

Report on FAIR Evaluation community survey

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** All TF members have had the opportunity to review and edit this document; invitations to be on the authorship list were open to all.

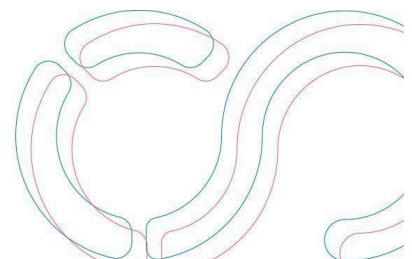
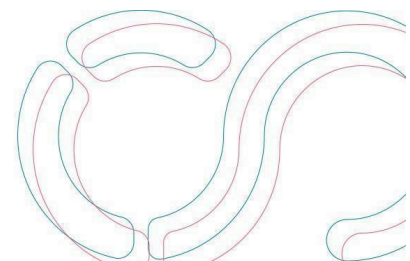


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Executive summary

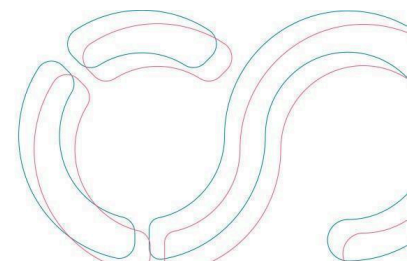
The EOSC-A FAIR Metrics and Data Quality Task Force (TF) supports the European Open Science Cloud Association (EOSC-A) by providing strategic directions on FAIRness (Findable, Accessible, Interoperable, and Reusable) and data quality. The report summarises the results of a survey conducted at the end of 2022/early 2023, targeting both developers and users of FAIR assessment tools. The survey aimed at supporting the harmonisation of FAIR assessments, in terms of what it evaluated and how, across existing (and future) tools and services, as well as explore if and how a community-driven governance on these FAIR assessments would look like.

The survey received 78 responses, mainly from academia, representing various domains and organisational roles. Respondents were involved in multiple projects, with significant representation from EOSC projects. From the total responses, 61 capture the FAIR assessment practices, while 17 give opinions only for FAIR assessment governance. The key findings are as follows:

- 1. FAIR Assessments and Tools:** Most respondents have applied FAIR principles for assessing data, software or any other research outputs and digital objects (either with the support of tools or according to one's own interpretation), with self-assessments being the most common answer. Tools used for FAIR assessments varied, with some developed specifically for this purpose. The survey also highlighted different tools for assessing various digital objects.
- 2. Challenges and Confidence in FAIR Assessments:** Respondents identified challenges related to the interpretation of FAIR principles, understandability of criteria, and validity of results. Trust in FAIR assessment results was moderate, with technical respondents showing higher trust levels.
- 3. FAIR Governance and Community Involvement:** There was a general favour for establishing a FAIR Assessment Governance Body. Respondents emphasised the need for community involvement, transparency, and the development of best practices and infrastructures.
- 4. Awareness and Adoption of FAIR Principles:** There was a mix of confidence and uncertainty regarding the interpretation of FAIR principles. Awareness of FAIR principles varied, and there were suggestions for increasing awareness among researchers.
- 5. CARE and TRUST Principles:** The survey also explored the adoption of CARE (Collectable, Accessible, Reusable, Expendable) and TRUST (Transparency, Responsibility, User focus, Sustainability, and Technology) principles, finding that awareness and application of these were less established compared to FAIR principles.

Conclusions:

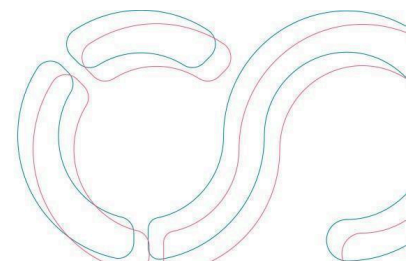
- The research community is mainly knowledgeable and confident in interpreting FAIR principles, yet concerns remain about tool interpretations and assessment criteria.
- There is a need for clearer governance structures, better training, and collaborative efforts to mitigate challenges in implementing FAIR principles.
- The survey highlights the importance of distinguishing between FAIR data and FAIR



metadata assessments and suggests that more transparency in FAIR assessment processes could increase trust in tools.

- There is a potential for exploring the incorporation of CARE and TRUST principles in FAIR assessments.

Overall, the survey underlines the evolving landscape of FAIR practices and the importance of community-driven approaches, clear governance, and the need for continuous development of assessment tools and methods.



Introduction

The [FAIR Metrics and Data Quality Task Force \(TF\)](#) supports the [European Open Science Cloud Association \(EOSC-A\) in its ambition to develop a 'Web of FAIR Data and Services' for science in Europe](#). It is therefore crucial in guiding the EOSC's development and implementation, particularly in metadata and quality assurance. The TF's primary mission is to ensure that research objects are not only discoverable and understandable but also reusable. It aims to establish and enforce benchmarks for assessing FAIRness (Findability, Accessibility, Interoperability, and Reusability) and data quality, ensuring reliability and trust in the content.

This report encapsulates the findings from a survey conducted by the FAIR metrics group in late 2022 and early 2023. Targeting both developers and users of FAIR assessment tools, the survey was an integral part of the TF's broader initiative to harmonize FAIR assessment results across various service providers and to foster a community-led approach to FAIR governance.

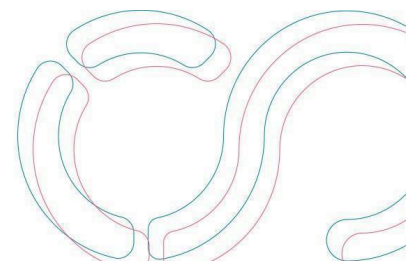
The survey comprised four sections:¹

- A. *About You*, to collect information of the respondents' profiles.
- B. *Application of the FAIR Principles for Assessment* to record the practices followed in implementation and the needs expressed by the community.
- C. *FAIR Assessment Governance*, to explore community perceptions on governing mechanisms for FAIR assessments to support policy compliance.
- D. *Personal Reflections*, to record respondents' views about their practices with adopting data principles, including FAIR, TRUST, and CARE.

Our report begins by outlining the methodology and the guiding principles of our data management approach. It then presents a detailed analysis of the survey results, examining each of the four sections individually and collectively. The discussion section provides insightful observations and critical findings, framing them within a broader context. Based on these insights, the report concludes with concrete recommendations and proposed next steps.

For a comprehensive understanding of our work on FAIR assessment, we recommend reading this report in conjunction with two other significant TF publications: [FAIR Assessment Tools: Towards an "Apples to Apples" Comparisons](#); and [Community-driven Governance of FAIRness Assessment: An Open Issue, an Open Discussion](#), where the former examines the complexity of automated FAIRness assessments, and suggests the need for a governance mechanism to help harmonise the assessment landscape, while the latter explores possible models for such a governance body.

