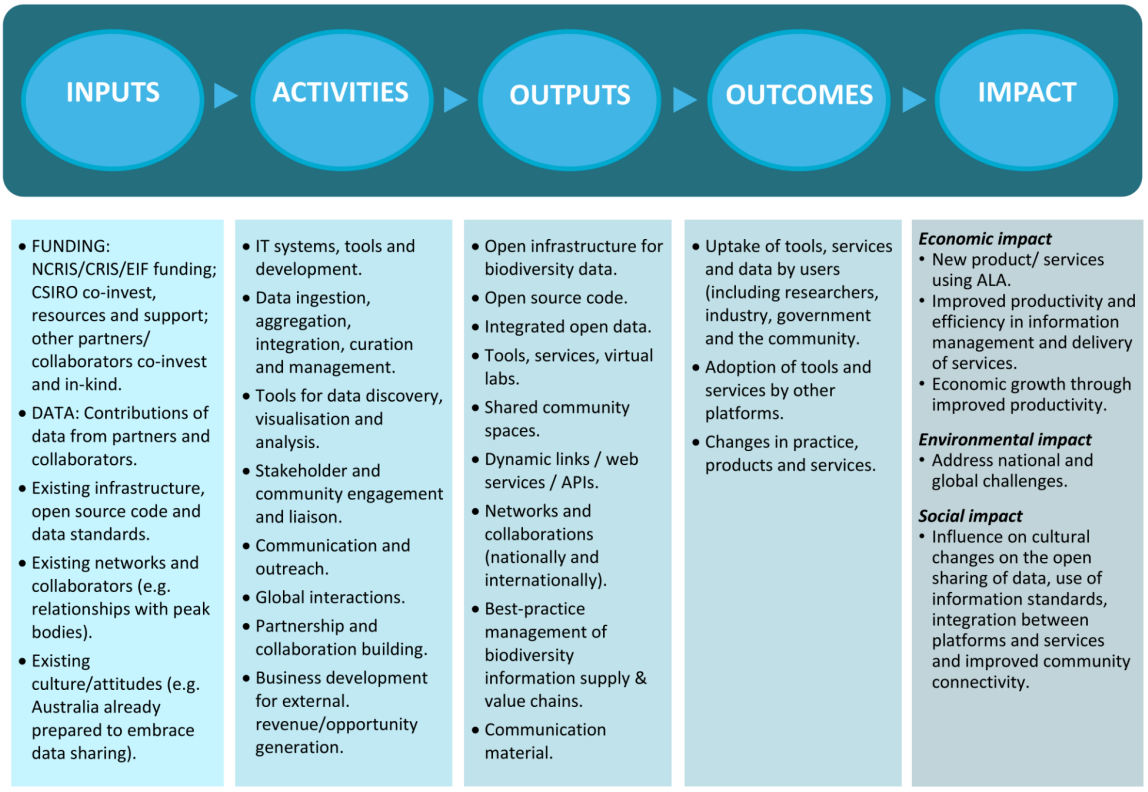

Figure 2. Impact pathway applied in the assessment of ALA RI (Alluvium, 2016).

The assessment exercise, based on online surveys, individual interviews, web metrics and case studies, was developed for two output areas and five impact areas (Table 7).

Table 7. Output and impact areas of the assessment of ALA.

Output area	Number of indicators	Type of indicators
Data	1	quantitative
Tools, services and infrastructure	1	quantitative/narrative
Impact area		
Influence on Cultural Change	6	quantitative/narrative
New Products and Services	3	quantitative/narrative
Productivity and Efficiency	5	quantitative/narrative
Applications and Derivatives	4	quantitative/narrative

The ALA assessment has led to a range of delivered and potential impacts, including: increased open sharing of data and standards; production of reports, papers and publications; significant efficiency gains for biodiversity data management and on-ground intervention and actions relating to biodiversity. The ALA Impact Evaluation indicated efficiency gains applied to Commonwealth expenditure on biodiversity and national parks to be 26.9 million AUD in 2016, with a benefit-cost ratio of 3.5:1.

5.3. The Value of Digitising Natural History Collections

A study commissioned by the Natural History Museum, London, aimed to determine the economic impacts of the digitisation of the 80 million specimens held in collections (Popov et al., 2021). In the scope of the study, digitisation may include several processes, like data transcription to databases, imaging, microscopy and computerised tomography scans, chemical, and molecular or genomic analyses.

Digitisation may result in several benefits, related to the increase of accessibility of collections, which become available: i) to a global audience at a lower cost, compared to in-person visits; ii) to the searchability of data transcribed or extracted, including its integration with other data; iii) to the preservation of specimens, for which physical handling requests will be lower and cause less damage, and iv) to the interaction of researchers with the collection, not limited by physical space or time, enabling multiple accesses to specimens.

The study applied a methodology based on a theory of change/logic model, which used inputs from museum collaborators and literature review to identify different pathways to impacts or benefits, how these will be materialised, their significance and who will benefit (e.g. visitors, scientists, taxpayers, society at large). The model developed is reproduced in Figure 3.

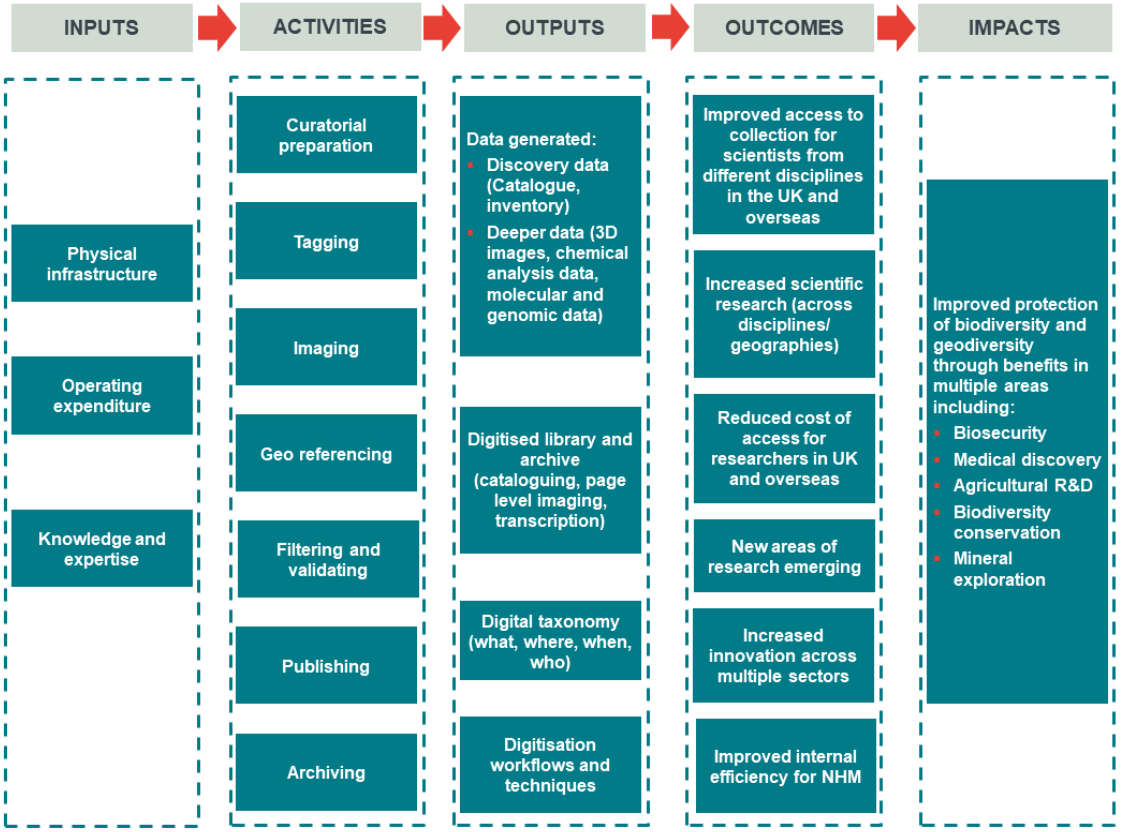

Figure 3. Theory of change showing the four components (inputs, activities, outputs and outcomes) with examples that lead to impact (Popov et al., 2021 https://doi.org/10.3897/rio.7.e78844.figure7).

The analysis took two approaches in valuing the impact of digitisation, namely on the return of investment:

- **top down** - estimation at the aggregate level of the expected returns on investment in science is likely to generate. This includes cost savings in terms of researchers not having to travel, or the amount of new research made possible;
- **thematic** - valuing specific benefits in a particular research area expected from digitisation, in five thematic areas - biodiversity conservation, invasive species, medicines discovery, agricultural research & development, and mineral exploitation (Figure 4).