¹ Please check Annex I



1. Data management and methods

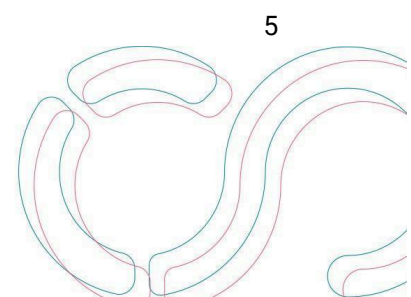
Data was collected using the [EUSurvey tool](#) between 15.11.2022 and 18.01.2023 when the recipients' data were downloaded for analysis. The survey invitation was sent to research communities, infrastructures, and networks across domains connected to group members, including their affiliated organisation(s), as well as to known FAIR assessment tool providers and individuals active on the FAIR spectrum of science and EOSC (through, for instance, EOSC Association communication channels). In total, there were 79 responses, but one respondent claimed their GDPR rights, and their response was deleted, so the final data contains 78 responses. Out of the 78 responses, 17 provided their input only about Governance and shared their reflections on implementing the FAIR principles. Undoubtedly, the small number of survey responses makes the findings and analysis more indicative than conclusive. But, at the same time, it provides insight into the current practices and perceptions of FAIR assessments and presents an excellent opportunity for longitudinal and other future studies.

Upon collection, the data were cleaned for analysis curating acronyms, typos, duplicates and open-ended questions. An extra step was taken in this process to distinguish FAIR Assessment tool providers from their users. Free text input was categorised and transformed into tabular data for some questions and was kept in its initial form and enhanced to provide a more comprehensive narrative in other cases.

The EUSurvey tool provided basic results (frequencies, charts). Cross-tabulations were done using SPSS and Excel which were also used to add variable metadata (variable and value labels), to re-classify variables for analysis purposes, and to maintain respondent's anonymity.

The raw data were kept under restricted access during data processing at ATHENA Research Center's institutional OneDrive account. Figures and visualisations of the processed data were made available to all FAIR Metrics TF members in a shared Google folder. Re-identification possibilities and risks associated with data were considered and minimised through the anonymization process. The anonymised dataset is available on Zenodo².

² Dataset: <https://zenodo.org/doi/10.5281/zenodo.10679361>



2. Results

In this section, we present the findings of our survey that address:

- the way that FAIR assessments are performed today by the research community, reflecting both the technical implementation of FAIR metrics and the personal choices for the interpretation of FAIR principles for assessment in different contexts.
- the need for establishing a FAIR Assessments Governance Body driven by the community to provide the workflows and tools that will support common understanding and agreement over FAIR awareness and compliance across countries and domains.

2.1 Characteristics of respondents

The majority (94%) were from academia, representing various organisations; 62 organisations were mentioned. Respondents came from multiple domains (figure 1) and represented various organisational roles (figure 2).

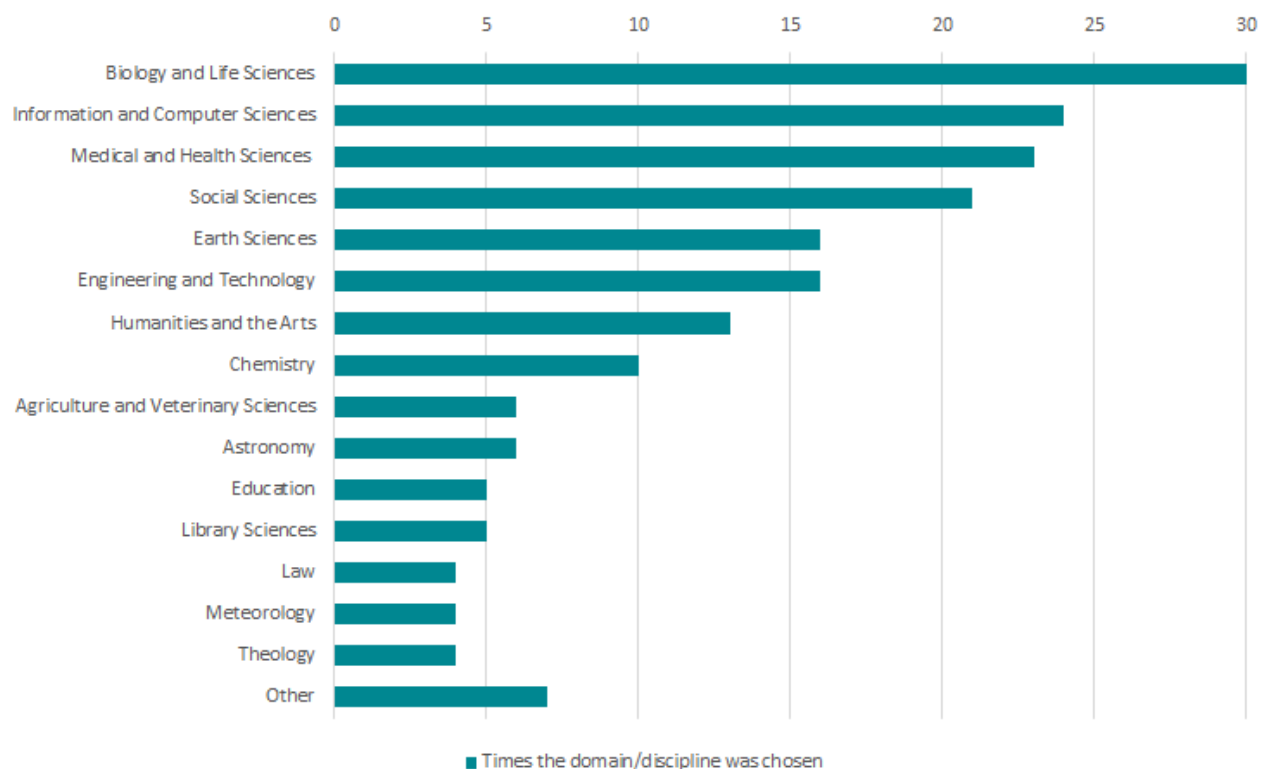
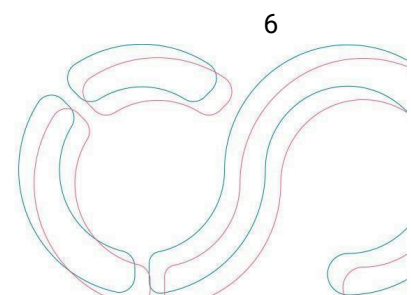


Figure 1a. How many times the disciplines/domains were chosen by the respondents. They could choose multiple options. (n=78, where n is the number of respondents.)



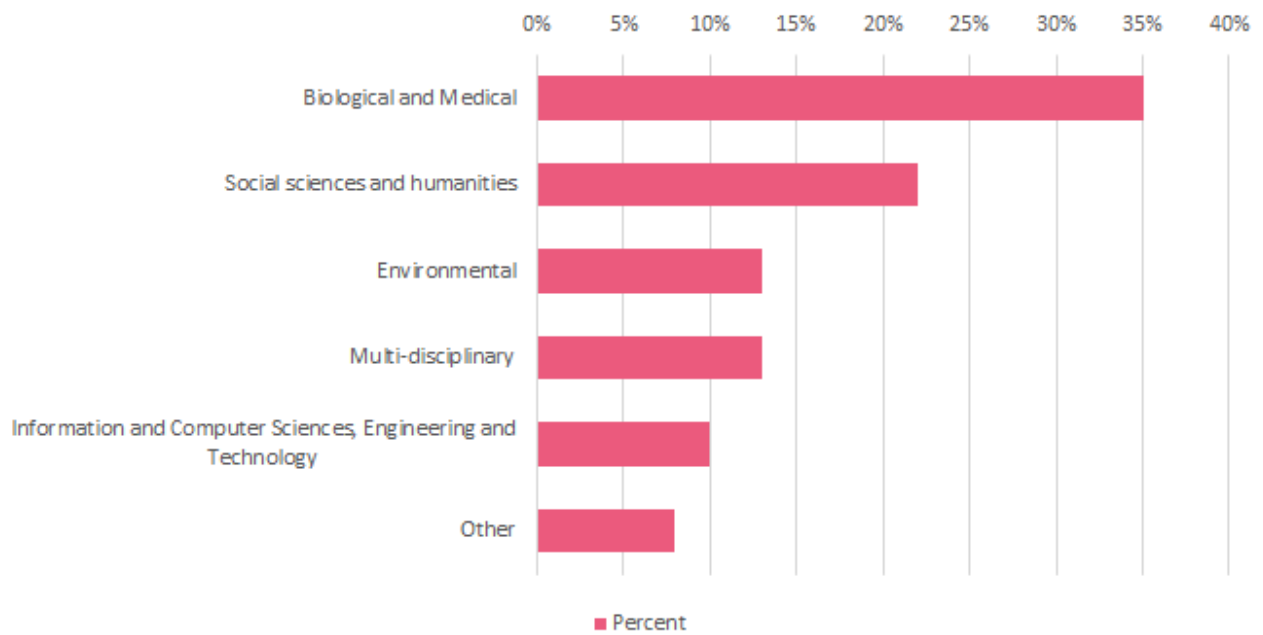


Figure 1b. Respondents and the domains or research areas they represent. The responses were clustered based on ESFRI thematic clusters. (n=78)

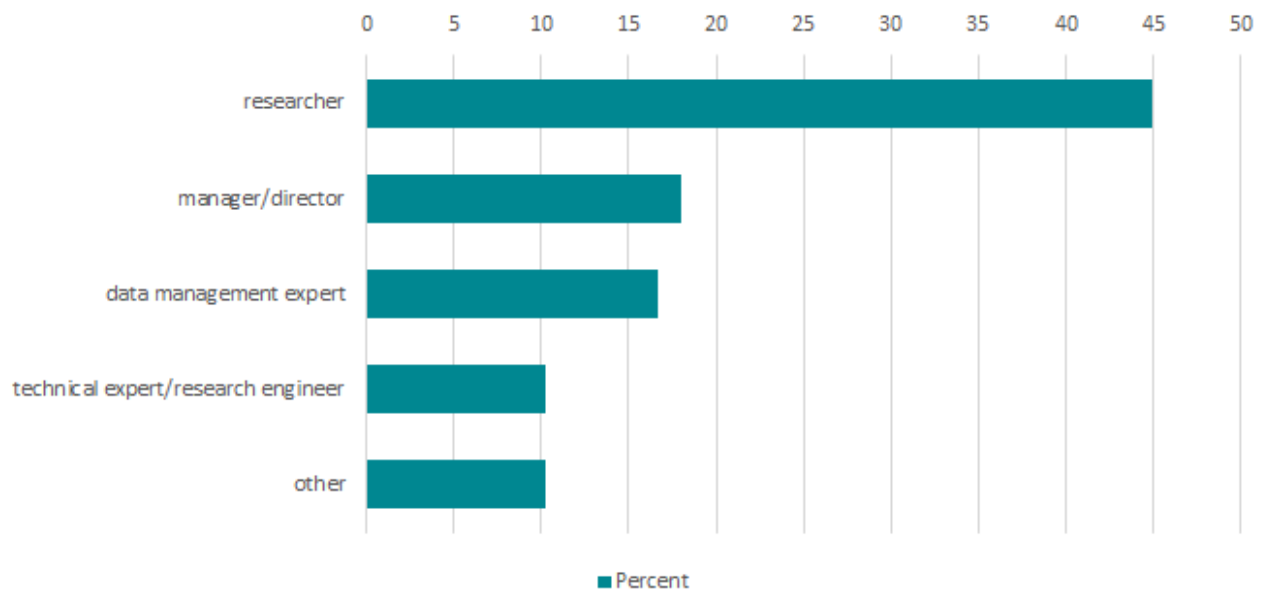
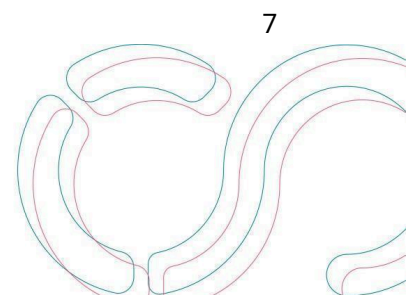


Figure 2. Respondent's role in organisation (n=78).



When asked in which capacity they responded, all respondents mentioned at least one capacity. Many mentioned more than one, and the average was two capacities. 'Data steward or curator' and 'service or data provider' were most mentioned. There were no funders among the respondents but otherwise, stakeholder communities were represented.

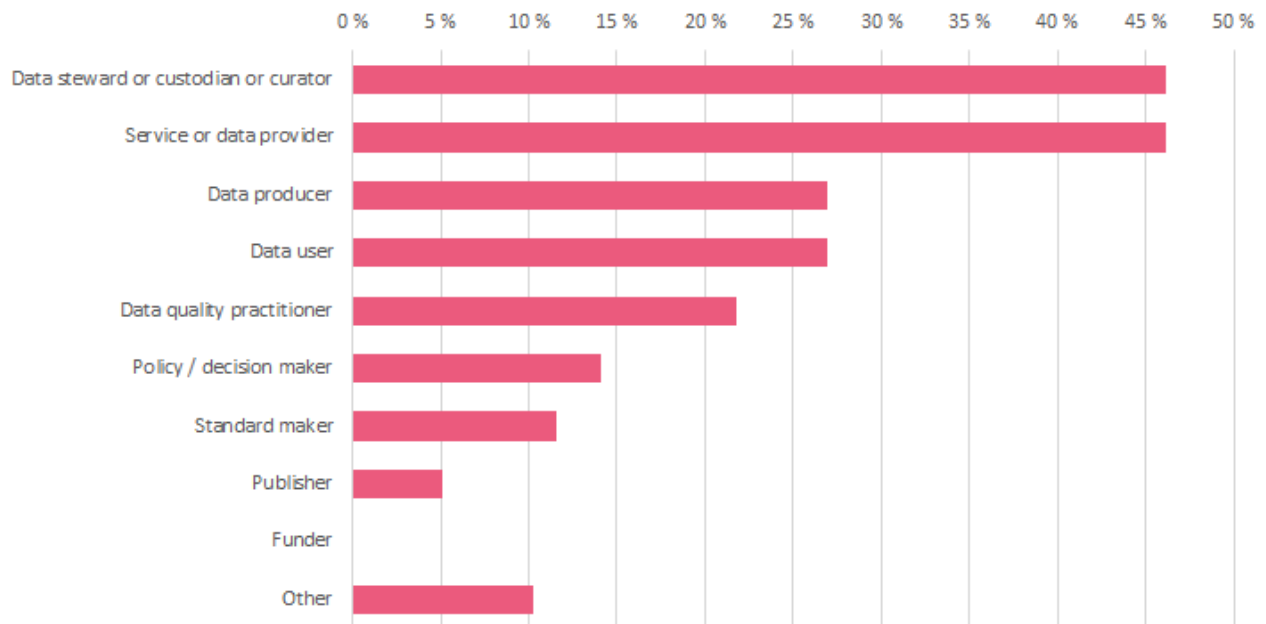
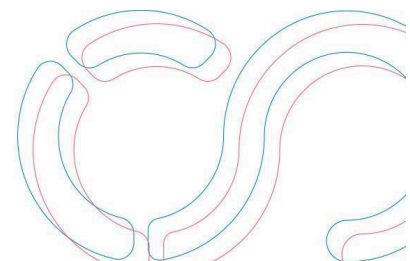


Figure 3. Percentage of respondents that chose a capacity when asked in which capacity they answered the survey. The respondents could choose multiple answers.