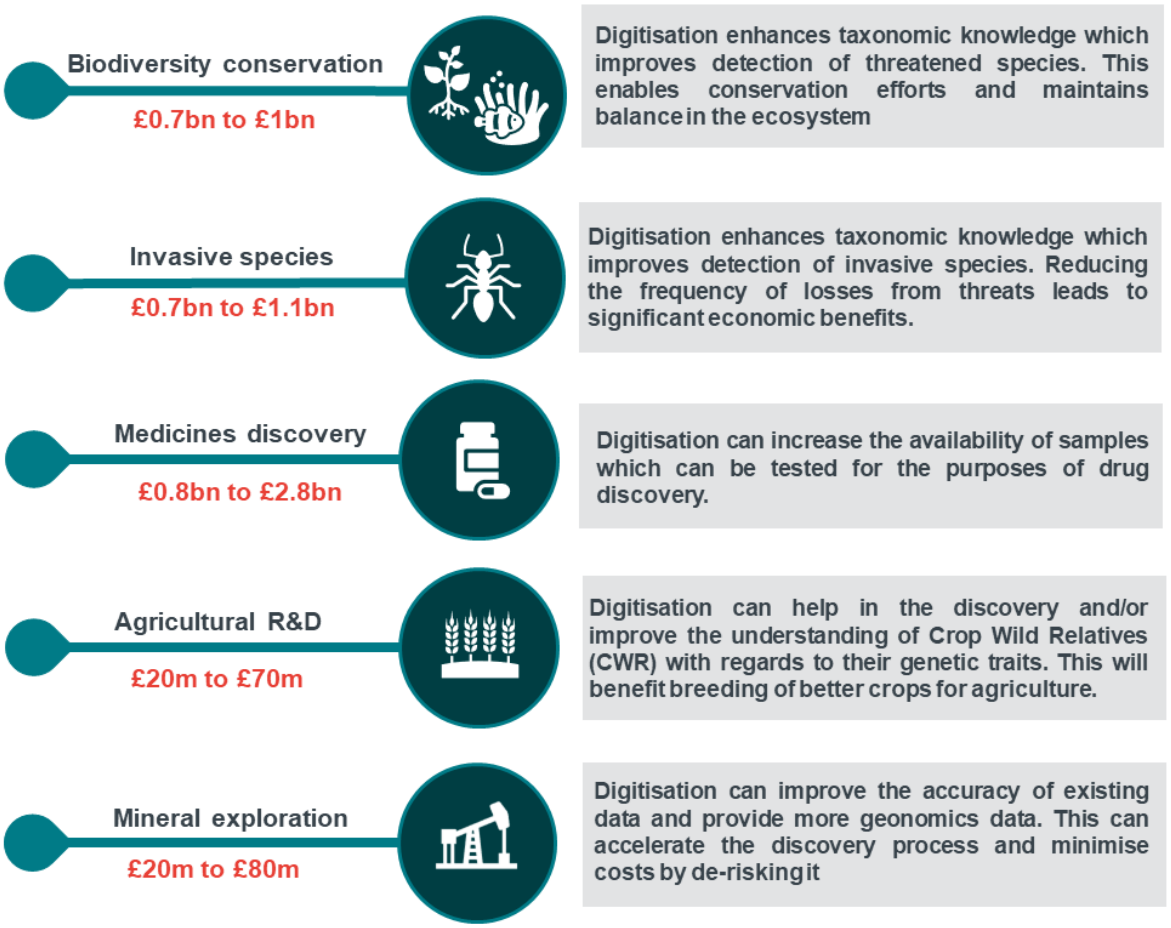

Figure 4. Valuing pathways to impact across five key areas (Popov et al., 2021 https://doi.org/10.3897/rio.7.e78844.figure3).

For the thematic approach, and while acknowledging limitations of data available, the study applied the estimates in Table 8.

Table 8. Economic benefits and estimates of the thematic approach to the valuing study of collections digitisation (Popov et al., 2021).

Thematic area	Economic benefits	Estimates
Biodiversity conservation	Efficiency of identification of threatened species Reduction of information gaps for countries rich in biodiversity but poor in biodiversity data	Estimate the value UK citizens place on preventing species declining anywhere in the world; Estimate the rate at which digitisation accelerates the identification of threatened species.
Invasive species	More comprehensive and updated database to identify species. Faster and easier access to	Estimate the reduction in time by avoiding delay/uncertainty in detecting threats; Estimate the reduction in damages

Thematic area	Economic benefits	Estimates
	specimen databases	due to the faster detection of threats or prevention of misdiagnoses, with greater certainty.
Medicine discovery	Research value - biodiscovery of collection samples with the potential to be explored for bioactive compounds Development value - commercialised value of the species sample	Estimate the impact of digitisation on the number of samples available for testing; Estimate the health benefits due to the increased number of commercialised samples.
Agricultural R&D	Accelerate the rate at which researchers are able to discover and improve their understanding of different natural species Faster and easier access to crucial information that can speed up the research process	Identify the rate at which digitisation increases the discovery and/or understanding of natural species for the purposes of agricultural R&D; Identify how this increased research creates economic value.
Mineral exploration	Efficiency of discovery Efficiency of processing	Estimate how digitisation affects the discovery process and/or fundamental scientific research; Estimate the value of any efficiencies it helps to achieve during discovery and/or try to value the fundamental research that might take place.

06 SCOPE OF DiSSCo AND AREAS OF SOCIO-ECONOMIC IMPACT

The DiSSCo RI is a distributed research infrastructure in the domain of environment that aims to create a new business model to integrate all European natural science assets under common access, curation, policies and practices, for one European collection. It will:

- support and coordinate the digitisation of data, under the FAIR principles framework, across the distributed facilities;
- promote the necessary developments (scientific, technical, social) to link dispersed scientific information in NHC derived from the study of scientific collections;
- enable a unique access point for integrated data analysis and interpretation through a wide array of digital services provided by its community;

DiSSCo was included in the ESFRI Roadmap 2018, which Landscape Analysis identified needs related to the taxonomic gap and impacts of invasive alien species to biodiversity (ESFRI, 2018). The services and activities of DiSSCo are rooted in the already multi-century-old representation of the earth's life and natural resources through natural history collections based in museums, botanical gardens and universities.

The definition of a SEI analysis of DiSSCo must consider the type of infrastructure, its phase in the life cycle of an RI and, in particular, the scientific domain of the community for it will provide services and its strategic objectives. Kolar et al. (2019) analysed the relevance of the KPIs proposed by the ESFRI WG (ESFRI, 2019) in relation to its scientific domain. They found that there are significant differences in the relevance of certain indicators depending on the ESFRI domain of the RI. The indicators need to be adapted to the type of infrastructure, and further involvement of RI in the domains of energy, environment and health.

DiSSCo is currently in the Preparation Phase, and according to its timeline, it is expected to complete implementation and become operational in 2026. The type and applicability of the indicators are naturally different for each phase, although some are applicable at all phases. This factor needs to be considered also when selecting indicators for the SEI assessment of DiSSCo.

Another dimension of impact strategically important for RIs in the context of ESFRI projects and Landmarks is the participation in an “integrated ecosystem” that ensures links and complementarity between national and European priorities. The interconnected RIs should promote frontier research, under an interdisciplinary paradigm. However, achieving this integration is not effortless, although it can also be a source of innovation. These aspects of

integration - interoperability and connections with other RIs in the same or related knowledge domains - should also be considered in development of the monitoring schema.

6.1. Areas of impact of DiSSCo

The initial proposal of DiSSCo to ESFRI previews the impact of the RI, related to its goals, in several areas, which need to be captured by indicators. These include:

- **Scientific**
  - DNA barcodes, genomes, proteomes and metabolomes
  - 2D/3D imaging
- **Industry and innovation**
  - information science (big data)
  - computer vision
  - 2D/3D scanning
  - new pharmaceuticals (combining collection data with metabolomic)
  - new cultivars and animal breeds
  - new standards
  - new materials inspired by nature
- **Direct socio-economic impacts**
  - job creation
  - industry-oriented economic benefits
    - impact on organisations
    - applications in agriculture, environmental assessment, land use planning
    - new hardware/software - Small and Medium Enterprises
- **Mid and long term socio-economic benefits**
  - Economy of scale
    - common digital data processing
    - purchasing equipment
  - Economy of scope
    - industrialization of digitisation
    - robotics, optics, imaging
- **Innovation activity in the production of goods and services**
  - Direct contributions to food, textile, building materials, medicines, provision of sustainable energy, rare minerals, ecosystem services
- **Technological innovation** - critical step for its implementation, direct spin-off, driver for industry-led innovations
  - (meta-)data standardisation, information management, computer vision, robotics and automation, and 2D/3D imaging
- **Social innovation** - citizen science and crowdsourcing focus (through the institution's traditional focus) in public engagement
- **Attract innovation-oriented resources**
  - Industry as supplier - 2D/3D imaging, robotics and automation, image/pattern recognition algorithms as well as information management technologies

    - Industry as user - companies will be able to augment their datasets with quality information on the natural world
- **Tackling (grand) societal challenges:**
    - DiSSCo data and expertise can directly contribute to “ecosystem health”
    - genetic material support the development of new agricultural varieties
    - describing and understanding bio- and geo-diversity on earth

6.2. Users of DiSSCo

The user groups of DiSSCo range from scientific researchers, to citizens and to decision makers. As identified by the user cases and user stories compilation (reports from Task 1.1 and 1.2, Fitzgerald et al., 2021, von Mering et al., 2021), the groups are:

- Research (academic, non-academic, including Citizen Science)
- Collection management
- Technical support (IT & IM)
- Policy (institutional, national & international)
- Education (academic & non-academic)
- Industry
- External (media & empowerment initiatives)

The services and support of these groups should be captured by the impact assessment. Many of these user groups are also stakeholders of the infrastructure. The interests of these vary, depending on their needs or different strategic visions. The short list of DiSSCo stakeholders and interests are presented in Table 9.

Table 9. Short list and interests of stakeholders in DiSSCo.