Respondents from the SSH and Environmental sciences had applied the FAIR principles for assessment in their process and results from more times than Biological and Medical sciences, Information and Computer Sciences, and multidisciplinary studies.



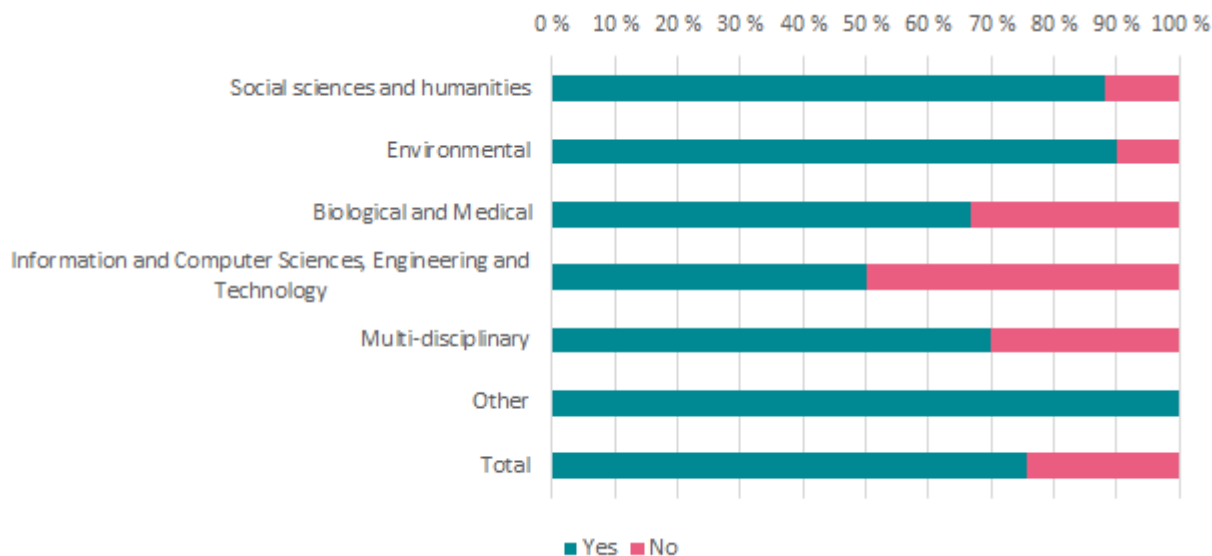


Figure 4. Respondents from all domains had applied FAIR principles for assessing data, software or any other research outputs and digital objects (n=78).

About half (40) of the respondents mentioned EOSC projects they were involved in. In total, 43 different projects were mentioned, and those who mentioned project involvement were involved in, on average, two projects, and the maximum number of projects was six. The most frequently mentioned projects were EOSC-Future (11 mentions), EOSC Life (7), FAIR-IMPACT (6), and FAIRsFAIR (4). One mention of EOSCpilot shows that some of the respondents have been following EOSC developments since its first implementation project.

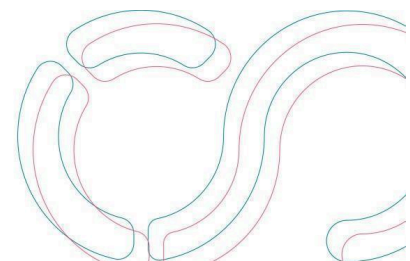
2.2 FAIR assessment: behaviours and tools

Three out of four respondents (76%) had applied the FAIR principles to assess different outputs and artefacts by themselves (figure 4). Only two respondents mentioned that someone else had performed or supported them in performing the FAIR assessment.

Most respondents (63%) had self-assessed their records, either artefacts or digital objects or entities; 42% had assessed third-party records, and 22% had compared their records with third-party records (20% did not answer this question).

The most common artefact/digital object for which assessment was performed was metadata, mentioned by 67%, followed closely by data (65%); the one who answered 'other' specified that they had assessed standards (figure 5). The respondents could select multiple options, and the three most popular combinations were:

- data; metadata (chosen by 6 respondents)



- data; metadata; software; repository/ies (4), and
- data; metadata; repository/ies (3).

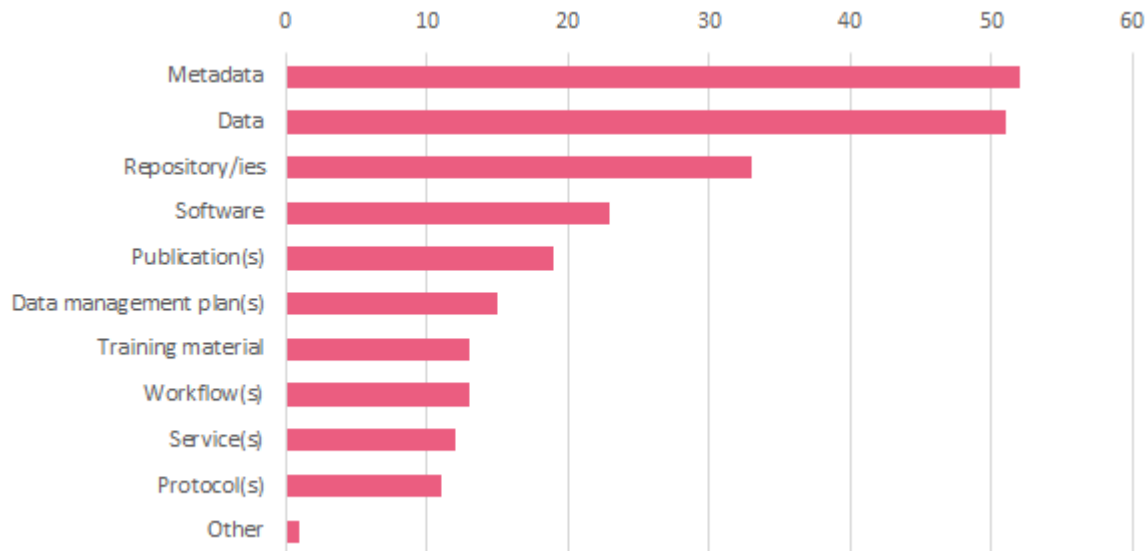
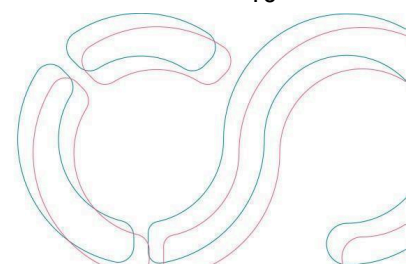


Figure 5. The number of respondents who had designed or performed FAIR assessments for various types of artefacts/digital objects (n=61).

One-third (32%) had performed FAIR assessments on one artefact/digital object and a collection³, 26% had assessed collections only, and 14% had assessed individual artefacts only. Several respondents provided more specific information about the scope and objectives of their assessment, for example:

- “part of infrastructure support/curation workflows”*
- “design institutional pathways to follow FAIR principles”*
- “achieving better interoperability and standardisation”*
- “find out how to improve FAIRness”*
- “just for experimental”*
- “try to make all of my work reproducible”*
- “check data formats, metadata and interoperability of the data”*
- “EOSC project pilots and deliverables”*
- “we just do the right thing to the best of our ability and that happens to be FAIR”*
- “baselines for data improvements per dataset”*
- “evaluation of the FAIRness of a repository and datasets from the repository”*
- “develop / extend a tool”*

³ Here, the collection is defined as a group or a combination of artefacts or digital objects or entities.



“testing a tool”

“internal FAIR gap analysis”

“project data management plan elaboration”

“support of researchers, helping them in FAIRification”

“design of FAIR training or training material”

Most of these open answers provided no further indication to the scope and objectives (12 respondents) while others specified the type of artefact/digital object that they had assessed (four mentioned assessing data, two mentioned assessing repositories and one mentioned assessing a collection). Assessment or improvement of data quality was mentioned by four respondents; enhancing interoperability, enhancing reproducibility, tool developments and certification all got two mentions. Other objectives included gap analysis, landscape overview, project work, testing, support, building metadata model, and following RDA recommendations.

2.2.1 FAIR assessment tools used

Almost half of the respondents (45%) had used a tool to perform FAIR assessments and half of them (23% of all respondents) reported that they had used multiple tools. In total, 29 respondents provided information about tools they had used: F-UJI got the most mentions (16) followed by the FAIR Evaluator (7). In total, fourteen different tools⁴ were mentioned (figure 6).

⁴ The mentioned tools are as follows and can be found in the form of table on Appendix II:

Checklist for Evaluation of Dataset Fitness for Use: <https://doi.org/10.15497/rda00034>

CLARIN Curation Dashboard: <https://curation.clarin.eu/>

Curation application for PHI-base: <https://canto.phi-base.org/>

Data Stewardship Wizard: <https://ds-wizard.org/>

FAIR checker <https://fair-checker.france-bioinformatique.fr/>

FAIR Data Self Assessment Tool (ARDC): <https://ardc.edu.au/resource/fair-data-self-assessment-tool/>

FAIR Enough: <https://fair-enough.semanticscience.org/>

FAIR Evaluator: <https://fairsharing.github.io/FAIR-Evaluator-FrontEnd/>

FAIR-Aware: <https://fairaware.dans.knaw.nl/>

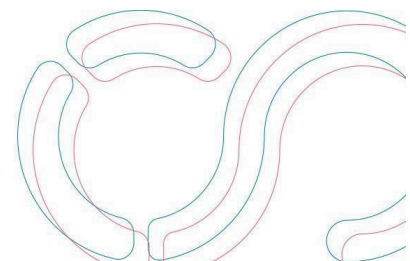
FAIRplus Dataset Maturity (DSM) Model: <https://fairplus-project.eu/>

FAIRshake: <https://fairshake.cloud/>

F-UJI: <https://www.f-uji.net/>

howfairis: <https://github.com/fair-software/howfairis>

RDA SHARC IG templates: <https://zenodo.org/record/3922069>



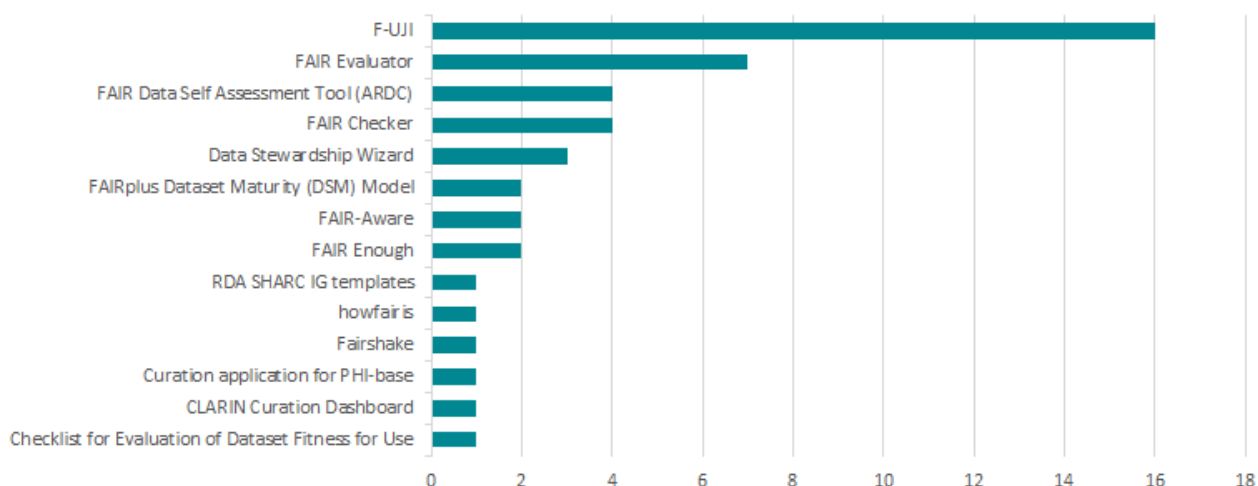


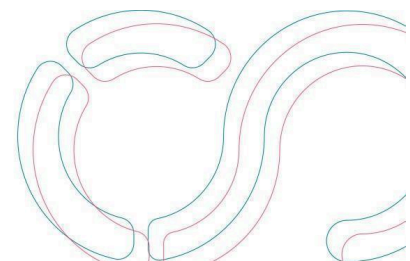
Figure 6. The number of times the various tools were mentioned. 29 respondents answered this question.

The F-UJI tool was also widely used across domains (table 1).

	Social sciences and humanities	Environmental	Biological and Medical	Information and Computer Sciences, Engineering and Technology	Multi-disciplinary	Other
CLARIN Curation Dashboard	1	0	0	0	0	0
Fairshake	0	1	0	0	0	0
RDA SHARC IG templates	0	0	0	0	0	1
Checklist for Evaluation of Dataset Fitness for Use	0	1	0	0	0	0
Curation application for PHI-base	0	0	1	0	0	0
Data Stewardship Wizard	0	1	1	0	1	0
FAIR Checker	1	0	2	0	0	1
FAIR Data Self Assessment Tool (ARDC)	1	1	1	0	0	1
FAIR Evaluator	2	1	3	1	0	0
F-UJI	4	4	2	2	2	2
FAIR Enough	0	0	1	0	0	1
FAIR-Aware	0	0	0	0	2	0
FAIRplus Dataset Maturity (DSM) Model	0	0	2	0	0	0
howfairis	0	0	0	0	1	0

Table 1. Number of times a tool was mentioned by the 29 respondents who mentioned one or more tools, by domain.