Stakeholder	Interests
RI funders (national, regional, others)	• Help to achieve the vision and mission in relation to the communities they represent/are interested in • Justify the investment
Scientific community	• Improve capacity to develop research activities
Industry	• Develop innovation products • Use of digital resources (images, videos) in paper (textbooks, newspapers and magazines) and digital products (webpages, platforms, etc.). • Science Tourism and Leisure
Other RIs	• Leverage technological developments • Promote interoperability and integration at the scientific domain or regional level
RI management	• Monitor impact and achievements compared to goals, vision and mission

Stakeholder	Interests
National nodes and institutional partners	• Improve and upgrade services to their users • Better coordination • Reach wider communities

6.3. Services of DiSSCo

New services to be or in implementation by DiSSCo and aligned projects will promote a transformation in the way users, particularly researchers, will access and use natural history collections. The digitisation of collections makes it possible to create services based on common access, curation, policies and practices. The set of planned services are identified in https://www.dissco.eu/services/, which is briefly listed here.

European Loans and Visits System (ELViS) – a web platform to provide a unified way to request visits, loans and virtual access. ELViS will enable digitisation on demand and support for collaborating on Virtual Access ideas and proposal submission. The request mechanism implemented in ELViS also enables future services for tracking usage metrics, monitoring and reporting and connecting collection usage with research outputs. This tracking service is important to support SEI indicators.

Collection Digitisation Dashboard (CDD) – a visual dashboard with information about the digitisation status, content and strengths of collections across the community of institutions. It displays progress in digitisation and provides summaries and comparisons regarding the number of objects, taxonomic scope, categories of preservation, stratigraphic age, geospatial range, level of digitisation and digital content availability for reuse. The data aggregation and compilation to support the dashboard can be used to support SEI indicators.

Specimen Data Refinery (SDR) – this will be another transformative service to be provided by DiSSCo, based on new models of digitisation workflows that process individual specimens and their metadata one-by-one into a model of industrial scale digitisation. It will integrate artificial intelligence and human-in-the-loop approaches to extract, enhance and annotate data at scale from digital specimen images and records (Walton et al. 2020). The refinery can enable potential applications by third party providers such as automated condition checking of specimens, natural language descriptions provision for specimens and taxonomic trait extraction.

Knowledge Base (KB) – a digital document repository of DiSSCo and related projects to support the infrastructure and users. It contains technical documentation and documented decisions, training materials, Frequently Asked Questions (FAQs), best practices, guidelines, and recommendations. The tools of the digital repository can be used to calculate indicators related to knowledge outputs.

Authorisation and Authentication Infrastructure (AAI) – this service will enable easy and integrated user authentication in the access to digital services, which can be linked to federated AAI services like eduGAIN, to enable institutional authentication or to external

services like ORCID. This service will enable granularity of services authorization to access data that has legal restrictions, such as sensitive data on rare species. This service can be used also as a resource for SEI indicators, in the segmentation of DiSSCo users.

Unified Curation and Annotation System (UCAS) – the service will enable the curation and annotation on the Digital Extended Specimens (DS) for experts in the community and for machines. Transactions on the data will be stored as well as provenance information related to the curation or annotation events. The DS is a digital twin of the physical specimens that will link to data derived from the specimen (sequences, morphological data, taxonomic traits). SEI indicators can be derived from the number of transactions.

Digital Specimen Repository – this service will be implemented as a data repository for experimentation with Digital Specimen and other DiSSCo-related FAIR Digital Objects. It uses Cordra software to manage the digital objects and resolvable identifiers (Handles, DOI).

Self-assessment tool – this tool is intended to support teams, institutions and national nodes in developing organisational readiness for provision of the DiSSCo services and data, helping them to identify and target areas for improvement. The aim is for this to tie into the future provision of training and support, as well as helping to identify the gaps at aggregate level where that training may be most useful.

Helpdesk – a central place for all questions related to DiSSCo services or access programmes such as the virtual access and transnational access calls in ELViS. It will be integrated with DiSSCo services. The service will use JitBit software, a ticketing platform which can be a source of data for SEI indicators.

This collection of services will promote changes in the access and use of natural history collections, both internally in the institutions and staff linked to these resources, and externally to the researcher community that access collections and related services. The SEI indicators should be selected or defined in order to enable them to capture these changes and its impact.

07 SUGGESTED LIST OF SEI INDICATORS FOR DiSSCo

The SEI indicators recommended for adoption by DiSSCo include 29 indicators. These were selected from a larger list compiled from four main frameworks - ESFRI (2019), OECD (2019), Helman et al. (2020), and Atlas of Living Australia (Alluvium, 2016) - reported in Milestone 1.4 (Figueira et al., 2022), after the consideration of the relevance and adaptability to DiSSCo scope and services.

The adequacy and relevance of the indicators to DiSSCo were evaluated in an initial exercise by the team of the University of Lisbon, who implemented the full consolidated list of indicators to assess their applicability. The relevance was further analysed by DiSSCo participants, through a survey conducted at the DiSSCo All Hands Meeting 2 Workshop dedicated to the SEI of DiSSCo. The results of this survey also enabled the indicators to be sorted according to the relevance, using the responses of the 26 participants in the workshop. The list of indicators suggested by this report is presented in Table 10.

Table 10. List of recommended SEI indicators for DiSSCo. The table includes the indicator name, the classification of indicators in terms of RI objectives (ESFRI framework, see Table 2), impact area (RI-PATHS framework, see Table 5) and category of impact (OECD framework), and the median relevance feedback by survey participants, in a 5-scale range from 1 (low relevance) to 5 (high relevance).

Indicator_Name	Objective	Impact area	Category of SEI	Feed back
1. Number of users served	Enabling Scientific Excellence	Human Resources	Scientific	5
2. Number of publications	Enabling Scientific Excellence	Human Resources	Scientific	5
3. Revenues	Facilitating economic activities	Economy and Innovation	Economic	3
4. Engagement achieved by direct contact	Outreach to the public	Society	Social and Societal	4
5. Outreach through printed, broadcast and web-based media	Outreach to the public	Society	Social and societal	4
6. Number of publicly available data sets used externally	Optimising data use	Economy and Innovation	Scientific	5
7. Participation of DiSSCo in policy related	Provision of	Policy	Social and	4

Indicator_Name	Objective	Impact area	Category of SEI	Feed back
activities	scientific advice		societal	
8. Number, volume, nature of procurement, by supplier type	Facilitating economic activities	Economy and Innovation	Economic	3
9. Technological impact: Number of new technologies and designs	Facilitating economic activities	Economy and Innovation	Economic	4
10. Grants and projects	Facilitating economic activities	Human Resources	Technological	4
11. Local expenditure of DiSSCo, employees & visitors	Facilitating economic activities	Economy and Innovation	Economic	3
12. Number of Full Time Equivalent (FTE) within the DiSSCo	Facilitating economic activities	Economy and Innovation	Economic	3.5
13. New tax payers	Facilitating economic activities	Economy and Innovation	Economic	3
14. Gender balance and diversity	Optimising management	Society	Social and societal	4
15. Corporate social responsibility	Optimising management	Society	Social and societal	4
16. Scientific attractiveness	Delivery of education and training	Human Resources	Training and education	4
17. User satisfaction	Enabling Scientific Excellence	Human Resources	Scientific	4
18. Number of spin-offs surviving to date	Facilitating economic activities	Economy and Innovation	Economic	3
19. Contribution to social sustainability: CSR, Social Inclusion, Culture	Provision of scientific advice	Society	Social and societal	4
20. Contribution to environmental sustainability: Energy & Waste issues	Optimising management and sustainability	Society	Social and societal	4
21. Improvement of wellbeing: Health & Ageing	Outreach to the public	Society	Social and societal	3
22. Participation of DiSSCo in local/ regional committees/networks (e.g. clusters)	Provision of scientific advice	Policy	Social and societal	4
23. Number of DiSSCo participations in relevant standardisation committees	Provision of scientific advice	Policy	Social and societal	4
24. Improvement of fitness-for-purpose of online biological and ecological data by embedding standards in DiSSCo	Optimising data use	Economy and Innovation	Technological	4
25. Improvement in the amount of “trusted” or quality data online as a consequence of the establishment of DiSSCo.	Optimising data use	Society	Technological	5

Indicator_Name	Objective	Impact area	Category of SEI	Feed back
26. Enablement of “communities” for collaboration, exchange and reuse of tools and resources	Optimising management	Economy and Innovation	Technological	4
27. Improvement of data management efficiency	Optimising data use	Economy and Innovation	Technological	5
28. Application of research to key national and global challenges	Provision of scientific advice	Policy	Social and societal	5
29. Help to undertake on-ground interventions with respect to biodiversity	Provision of scientific advice	Policy	Social and societal	4

The definition of each indicator was reworded to be as specific as possible in its applicability to DiSSCo. For each indicator, a detailed data sheet with all information items referred in Table 10 is presented in Annex 1. In some cases, the general indicator can be further broken down into categories, in order to provide detail about the indicator numbers (e.g. “number of users served” can be classified in terms of country of origin, type of user, type of access, discipline or application field, etc).

The detailed sheet for each indicator provided information about the means of calculation, the suggested breakdown categories (not exhaustive), the nature of the indicator (numeric, narrative), estimated cost of data collection and data reporting, and the recommended frequency of measurement of each indicator.

Of the 29 indicators, 15 are recommended to be measured annually, all of which are numeric. In generic terms, the collection of data for these can be implemented within the infrastructure, using plugins to administrative and management tools. The route to the implementation will need to be defined at a later stage of DiSSCo construction.

Other indicators have to be obtained by surveys to users and stakeholder communities. This requires a dedicated effort of participant engagement and data collection and analysis. Some indicators are narrative, where this format better fits the type of information to be collected (e.g. “Contribution to social sustainability: CSR, Social Inclusion, Culture”).