When respondents were asked which types of entities or digital objects they had assessed, the majority reported that they had assessed data and/or metadata (see figure 5). We analysed this



more by cross-tabulating the five most used tools with the entities the respondents had assessed (table 2). It is worth noting that the respondents were not directly asked which entities they were assessing with which tools, so some respondents may have been using different tools to assess different entities. In addition, we examined only the responses that mentioned the use of one tool instead of multiple, and the observation about data and metadata being the most selected options remains the same.

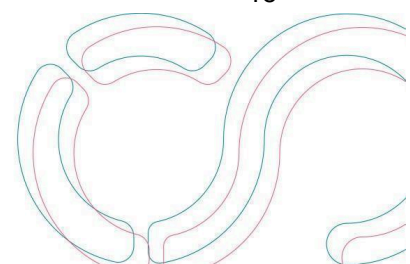
Entity assessed	F-UJI	FAIR Evaluator	FAIR Data Self Assessment Tool (ARDC)	FAIR Checker	Data Stewardship Wizard
Data	12	6	2	2	3
Metadata	16	7	3	4	3
Software	5	2	-	1	2
Repository/ies	8	4	1	2	2
Service(s)	3	1	-	1	-
Publication(s)	3	2	2	1	-
Training material	2	2	1	1	-
Data Management Plan(s)	3	3	1	1	1
Workflow(s)	2	3	1	2	-
Protocol(s)	2	2	1	1	-

Table 2. Entities the respondents had assessed and tools they mentioned they had used (n=29).

61 respondents answered the question about manual or automated assessments. 39% of them had performed a combination of manual and automated assessments, 36% had performed only manual and 8% only automated assessments. 13% had performed both manual and automated assessments but separately. When asked what kind of feedback the tool provided, quantitative scores got the most mentions (40), followed by qualitative scores (25 mentions) and narrative feedback (12 mentions). In most cases, the tools provided the evaluation scores separately for each FAIR sub-principle and as aggregated results, and the scores were delivered on screen or as exportable files.

Cross-tabulations showed that there is no tool providing only narrative results. Most respondents indicated that the tools they used provided narratives accompanied by a quantitative and/or qualitative analysis (27.6%). From the responses, we identified that five out of fourteen tools use only one method, either quantitative or qualitative in their results.

2.2.2 FAIR assessment tools developed by survey respondents



Although the survey identified several tools that are used for FAIR assessments today, only six respondents stated that they had developed their own tool to assess FAIRness. Four tools were mentioned⁵:

- OpenAIRE FAIR validator⁶
- O'FAIRe⁷
- FAIR-TLC⁸: Metrics to Assess Value of Biomedical Digital Repositories
- metaxreader⁹

From these, the metaxreader is not an assessment tool, but a demo to upload datasets to a FAIR Data Point¹⁰.

In addition, one respondent mentioned 'evaluation with spreadsheet' and another commented that they had applied the FAIR principles to assess research outputs manually to their work.

Four out of these six respondents stated that the designed or developed tool incorporates open standards in its workflows. Five had used or adapted the FAIR Data Maturity Model¹¹ for their assessments, for example using it alongside the FAIRsFAIR Data Object Assessment Metrics¹².

2.3 FAIR assessment: confidence and trust in results and challenges in metrics

All respondents were presented with a list of challenges regarding FAIR assessment tools and asked to order them in descending order. The respondent's biggest concern is the assessment tool's interpretation of the FAIR principles in their domain. Understandability of the criteria that they are assessed by and the validity of produced results also scored high.

⁵ These tools can be found in a table on Appendix II.

⁶ <https://www.openaire.eu/openaire-guidelines-for-literature-institutional-and-thematic-repositories>

⁷ <https://hal.archives-ouvertes.fr/lirmm-03630233>

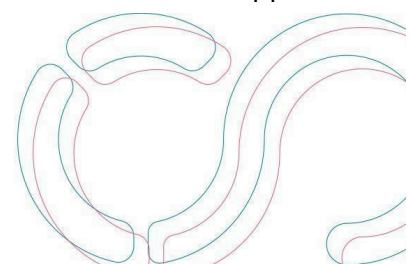
⁸ <https://doi.org/10.5281/zenodo.203295>

⁹ <https://github.com/CSCfi/metaxreader>

¹⁰ Fair Data Point: <https://www.fairdatapoint.org/>

¹¹ FAIR Data Maturity Model Working Group. (2020). FAIR Data Maturity Model. Specification and Guidelines (1.0). <https://doi.org/10.15497/rda00050>

¹² <https://zenodo.org/records/6461229>



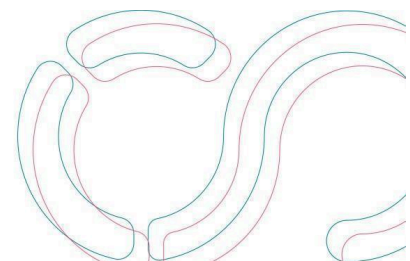
Challenge	Times mentioned (biggest challenge = 1st)						score
	1st	2nd	3rd	4th	5th	6th	
Concerns about the interpretation of the FAIR principles, in your context/domain, by the assessment tool	16	13	13	6	7	3	4,28
Understandability of assessment criteria/mechanism, their applicability and relative importance	9	18	18	8	5	11	3,78
Validity of results	11	9	9	16	15	1	3,7
Quality/readiness of data/outputs to be assessed	10	10	10	13	18	4	3,52
Scalability of performed activity	9	5	5	15	11	5	3,42
Other challenge(s)	6	6	6	3	5	37	2,32

Table 3. Respondents' assessment of the biggest challenges, in descending order. The rows show how many respondents ordered the challenge as 1st, 2nd,..., and 6th. When calculating the score, the biggest (1st) challenge got 6 points and the smallest (6th) 1 point; the score is the sum of points divided by the number of respondents.

There were no major differences in the challenges between the different role groups (researchers, data management experts, technical experts/research engineers, managers/directors). However, managers are slightly more concerned about the validity of results than the other groups. The biggest challenge varied slightly by the type of assessment the respondent had performed. For those who did manual assessments or a combination of manual and automated assessments, the number one challenge was an interpretation of the FAIR principles by the assessment tool. Those who did automated assessments only (i.e. 6%) were most worried about the understandability of the assessment.

Twenty-eight respondents had performed multiple assessments of the same (kind of) artefact (s)/digital object(s) or entity(ies). Reasons for performing multiple assessments include:

- Comparison of different tools (9 mentions)
- Assessment before and after FAIRification process, iterative assessments
- Assessment of author curation vs. professional curation
- Developing FAIR and data quality guidelines
- Comparison of different datasets
- Comparison of FAIR compliance over time
- Design of tools



Explanations for observed deviations between the assessment results performed on the same (kind of) digital object(s) include:

- Performance results on different computers
- Different tools, and different versions of the same tool, provided different scores
- Different metadata standards and PIDs evaluated
- New service iterations
- Publication errors (incorrect or outdated science and typos), author errors (misinterpretation of ontology term meaning), curator errors (misinterpretation of ontology term meaning), ontology errors (terms misdefined or misplaced in ontologies)
- Quality improvements between assessments
- Different weightings
- Testing the same object with URL or PID tends to lead to different results
- Deviations from metrics framework

When asked if the FAIR assessment results left them with confidence in the assessment, 23% of the 22 who responded answered yes; 32% answered partly and 45% no.

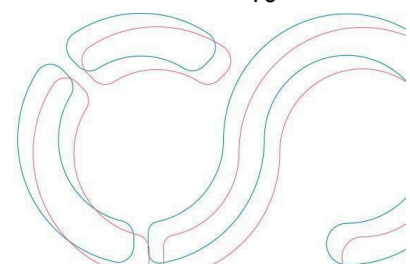
The respondents who had used multiple FAIR assessment tools were asked if the outputs from the tools were consistent. None of the 18 respondents who answered this question had found the outputs consistent; two-thirds had found the outputs somewhat consistent.

Several respondents noted that variation in results is expected since the indicators, metrics, and tests are all evolving. The open-ended answers provide further insight:

- *"the biggest challenge is awareness of FAIR principles among researchers"*
- *"all [challenges] equally important"*
- *"machine actionability is poor"*
- *"main challenge is understanding how to go from principles to sensible metrics"*
- *"there are increasing number of tools and sets of metrics, which are all slightly different"*
- *"FAIR data is a huge effort that can't be accomplished 1-2-3"*
- *"the challenges are related to the accuracy of the assessment on heterogeneous data with heterogeneous quality"*
- *"a problem is that often some of the criteria can be partly fulfilled"*
- *"a data set can be FAIR even though it is not fully available online due to legal restrictions"*
- *"slightly different interpretations of the metrics"*
- *"different tools focused on different principles"*
- *"interpretation, different mechanisms for dealing with lack of standardisation"*
- *"the automated tools do a good job, considering the difficulty of the task"*

The respondents also provided ideas for remedies:

- *"a benchmark to demonstrate functional equivalence on i) metadata location, ii) metadata formats/vocabularies recognized, iii) data formats recognized/can be validated."*



- “all datasets should follow a standard for exposing metadata or plugins should be developed (unrealistic)”
- “at least use of vocabularies and namespaces should provide similar results regarding interoperability.”
- “clear recommendations for both generic and domain-specific aspects”
- “more details required for technical guidance”

Despite all the aforementioned challenges, there is average to full trust in FAIR assessment results (figure 7).

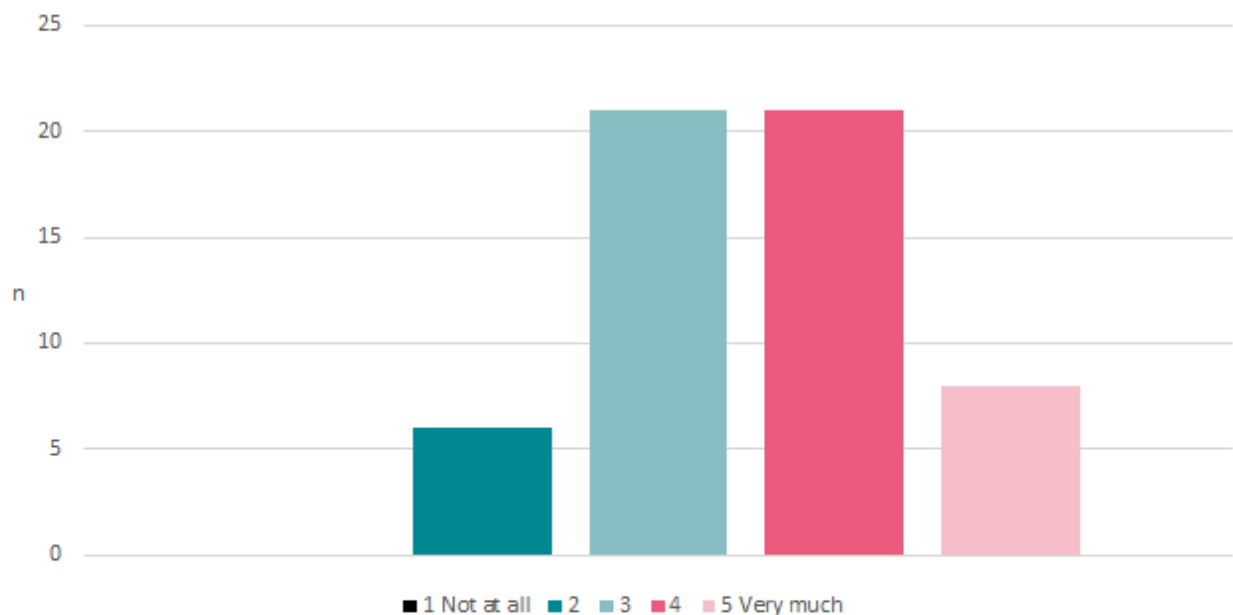
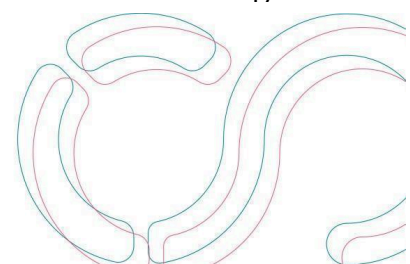


Figure 7. Trust in the results of FAIR assessment(s) [1 = not at all, 5 = very much] (n=56)

Cross-tabulation of trust in the results and the used assessment tool(s) did not reveal any significant differences in trust levels between the tools. F-UJI seemed to be recognised more than the other tools on this matter, but not completely (‘very much’ was not selected from respondents mentioning F-UJI).

The respondents were fairly confident with how they interpreted FAIR principles in their work. Only five respondents did not answer the question, and none chose ‘not confident’ (figure 8).



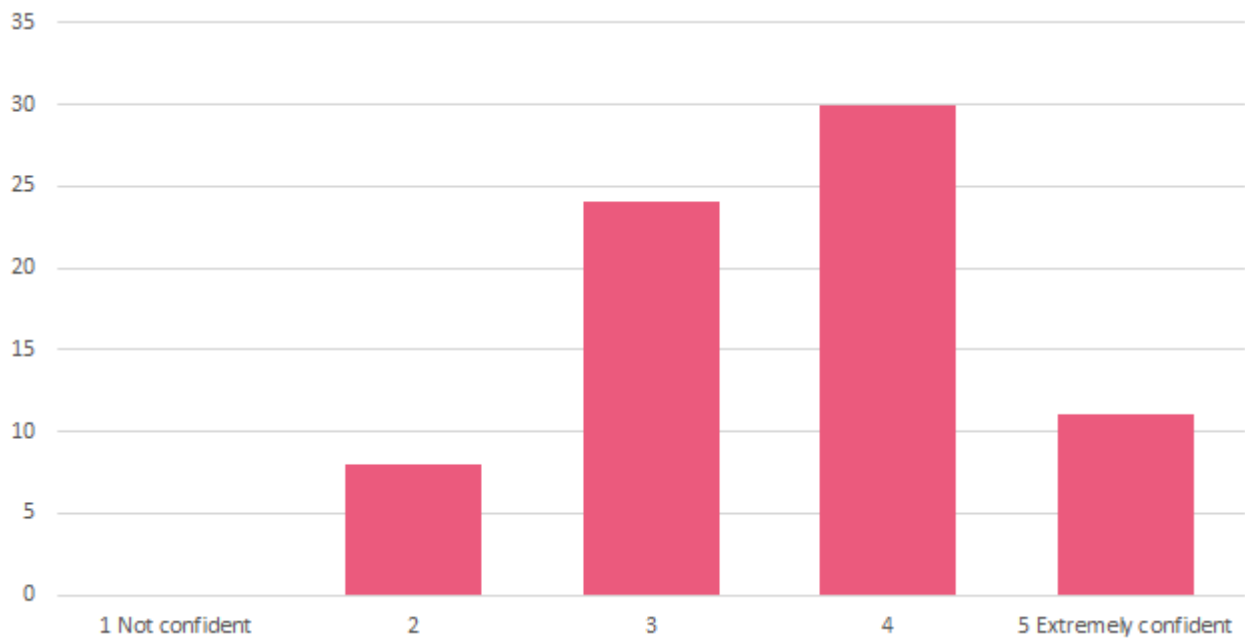
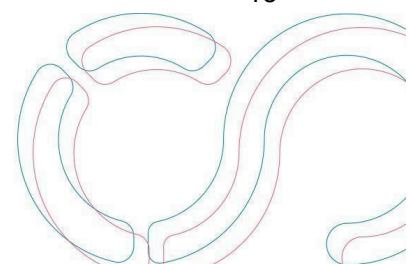