Some descriptors of the indicators are adapted from the main source SEI framework uses as source. This includes:

- Objective, based on ESFRI framework, see Table 2;
- Impact area, based on RI-PATHS framework, see Table 5;
- Impact category, based of OECD framework, see page 14;

These classifiers are useful to verify if the selected set of indicators achieve a good balance in terms of impact area - human resources, economy and innovation, policy and society - and category of impact - scientific, economic, social and societal and technologic. The indicators also cover eight of the nine general objectives for RIs as defined in the ESFRI framework (ESFRI, 2019). Table 11 provides a summary account for this distribution.

Table 11. Number of indicators that fall into one of the classifiers of indicator type: objective, impact area and category of SEI impact. HR - Human Resources, E&I - Economy and Innovation, Policy and Society.

		Objective							
		Delivery of education and training	Enabling Scientific Excellence	Facilitating economic activities	Optimising data use	Optimising management	Optimising management and sustainability	Outreach to the public	Provision of scientific advice
Impact area	Category of SE impact								
E&I	Economic	0	0	7	0	0	0	0	0
	Scientific	0	0	0	1	0	0	0	0
	Technological	0	0	0	2	1	0	0	0
HR	Scientific	0	3	0	0	0	0	0	0
	Technological	0	0	1	0	0	0	0	0
	Training and education	1	0	0	0	0	0	0	0
Policy	Social and societal	0	0	0	0	0	0	0	5
Society	Social and Societal	0	0	0	0	2	1	3	1
	Technological	0	0	0	1	0	0	0	0

08 CONSIDERATIONS FOR THE IMPLEMENTATION OF SEI INDICATORS

The following aspects should be taken into consideration towards the implementation of a SEI assessment of DiSSCo.

8.1. Socio-economic impact indicators and key-performance indicators

As stated earlier, the purpose of two types of indicators is not the same: SEI indicators measure the transformative effect of the RI in the aspects of economic and society in which it intervenes, while KPIs monitor several aspects of the progress of the RI towards a certain objective. Both are related, as KPIs frequently provide the values used to evaluate the socio-economic impact at a certain point in time. Some of the indicators can be used for both impact and performance monitoring. SEI assessments require additional analysis to consider the change promoted by the RI. It also requires a baseline to be established, which identifies the status before the start of the operation, so that the change can be measured.

8.2. Selection and number of SEI indicators to be implemented

The implementation of the recommended indicators will be useful in several aspects of DiSSCo, but their relevance can also change in relation to the phase of the RI, i.e., construction or operation. However, the effort and costs in data collection for some indicators can be high, which does not always result in the corresponding added value for the impact assessment. This means that the number of indicators should be reasonable, and should be prioritised on their implementation.

They should also be carefully selected in terms of their appropriateness in relation to the specific RI. For example, patents creation may not be appropriate as an indicator for DiSSCo, because innovation and transfer of technology is not at the core of its mission, purpose and services. In this context, the most important indicators are the ones that better highlight the transformative change that the RI enables and that also consider the different stakeholder types.

A third component to be considered is the number of indicators to be reported. As said, these should be adopted so that they better reflect the aspects where the RI is performing a transformative impact, but if the number is too high, this may lead to a loss of focus. It is possible that, for reporting, a number between 10 to 15 indicators can be better in capturing and expressing that transformative change at a wider scale.

8.3. Route to the implementation of the SEI indicators

Having the previous considerations in mind, the following steps are suggested towards the implementation of the SEI indicators:

- Perform a survey to all DiSSCo stakeholders to prioritise the suggested list of SEI indicators, and identify any gaps not covered by the list. This will identify the most important indicators to be included in the reports for the different stakeholders;
- Identify detailed data requirements and corresponding actors in order to implement data gathering and aggregation workflows for services, tools and activities;
- Establish a pilot study of indicator quantification to establish background status of SEI indicators before operation;
- Define roles within the DiSSCo organisation for data gathering, analysis and reporting of SEI indicators;
- Design and implementation of the information management system for data gathering, analysis, reporting and archiving. New developments may be required to automate processes.

The suggested route steps should be considered at the construction phase of DiSSCo.

09 GLOSSARY

Activity – Initiatives and endeavours undertaken using the resources of a Research Infrastructure or work performed by Research Infrastructure staff.

Activity indicator - Indicators that capture the scale and nature of a Research Infrastructure's activities; a measure that should form part of internal reporting.

Digital Specimen - a digital specimen exposes supplementary information about related literature, traits, tissue samples and DNA sequences, chemical analyses, environmental information, stored elsewhere than in the natural science collection itself

FAIRification - informal term to designate the process in which data is transformed and framed by the technologies that enables them to be in accordance to FAIR (Findable, Accessible, Interoperable and Reusable) principles. These principles are adopted in Programme Guidelines on FAIR Data Management in Horizon 2020.

Impact – Intended and unintended long-term effects of activities using the resources of a Research Infrastructure or work performed by Research Infrastructure staff.

Impact indicator - An indicator that reflects the extent and nature of generated effects in the economy and wider society; with few exceptions, impact indicators are estimations.

Outcome – Longer-term effects that stem from the stakeholder uptake of or interaction with Research Infrastructure outputs.

Outcome indicator - Indicators that document the result of the first productive interactions; collecting data by reaching out to involved stakeholders, e.g. via a survey, interview, external reporting or other data-gathering means.

10 ABBREVIATIONS AND ACRONYMS

ACTRIS - Aerosols, Clouds and Trace gases Research Infrastructure

ALA - Atlas of Living Australia

BCA - Benefit-Cost Analysis

CBA - Cost-Benefit Analysis

DiSSCo - Distributed System of Scientific Collections

EIA - Economic Impact Analysis

ERIC - Educational Resources Information Center

ESFRI - European Strategy Forum on Research Infrastructure

FAIR - Findable, Accessible, Interoperable and Reusable

KPI - Key Performance Indicator

MBPF - Marginal Benefit of Public Funds

MCA - Multicriteria Analysis

MCF - Marginal Costs of Public Funds

NCRIS - National Collaborative Research Infrastructure Strategy)

OECD - Organisation for Economic Co-operation and Development

RACER - Relevant, Accepted, Credible, Easy and Robust

RI - Research Infrastructure

RI-PATHS - acronym of project “Research Infrastructure imPact Assessment paTHwayS”

SEI - Socio Economic Impact

WTA - Willingness to Accept compensation

WTP - Willingness to Pay

11 CITED REFERENCES

Alluvium (2016). Assessment of the Atlas of Living Australia's impact and value. Report produced for the CSIRO. Canberra. 50 pp.

Brooke, M.L. (2000). Why museums matter. *Trends in Ecology & Evolution* 15, 136–137

Deloitte Access Economics (2020). Cost benefit analysis of a mission to discover and document Australia's species | Deloitte Australia | Economics. Deloitte Access Economics Pty Ltd. 107 pp. https://www2.deloitte.com/au/en/pages/economics/articles/cost-benefit-analysis-mission-discover-document-australia-species.html

ESFRI (2018). Roadmap 2018. Strategic Report on Research Infrastructures. Part 2. Landscape Analysis, Environment. Printed on behalf of ESFRI by Dipartimento di Fisica – Università degli Studi di Milan. Available online at http://roadmap2018.esfri.eu.

ESFRI (2019). Report of the ESFRI Working Group on monitoring RIs performance. www.esfri.eu. (2019, December). https://www.esfri.eu/latest-esfri-news/report-esfri-working-group-monitoring-ris-performance

ESFRI (2021). ESFRI Strategic Report on Research Infrastructures Roadmap 2021 Public Guide. https://www.esfri.eu/sites/default/files/ESFRI_Roadmap2021_Public_Guide.pdf

Figueira, R., Fontainha, E., De Smedt, S., Casino, A., Mergen, P., Haston, E. (2022). DiSSCo Prepare Milestone report MS1.4 "Corpus of previous studies on socioeconomic impact compiled". DiSSCo Prepare. https://doi.org/10.34960/3mnv-h122

Fitzgerald, H., Juslén, A., von Mering, S., Petersen, M., Raes, N., Islam, S., Berger, F, von Bonsdorff, T., Figueira, R., Haston, E., Häffner, E., Livermore, L., Runnel, V., De Smedt, S., Vincent, S., Weiland, C. (2021). DiSSCo Prepare Deliverable D1.1 Report on Life sciences use cases and user stories. https://doi.org/10.34960/xhxw-cb

Greco, S., Ehrgott, M., & Figueira, J. R. (Eds.) (2016). Multiple criteria decision analysis: state of the art surveys. (2nd ed.) (International Series in Operations Research and Management Science; Vol. 233). Springer. https://doi.org/10.1007/978-1-4939-3094-4

Hajdinjak, M. (2019). A Practical Guide: Assessment of Socio-Economic Impacts of Research Infrastructures—Project ResInfra@DR (A. Havas, Ed.). Centre for Social Innovation. http://www.interreg-danube.eu/uploads/media/approved_project_output/0001/32/0b698b634cc4cc3df75dd303bdc3917f5ed6e2af.pdf

Helman, A. Barberis, M., Vignetti, S., Catalano, J., Griniece, E., Kroll, H., Zenker, A., Martin C., (2020). Validated IA Model, deliverable 5.1 produced in the framework of H2020 project Research Infrastructure imPact Assessment paTHwayS (Grant agreement 777563). https://ri-paths.eu/wp-content/uploads/2018/03/D5.1_Validated-IA-model.pdf.

Johansson, P. O., & Kriström, B. (2016). Cost-benefit analysis for project appraisal. Cambridge University Press.

Kolar, J., Cugmas, M., & Ferligoj, A. (2019). Towards Key Performance Indicators of Research Infrastructures. ArXiv:1910.00304 [Cs, Stat]. http://arxiv.org/abs/1910.00304

Mirasgedis, S., Sarafidis, Y., Mihalopoulos, N., Georgopoulou, E., Mona, L., Papagiannopoulos, N. (2019). Deliverable 8.3: Report on case studies for the socio-economic impact of ACTRIS

Mirasgedis, S., Mihalopoulos, N., Sarafidis, Y., Georgopoulou, E., & Theodosi, C. (2018). Deliverable D8. 1: Report on KPIs for the quantification of ACTRIS direct impact.Moody, D. L., & Walsh, P. (1999). Measuring the Value Of Information-An Asset Valuation Approach. ECIS, 496–512.

OECD (2015). Data-Driven Innovation: Big Data for Growth and Well-Being, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264229358-en

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

Popov, D., Roychoudhury, P., Hardy, H., Livermore, L., & Norris, K. (2021). The Value of Digitising Natural History Collections. Research Ideas and Outcomes, 7, e78844. https://doi.org/10.3897/rio.7.e78844

Rocha L.A., Aleixo A., Allen G., Almeda F. et al (2014). Specimen collection: an essential tool. Science 344, 814–815

Ruttkay, Z., & Bényei, J. (2018). Renewal of the Museum in the Digital Epoch. In G. Bast, E. G. Carayannis, & D. F. J. Campbell (Eds.), The Future of Museums (pp. 101–116). Springer International Publishing. https://doi.org/10.1007/978-3-319-93955-1_10

Suarez A.V., Tsutsui N.D. (2004). The value of museum collections for research and society. Bioscience 54, 66–74

Tewksbury J.J., Anderson J.G.T., Bakker J.D. et al (2014). Natural history's place in science and society. Bioscience 64, 300–310

von Mering, S., Petersen, M., Fitzgerald, H., Juslén, A., Raes, N., Islam, S., Berger, F, von Bonsdorff, T., Figueira, R., Haston, E., Häffner, E., Livermore, L., Runnel, V., De Smedt, S., Weiland, Claus (2021). D1.2 Report on Earth sciences use cases and user stories. https://doi.org/10.34960/n3dk-ds60

Vignetti, S., Griniece, E., Cvijanovic, V., Reid, A., Helman, A., & Kroll, H. (2019). Deliverable 3.2 Title: Report on stocktaking results and initial IA model. RI-PATHS Consortium.

Vignetti, S. (2021). Designing a Research Infrastructure with Impact in Mind. In H. P. Beck & P. Charitos (Eds.), The Economics of Big Science: Essays by Leading Scientists and Policymakers (pp. 79–84). Springer International Publishing. https://doi.org/10.1007/978-3-030-52391-6_11

Walton, S., Livermore, L., Bánki, O., Cubey, R.W.N., Drinkwater, R., Englund, M., Goble, C., Groom, Q., Kermorvant, C., Rey, I., Santos, C.M., Scott, B., Williams, A.R., Wu, Z. (2020). Landscape Analysis for the Specimen Data Refinery. Research Ideas and Outcomes 6: e57602. https://doi.org/10.3897/rio.6.e57602

12 OTHER REFERENCES

Barker, M., Olabarriaga, S. D., Wilkins-Diehr, N., Gesing, S., Katz, D. S., Shahand, S., ... & Costa, A. (2019). The global impact of science gateways, virtual research environments and virtual laboratories. Future Generation Computer Systems, 95, 240-248. https://doi.org/10.1016/j.future.2018.12.026

Beagrie, N., & Houghton, J. (2016). The value and impact of the european bioinformatics institute.https://vuir.vu.edu.au/33707/1/EBI-impact-report.pdf

Clough, G. W. (2013). Best of both worlds: museums, libraries, and archives in the digital age. Smithsonian Institution. https://repository.si.edu/handle/10088/21153

Ellenberg, J., Swedlow, J. R., Barlow, M., Cook, C. E., Sarkans, U., Patwardhan, A., ... & Birney, E. (2018). A call for public archives for biological image data. Nature Methods, 15(11), 849-854.https://doi.org/10.1038/s41592-018-0195-8

European Commission, Directorate-General for Regional and Urban Policy, *Guide to cost-benefit analysis of investment projects : economic appraisal tool for cohesion policy 2014-2020*, Publications Office, 2015. https://data.europa.eu/doi/10.2769/97516

Fell, M. J. (2019). The economic impacts of open science: A rapid evidence assessment. Publications, 7(3), 46.https://doi.org/10.3390/publications7030046

Florio, M. (2019). Investing in science: Social cost-benefit analysis of research infrastructures. MIT Press.

Gabella, C., Durinx, C., & Appel, R. (2017). Funding knowledge bases: towards a sustainable funding model for the UniProt use case. F1000Research, 6.

HMTreasury (2020). Magenta Book Central Government guidance on evaluation. March 2020. ISBN 978-1-913635-18-3 PU2957.

Martin, C. S., Repo, S., Arenas Márquez, J., Blomberg, N., Lauer, K. B., Pérez Sitjà, X., ... & Smith, A. (2021). Demonstrating public value to funders and other stakeholders—the journey of ELIXIR, a virtual and distributed research infrastructure for life science data. Annals of Public and Cooperative Economics, 92(3), 497-510.

Miller, C. G., Brewer, P., Carine, M., Comerford, G., Hardy, H., Hart, A., ... & Woodburn, M. (2022). Join the Dots: assessing a collection of 80 million items at The Natural History Museum, London. Museum Management and Curatorship, 1-20.

Nelson, G., & Ellis, S. (2019). The history and impact of digitization and digital data mobilization on biodiversity research. Philosophical Transactions of the Royal Society B, 374(1763), 20170391.https://doi.org/10.1098/rstb.2017.0391

Reid, A. (2021). Designing a socio-economic impact framework for research infrastructures: Preliminary lessons from the RI-PATHS project. In The Economics of Big Science (pp. 61-70). Springer, Cham. https://library.oapen.org/bitstream/handle/20.500.12657/42933/2021_Book_TheEconomicsOfBigScience.pdf?sequence=1#page=65

I. ANNEX 1. DATA SHEET FOR SEI INDICATORS

Indicator_Name	1. Number of users served
Definition	Physical access to facilities and number of specimen loans: number of accepted users Resource RIs: number of downloads/studies or provisions of service.
Rationale	Indicator to measure the size of the community served.
Assumptions	The number of users served will depend on the (physical/online) resources available, and is likely to increase with their availability. This indicator can also provide a measure of the efficiency of operations, provided that the quality of service is not diminished (for example, if the time allocated per user is reduced too far without any compensating improvement in performance per unit time, the output may be affected negatively).
Data_Information_needs_and_Resources	A tracking/recording system should be set up by DiSSCo, mainly by common services: ELVIS, SDR, KB, DSR
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	The number of accepted users/ number of downloads/number of studies or services provided is recorded and reported. For DiSSCo which provides more than one type of service (e.g. data, services, access to the facility, platform and event-based access, key science and PI projects), values for each category are reported. Subgroups may be reported, as per - Share of users per DiSSCo country; - International users; - Academic users; - Non-proprietary Industrial users.
Breakdown_categories	country type of user (e.g. students, trainees, researchers, industry, public sector, private sector) type of access: physical, virtual discipline/application (e.g. agriculture, health)
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Enabling Scientific Excellence

Impact_area	Human Resources
Category_of_SEimpact	Scientific
Type_of_indicator	Activity
Additional_Issues_Observations	International: users from non-DiSSCo member countries are possibly a group to identify in the breakdown
ID_source	ESFRI_KPI2

Indicator_Name	2. Number of publications
Definition	Number of publications based on the research performed using facilities/resources of the RI. Multiauthor publications are shared by the countries of the home institutions of all authors, the sum of the shares being one.
Rationale	Related primarily to the quantity of science enabled and secondly to the quality of the science enabled.
Assumptions	The number of publications based on research performed using facilities/resources of DiSSCo provides a measure of the extent of those services, the size of the user community and the combined performance of the two in transforming the experimental results or data into publishable material. Includes publications by DiSSCo staff and DiSSCo users. Assumes good citation practices by users, including a provided DOI for the data/service served.
Data_Information_needs_and_Resources	The tracking of scientific publications performed by GBIF can be a good source of information for datasets published by DiSSCo members served through that organisation. A similar approach could be implemented for other types of data served by DiSSCo. Much of the published output will be captured using commercial databases such as WoS and Scopus which contain mainly articles published in peer reviewed journals. However, the scope of the survey has to be wider in some scientific fields and may require DiSSCo to gather the information directly from the users, including proceedings papers, book chapters, books and technical reports, or use of e-tools such as web crawlers in order to identify the publications. It should be noted that not all publications based on work conducted using DiSSCo will cite DiSSCo and not all users are forthcoming in providing such data. Subgroups may be reported, as per - Share of publications per each of the RI countries; - Share of publications per each of the non-RI countries
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	1. Collect the publications based on the research performed using facilities/resources of DiSSCo resorting to the variety of means outlined above. 2. Count
Breakdown_categories	citation numbers, co-authorship with other RI, topic, type of publication
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Subscription to database. Manual cleaning of database.
Level_reporting_burden	Low to High
Frequency_of_measurement	Annually
Objective	Enabling Scientific Excellence
Impact_area	Human Resources
Category_of_SEimpact	Scientific

Type_of_indicator	Activity
Additional_Issues_Observations	The relevance of different types of publications varies significantly from discipline to discipline. DiSSCo can report a wide variety of publication types (in addition to journal articles).
ID_source	ESFRI_KPI3; ESFRI_KPI8; ESFRI_KPI17

Indicator_Name	3. Revenues
Definition	Share of revenue from the RI's economic activities (sale of services and goods, access provision) reported in the annual accounts
Rationale	Indicator for the level of commercial activity in relation to the overall level of operation of DiSSCo
Assumptions	Cost Benefit Analysis (CBA) uses this revenue data combined with benefits data (both evaluated in monetary units)
Data_Information_needs_and_Resources	The accounting data
Who_provides_information	The accounting department of DiSSCo
Indicator_Calculation	Sum of the revenues from DiSSCo economic activities (sale of services and goods; access provision from users, which are not funded by a public funder), and the number of entities
Breakdown_categories	sources, number of entities paying for services, sales
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Generally low. It is medium for entities, where operation of DiSSCo is only a part of the activities and thus assigning revenues to DiSSCo is not always straightforward.
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Activity
Additional_Issues_Observations	Not all RIs share this objective. Some RIs might not be able to undertake commercial activities. It is needed to assess adequacy to DiSSCo.
ID_source	ESFRI_KPI10

Indicator_Name	4. Engagement achieved by direct contact
Definition	Outreach by public relations/direct contact with specific target groups: organisation of (e.g. summer schools, events for industry, government sector etc.) or participation at events organised by third parties; and visitors to the RI
Rationale	Provides a measure of the impact of DiSSCo in terms of raising public awareness and understanding of research in the fields in which DiSSCo operates. It can include visitors of exhibitions which use DiSSCo resources (e.g. 3D models).
Assumptions	DiSSCo has in place a tracking system for visitors, attendees at events organised by DiSSCo and participation of staff at external events, etc.
Data_Information_needs_and_Resources	The data is gathered internally by event managers and visitor services. The basic requirement comprises gathering (respecting GDPR rules) data on type of visitor/participant, age, gender, origin, etc. as well as standard visitor/participant satisfaction statistics. Subgroups may be reported, as per - School children - General public - Policy makers
Who_provides_information	The information should be gathered by the DiSSCo media/public relations and communications staff.
Indicator_Calculation	The indicators tracked include - number of visitors, - participants of the events and - events organised, number and hours (reported to a minimum 0.25 days)
Breakdown_categories	events (host, participation), visitors (students, researchers, public, etc), guided tours
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Outreach to the public
Impact_area	Society
Category_of_SEimpact	Social and Societal
Type_of_indicator	Activity
Additional_Issues_Observations	The indicator applies to physical DiSSCo facilities and less so to data infrastructures.
ID_source	ESFRI_KPI11

Indicator_Name	5. Outreach through printed, broadcast and web-based media
Definition	Impact of press and communication actions in raising awareness of RI mission, activities and societal relevance of results
Rationale	Measures the outcome of DiSSCo activity in terms of awareness and understanding within the general public and policy circles
Assumptions	It is assumed that DiSSCo has in place a public relations/media strategy and at least one member of staff working in this field to ensure reporting and monitoring occurs
Data_Information_needs_and_Resources	The information required concerns compiling a record of mentions of DiSSCo in different media (press, TV, radio, etc.) – this may include interviews of DiSSCo management or researchers, articles/reporting based on press releases, etc
Who_provides_information	The information should be gathered by DiSSCo media/public relations and communications staff.
Indicator_Calculation	Number of times DiSSCo is mentioned in press articles, radio or TV broadcasts or web-based media not-related to RI. Multiple mentions within one media report is counted as one.
Breakdown_categories	media, web, social networks, etc.
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Media tracking can be done internally at DiSSCo or can be outsourced to various commercial providers. Cost will vary depending on the method used.
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Outreach to the public
Impact_area	Society
Category_of_SEimpact	Social and societal
Type_of_indicator	Outcome
Additional_Issues_Observations	Negative reporting in the media may significantly affect the value of this indicator.
ID_source	ESFRI_KPI12

Indicator_Name	6. Number of publicly available data sets used externally
Definition	Number of data sets produced as a consequence of access to the RI that are subsequently accessed by other users
Rationale	Indicator of the extent to which the data that DiSSCo produces/makes available is regarded as useful by people who could be in the same scientific domain, in other scientific domains, by the economic sector or even by the general public. It thus provides some indicator of the wider significance of the data.
Assumptions	The 'rationale' for this indicator assumes that external access to the data provides some added value and this can only be checked by tracking its subsequent use.
Data_Information_needs_and_Resources	Monitoring system for access to DiSSCo database(s), linking specific datasets to specific requests for access
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	1. Identify 2. Count
Breakdown_categories	type of data, type of licence, type of use (training, research, applications, industry, public entities, public policies), quantity of access, quantity of use, quantity of store/archive
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Cost of setting up systems to provide monitored access to DiSSCo digital platform, including administrative overhead (e.g. sorting out legal issues).
Level_reporting_burden	Low. Medium in the case of multiple databases.
Frequency_of_measurement	Annually
Objective	Optimising data use
Impact_area	Economy and Innovation
Category_of_SEimpact	Scientific
Type_of_indicator	Outcome
Additional_Issues_Observations	The amount of data in a dataset may vary considerably, even within the same RI. Additional details, asked for at login, may lower user friendliness and result in fewer users.
ID_source	ESFRI_KPI14

Indicator_Name	7. Participation of DiSSCo in policy related activities
Definition	Number of participations, reimbursed by the organisers, in policy related working groups, committees & advisory boards. In the case of working groups, etc, organised by intergovernmental organisations, the invitation suffices.
Rationale	Indicator of the extent to which DiSSCo is deemed as relevant by policy makers. Both for science policy and for addressing societal challenges.
Assumptions	DiSSCo may enable scientific developments within a particular challenge and may contribute to developments of policies such as those contributing to development of ERA, ESFRI, etc. Invitations of the staff linked to DiSSCo, with the affiliation of DiSSCo acknowledged, to participate in working groups, committees and advisory boards (contributing to the SDG or other societal challenges as well as to the European Research Area or dedicated to industry), reflect the policy relevance of DiSSCo. Working groups, committees and advisory boards should be external to DiSSCo and should have an international composition, or advise an international or national body (e.g. UN entities, ministries, agencies). In the case of multiple meetings linked to one e.g. advisory group, every attendance counts as a participation.
Data_Information_needs_and_Resources	The information is collected by DiSSCo.
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	1. Collate information on participation to and contributions by DiSSCo staff to policy events, relevant working groups, etc. 2. Presentations, working papers, reports etc. to which DiSSCo has contributed can be collated and shared via dedicated space on the DiSSCo website or via ResearchGate, etc. 3. Analyse contributions broken down by level (Global, European, national, etc.) or by theme
Breakdown_categories	national, international, global advisory boards; thematic boards
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Provision of scientific advice
Impact_area	Policy
Category_of_SEimpact	Social and societal
Type_of_indicator	Activity
Additional_Issues_Observations	
ID_source	ESFRI_KPI15

Indicator_Name	8. Number, volume, nature of procurement, by supplier type
Definition	Number of suppliers (regional and local). (Griniece et al, 2015)
Rationale	Increased revenues of suppliers and related new skills impact the economic activity of the region
Assumptions	
Data_Information_needs_and_Resources	Number of suppliers (regional and local). (Griniece et al, 2015)
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Number of suppliers (regional and local). (Griniece et al, 2015)
Breakdown_categories	Number, volume, nature of procurement, by supplier type, local/regional suppliers
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Impact
Additional_Issues_Observations	The relevance of this indicator needs to be evaluated in terms of infrastructure construction plans. Some members may make considerable investments that may be considered.
ID_source	OECD_E35

Indicator_Name	9. Technological impact: Number of new technologies and designs
Definition	Production capacities (of drugs, food, etc.)
Rationale	Facilitating economic activities
Assumptions	The number of new technologies and designs based on research performed using facilities/resources of DiSSCo provides a measure of the extent of those services, the size of the user community and the combined performance of the two in transforming the experimental results or data into new technologies and designs. Includes the development of new technologies and designs by DiSSCo staff and DiSSCo users. Assumes acknowledgment practices by users.
Data_Information_needs_and_Resources	Systematic surveys of supplier and user firms/industries to track the impacts (i.e. innovations in products/processes, reputation effects, etc.) of their collaboration with DiSSCo
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Systematic surveys of supplier and user firms/industries to track the impacts (i.e. innovations in products/processes, reputation effects, etc.) of their collaboration with DiSSCo
Breakdown_categories	new software tools, new technologies, new designs, new standards, scientific instruments, infrastructures, new drugs, new applications in agriculture
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium to high
Level_reporting_burden	Medium to high
Frequency_of_measurement	Biennial
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Activity
Additional_Issues_Observations	
ID_source	RIPATHS_042

Indicator_Name	10. Grants and projects
Definition	Number of grants/total amount from the host country for research and development projects. (Rosenberg, 1992)
Rationale	National grants received demonstrate DiSSCo excellence
Assumptions	The number of grants and projects based on research using facilities/resources of DiSSCo provides a measure of the extent of those services, the size of the user community and the combined performance of the two in obtaining research funding. Includes grants and projects awarded to DiSSCo staff and DiSSCo users.
Data_Information_needs_and_Resources	Number of grants/total amount from the host country for research and development projects. (Rosenberg, 1992)
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Number of grants/total amount from the host country for research and development projects. (Rosenberg, 1992)
Breakdown_categories	national, international, with industrial partners, with other RIs
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	low
Level_reporting_burden	low
Frequency_of_measurement	Annually
Objective	Facilitating economic activities
Impact_area	Human Resources
Category_of_SEimpact	Technological
Type_of_indicator	Activity
Additional_Issues_Observations	
ID_source	OECD_T15

Indicator_Name	11. Local expenditure of DiSSCo, employees & visitors
Definition	Total expenditure in regional area, including total amount of purchase from suppliers, contract with suppliers and others, estimation of economic impact on regional area. (Rochow et al., 2011; Prettner and Werner, 2016)
Rationale	All the regional/local DiSSCo expenditures have an impact on the economy
Assumptions	
Data_Information_needs_and_Resources	Total expenditure in regional area, including total amount of purchase from suppliers, contract with suppliers and others, estimation of economic impact on regional area. (Rochow et al., 2011; Prettner and Werner, 2016)
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Analysis of documents and internal databases, as financial documents, internal reports, procurement databases.
Breakdown_categories	Main economic sector affected (increase in the market), main jobs created (number of new jobs net created), directly and indirectly.
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Annually
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Impact
Additional_Issues_Observations	This indicator is better fitted to single site RIs, however its use in DiSSCo can help to determine the impact of visitors in the regions they visit.
ID_source	OECD_E30

Indicator_Name	12. Number of Full Time Equivalent (FTE) within the DiSSCo
Definition	Number of FTE (all persons working within the RI evaluated as full time equivalent), per year. Diversity distribution. RI Alumni. (Griniece et al, 2015; Florio, Forte and Sirtori, 2016)
Rationale	Development of new skills and increase of jobs and the economic activity of the region (multiplier)
Assumptions	
Data_Information_needs_and_Resources	The data is gathered internally by DiSSCo partners. The basic requirement comprises gathering (respecting GDPR rules) data on type of collaborator/participant, time of work, age, gender.
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	The indicators tracked include researchers, instructors and alumni working in DiSSCo.
Breakdown_categories	Full Time Instructors, alumni, researchers, gender
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low to medium
Level_reporting_burden	Low to medium
Frequency_of_measurement	Annually
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Impact
Additional_Issues_Observations	The FTE is the usual metric used for quantifying human resources in institutions. If an employee performs two kind of tasks: within DiSSCo and non-DiSSCo it is not easy to compute the exact FTE in DiSSCo (Standardised procedures of time accounting must be implemented)
ID_source	OECD_E34

Indicator_Name	13. New tax payers
Definition	Number of employees, living in the local area for 3 years at least. (Florio, Forte and Sirtori, 2016)
Rationale	Employees living in the local area of DiSSCo can increase revenues for the region
Assumptions	DiSSCo will contract collaborators
Data_Information_needs_and_Resources	The data is gathered internally by DiSSCo partners administrative services.
Who_provides_information	provided by DiSSCo
Indicator_Calculation	Number of employees, living in the local area for 3 years at least. (Florio, Forte and Sirtori, 2016)
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Medium
Frequency_of_measurement	Annually
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Outcome
Additional_Issues_Observations	
ID_source	OECD_E33

Indicator_Name	14. Gender balance and diversity
Definition	Gender distribution of employees, users and trainees. Diversity of the staff, users... (Björling, 2018)
Rationale	Demonstrates the effort made by DiSSCo for gender equity (RI exemplarity)
Assumptions	DiSSCo will follow recommendations to promote gender equality through contracts and use of DiSSCo facilities and data
Data_Information_needs_and_Resources	Data is gathered internally by DiSSCo partners administrative services.
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Gender distribution of employees, users and trainees. Diversity of the staff, users... (Björling, 2018)
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Optimising management
Impact_area	Society
Category_of_SEimpact	Social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	OECD_O57

Indicator_Name	15. Corporate social responsibility
Definition	Internal survey. Ethical guidelines. Responsible suppliers (label). Good working conditions
Rationale	Showing the DiSSCo as an example of social responsibility
Assumptions	
Data_Information_needs_and_Resources	Internal survey. Ethical guidelines. Responsible suppliers (label). Good working conditions
Who_provides_information	provided by DiSSCo
Indicator_Calculation	Internal survey. Ethical guidelines. Responsible suppliers (label). Good working conditions
Breakdown_categories	
Nature_of_indicator	narrative
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Low
Frequency_of_measurement	Biennial
Objective	Optimising management
Impact_area	Society
Category_of_SEimpact	Social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	OECD_O58

Indicator_Name	16. Scientific attractiveness
Definition	Scientific attractiveness
Rationale	Showing DiSSCo as a scientific RI of excellence which can attract researchers and students
Assumptions	Employment and conditions to attract researchers and students
Data_Information_needs_and_Resources	Survey to identify the potential of DiSSCo in terms of employment/usage opportunity for scientific users based on activities, working conditions and other relevant variables
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Survey to identify the potential of DiSSCo in terms of employment/usage opportunity for scientific users based on activities, working conditions and other relevant variables
Breakdown_categories	Countries, institutions, status in the scientific career, level in higher education (e.g. Master, PhD, Post PhD); number of applications; number of admissions
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	medium
Level_reporting_burden	medium
Frequency_of_measurement	Biennial
Objective	Delivery of education and training
Impact_area	Human Resources
Category_of_SEimpact	training and education
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	RIPATHS_010

Indicator_Name	17. User satisfaction
Definition	Satisfaction of RI users regarding project selection, access, support, availability of instruments… (Griniece et al., 2015)
Rationale	Based on survey results; a survey can be run to measure user satisfaction on project selection, access, support and other items related to DiSSCo services, to evaluate how DiSSCo RI answers its user needs
Assumptions	DiSSCo will be widely used and provide infrastructures of excellence
Data_Information_needs_and_Resources	Based on survey results; a survey can be run to measure user satisfaction on project selection, support and other items, to evaluate how DiSSCo RI answers its user needs
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Satisfaction of RI users regarding project selection, access, support, availability of instruments… (Griniece et al., 2015)
Breakdown_categories	Type of user (e.g. researcher, student, firm); goal of the use (e.g. commercial, scientific, educational)
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Enabling Scientific Excellence
Impact_area	Human Resources
Category_of_SEimpact	Scientific
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	OECD_S7

Indicator_Name	18. Number of spin-offs surviving to date
Definition	Number of spin-offs surviving to date
Rationale	Importance of DiSSCo as data provider to start-ups and spin-offs
Assumptions	DiSSCo will have important infrastructures to support start-ups and spin-offs survival
Data_Information_needs_and_Resources	Systematic surveys of start-ups and spin-offs to better understand the contribution of DiSSCo to their growth
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Systematic surveys of start-ups and spin-offs to better understand the contribution of the RI to their growth
Breakdown_categories	area of activity of spin-off: software tools, technologies, scientific instruments, infrastructures, drugs, applications in agriculture
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium to high
Level_reporting_burden	Medium to high
Frequency_of_measurement	Biennial
Objective	Facilitating economic activities
Impact_area	Economy and Innovation
Category_of_SEimpact	Economic
Type_of_indicator	Outcome
Additional_Issues_Observations	
ID_source	RIPATHS_052

Indicator_Name	19. Contribution to social sustainability: CSR, Social Inclusion, Culture
Definition	Contribution to social sustainability: CSR, Social Inclusion, Culture
Rationale	Indicator to identity the use and contribute of DiSSCo by society at various levels, from education to biodiversity conservation, food security, health and culture
Assumptions	Society will use DiSSCo
Data_Information_needs_and_Resources	Qualitative data collection (e.g. semi-structured interviews) to identify specific contributions of DiSSCo to gender balance, social inclusion, environmental issues both internally within the organisation and externally throughout society
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Qualitative data collection (e.g. semi-structured interviews) to identify specific contributions of the RI to gender balance, social inclusion, environmental issues both internally within the organisation and externally throughout society
Breakdown_categories	Categories of social sustainability
Nature_of_indicator	narrative
Estimated_Cost_Data_Collection	medium
Level_reporting_burden	medium
Frequency_of_measurement	Biennial
Objective	Provision of scientific advice
Impact_area	Society
Category_of_SEimpact	social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	RIPATHS_074

Indicator_Name	20. Contribution to environmental sustainability: Energy & Waste issues
Definition	Contribution to environmental sustainability: Energy & Waste issues
Rationale	Use of DiSSCo by the environmental stakeholders at various levels
Assumptions	Environmental stakeholders will use DiSSCo to improve their environmental sustainability performance
Data_Information_needs_and_Resources	Surveys of users to assess their willingness to pay for a solution (e.g. treatment of cancer, waste management) provided by the RI
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Surveys of users to assess their willingness to pay (WTP) for a solution (e.g. treatment of cancer, waste management) provided by DiSSCo
Breakdown_categories	Energy categories; waste categories
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Optimising management and sustainability
Impact_area	Society
Category_of_SEimpact	social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	Although DiSSCo may play a role in the sustainable use of energy and waste management, this is not in the core mission. Maybe this indicator could be removed from the final list.
ID_source	RIPATHS_077

Indicator_Name	21. Improvement of wellbeing: Health & Ageing
Definition	Improvement of wellbeing: Health & Ageing
Rationale	DiSSCo has contributed to answer social-ecological issues
Assumptions	DiSSCo will act as an example and data provider to promote health and wellbeing
Data_Information_needs_and_Resources	Qualitative data collection (e.g. semi-structured interviews) to identify specific contributions of DiSSCo to gender balance, social inclusion, environmental issues both internally within the organisation and externally throughout society
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Qualitative data collection (e.g. semi-structured interviews) to identify specific contributions of the RI to gender balance, social inclusion, environmental issues both internally within the organisation and externally throughout society
Breakdown_categories	health, ageing
Nature_of_indicator	narrative
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Outreach to the public
Impact_area	Society
Category_of_SEimpact	social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	RIPATHS_079

Indicator_Name	22. Participation of DiSSCo in local/ regional committees/networks (e.g. clusters)
Definition	Participation of RI in local/ regional networks (e.g. clusters)
Rationale	DiSSCo has strengthen its participation in local/regional networks
Assumptions	DiSSCo will develop efforts to participate in local/regional networks
Data_Information_needs_and_Resources	Tracking of DiSSCo presence in relevant thematic committees/networks, including qualitative analysis of specific contributions to the definition of scientific norms and standardisation.
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Tracking DiSSCo's presence in relevant thematic committees/networks, including qualitative analysis of specific contributions to the definition of scientific norms and standardisation
Breakdown_categories	participation by areas of intervention or policy
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Medium
Frequency_of_measurement	Annually
Objective	Provision of scientific advice
Impact_area	Policy
Category_of_SEimpact	social and societal
Type_of_indicator	Activity
Additional_Issues_Observations	The identification of the committees/networks that exist at local/regional is the first step before selecting those where DiSSCo will participate. For example: networks of museums, archives and/or documentation
ID_source	RIPATHS_099

Indicator_Name	23. Number of DiSSCo participations in relevant standardisation committees
Definition	Participation of RI in relevant standardisation committees
Rationale	DiSSCo has incorporated relevant committees in the domains of data fairness and biodiversity and environment data.
Assumptions	DiSSCo will develop efforts to integrate relevant committees which promote regional and global coordination about data fairness.
Data_Information_needs_and_Resources	Tracking DiSSCo's presence in relevant thematic committees/networks, including qualitative analysis of specific contributions to the definition of scientific norms and standardisation
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Tracking DiSSCo's presence in relevant thematic committees/networks, including qualitative analysis of specific contributions to the definition of scientific norms and standardisation Number of participations or contributions from DiSSCo in the total of committees for definition of scientific norms and standardisation.
Breakdown_categories	Domains of scientific norms and standardisation.
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Low
Level_reporting_burden	Low
Frequency_of_measurement	Annually
Objective	Provision of scientific advice
Impact_area	Policy
Category_of_SEimpact	social and societal
Type_of_indicator	Activity
Additional_Issues_Observations	
ID_source	RIPATHS_100

Indicator_Name	24. Improvement of fitness-for-purpose of online biological and ecological data by embedding standards in DiSSCo
Definition	The extent to which the embedding of standards in DiSSCo systems has improved the fitness-for-purpose, consistency and accessibility of all online biological and ecological data.
Rationale	DiSSCo has an impact through an influence on cultural change among its partners and users community by the embedding of standards in DiSSCo systems, contributing to improved the fitness-for-purpose, consistency and accessibility of all online biological and ecological data.
Assumptions	DiSSCo will incorporate standards in DiSSCo systems to improve the fitness-for-purpose, consistency and accessibility of all online biological and ecological data.
Data_Information_needs_and_Resources	Impact survey. Example: Question - In your opinion, to what extent do you think RI systems have improved the fitness-for-purpose embedding of standards, consistency and accessibility of all online biological and ecological data?
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Impact survey
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Optimising data use
Impact_area	Economy and Innovation
Category_of_SEimpact	technological
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	ALA_13

Indicator_Name	25. Improvement in the amount of “trusted” or quality data online as a consequence of the establishment of DiSSCo.
Definition	The extent to which there has been an improvement in the amount of “trusted” or quality data online as a consequence of the establishment of the ALA.
Rationale	DiSSCo has an impact through an influence on cultural change among its partners and users community by an improvement in the amount of “trusted” or quality data online.
Assumptions	DiSSCo will seek to improve the amount of “trusted” or quality data online
Data_Information_needs_and_Resources	Impact survey. Response to Impact Survey question - In your opinion, to what extent has there been an improvement in the amount of “trusted” or quality data online as a consequence of the establishment of the RI?
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Impact survey.
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Optimising data use
Impact_area	Society
Category_of_SEimpact	technological
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	ALA_14

Indicator_Name	26. Enablement of “communities” for collaboration, exchange and reuse of tools and resources
Definition	The extent to which the ALA has enabled “communities” or groups to connect, collaborate and self-organise in groups of interest to improve their own activities, avoid re-inventing the wheel, reduce duplication, provide critical mass, and attract new customers/clients/partners.
Rationale	DiSSCo promotes and enables “communities” or groups to connect, collaborate and self-organise in groups of interest to improve their own activities, avoid re-inventing the wheel, reduce duplication, provide critical mass, and attract new customers/clients/partners.
Assumptions	DiSSCo will promote the connection, collaboration and self-organisation of “communities” or groups to improve their own performance
Data_Information_needs_and_Resources	Impact survey. Response to Impact Survey question - In your opinion, to what extent has the RI enabled “communities” or groups to connect, collaborate and self-organize in groups of interest to improve their own activities, avoid re-inventing the wheel, reduce duplication, provide critical mass, and attract new customers / clients / partners?
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Impact survey
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Optimising management
Impact_area	Economy and Innovation
Category_of_SEimpact	technological
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	ALA_17

Indicator_Name	27. Improvement of data management efficiency
Definition	The extent to which use of DiSSCo has improved data management efficiency in relation to the time and resources spent in biodiversity data access.
Rationale	Data, tools and resources provided by DiSSCo contribute to improve data management efficiency in relation to the time and resources spent in biodiversity data access.
Assumptions	DiSSCo will promote data management efficiency in relation to the time and resources spent in biodiversity data access.
Data_Information_needs_and_Resources	Impact survey. Response to Impact Survey question - To what extent do you think your use of the RI has improved your organisation's data management efficiency in relation to the time and resources spent in biodiversity data access?
Who_provides_information	Provided by the RI
Indicator_Calculation	Impact survey
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Optimising data use
Impact_area	Economy and Innovation
Category_of_SEimpact	technological
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	ALA_21

Indicator_Name	28. Application of research to key national and global challenges
Definition	The extent to which DiSSCo has helped in the application of research to key national and global challenges
Rationale	DiSSCo data, resources and tools support reporting and advice on national and global challenges
Assumptions	DiSSCo will promote the application of research to key national and global challenges
Data_Information_needs_and_Resources	Impact survey. Response to Impact Survey question - In your opinion, to what extent has the DiSSCo RI helped in the application of research to key national and global challenges?
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Impact survey
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Provision of scientific advice
Impact_area	Policy
Category_of_SEimpact	social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	ALA_28

Indicator_Name	29. Help to undertake on-ground interventions with respect to biodiversity
Definition	The extent to which DiSSCo has helped the community to undertake on-ground interventions with respect to biodiversity (e.g. restoration, community participation, surveys).
Rationale	DiSSCo services assist with the enrollment of the community in on-ground interventions with respect to biodiversity (restoration, community, surveys, etc)
Assumptions	DiSSCo will assist the enrollment of the community in on-ground interventions with respect to biodiversity
Data_Information_needs_and_Resources	Impact survey. Response to Impact Survey question - In your opinion, to what extent has the RI helped the community (Natural Resource Management bodies) to undertake on- ground interventions with respect to biodiversity (restoration, community, surveys, etc)?
Who_provides_information	Provided by DiSSCo
Indicator_Calculation	Impact survey
Breakdown_categories	
Nature_of_indicator	numeric
Estimated_Cost_Data_Collection	Medium
Level_reporting_burden	Medium
Frequency_of_measurement	Biennial
Objective	Provision of scientific advice
Impact_area	Policy
Category_of_SEimpact	Social and societal
Type_of_indicator	Impact
Additional_Issues_Observations	
ID_source	ALA_29

Annex 1 References

Björling, S. (2018). Impact assessment, Perspectives from the Swedish Research Council, Head of the Department of Research Infrastructures The Swedish Research Council, OECD Workshop 19-20 March 2018.

Florio, M., S. Forte and E. Sirtori (2016). “Forecasting the socio-economic impact of the Large Hadron Collider: A cost–benefit analysis to 2025 and beyond”, Technological Forecasting and Social Change, Vol 112, pp. 38-53, https://doi.org/10.1016/j.techfore.2016.03.007.

Griniece, E., A Reid and J. Angelis (2015). Guide to Evaluating and Monitoring Socio-Economic Impact of Investment in Research Infrastructures. Technopolis Group. Tallinn. Estonia, http://www.technopolis-group.com/wp-content/uploads/2015/04/2015_Technopolis_Group_guide_to_impact_assessment_of_research_infrastructures.pdf

Prettner, K. and K. Werner (2016). “Why it pays off to pay us well: The impact of basic research on economic growth and welfare”, Research policy, N°45(5), pp. 1075-1090, https://doi.org/10.1016/j.respol.2016.03.001

Rosenberg, S.R. (1992). The social impact of computers, First Edition, Academic Press.

Rochow, R. et al. (2011). Foresight enriched Research Infrastructure Assessment Methodology (fenRIAM), https://www.researchgate.net/publication/236645351_FenRIAM_full_guide_Proposal_for_a_Foresight-enriched_Research_Infrastructure_Impact_assessment_Methodology