Figure 8. Confidence in one's own interpretation of FAIR principles in research or work (n=73).

Respondents' confidence in their interpretation of the FAIR principles varied slightly by domain (figure 9). Participants from the Environmental sciences seem to exude higher confidence (70%), followed by Biological and Medical sciences (54.2%), Social sciences and humanities (47%), Information and Computer Sciences, Engineering, and Technology (43%), and multidisciplinary (67%).



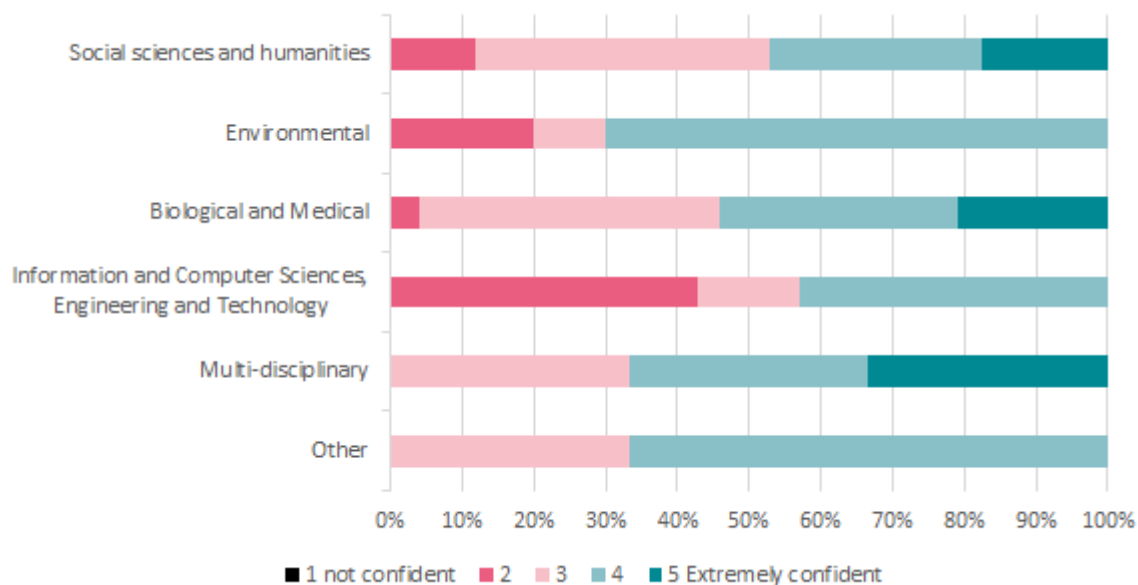


Figure 9. How confident in interpreting FAIR principles in research or work by domain (n=73).

Confidence varied according to the capacity or role of the respondent (Figure 10). All respondents have somewhat and moderate confidence over how they interpret the FAIR principles in their assessments. Data quality practitioners collectively hold the highest ranking, with about 80% feeling fairly and extremely confident, followed by policy/decision makers (about 75%). Overall, data quality practitioners and publishers show above-average confidence.

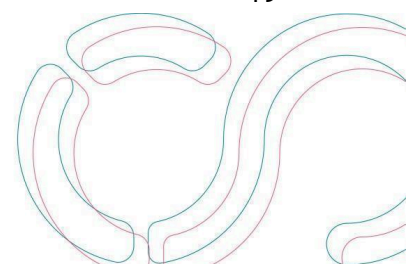
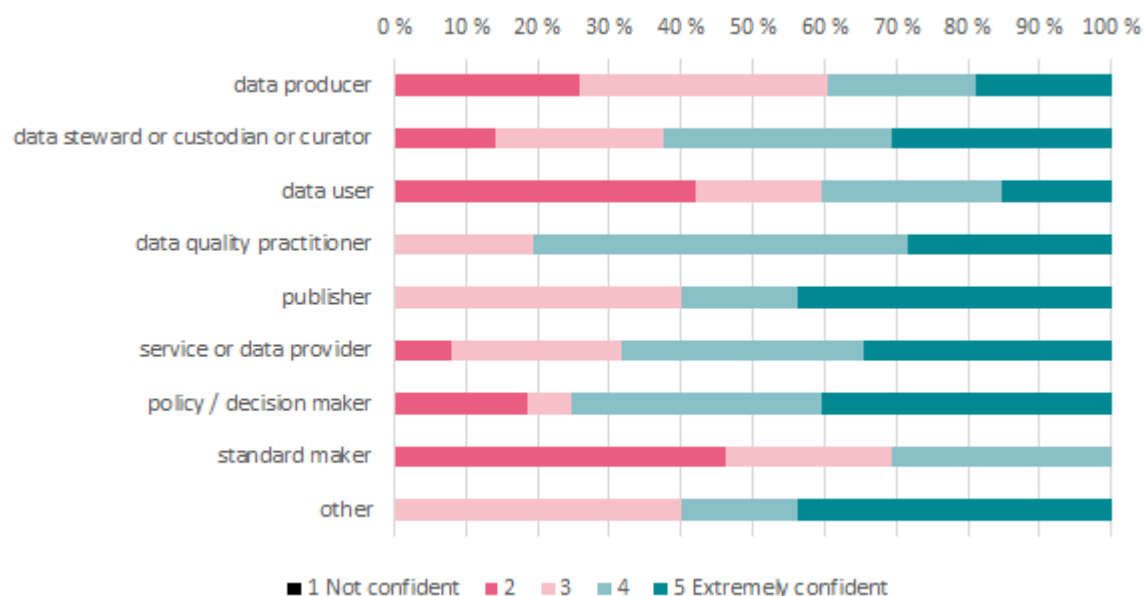


Figure 10. Level of confidence by the respondents according to the capacity that they answered the survey (n=73).

When examining the trust that respondents have in tools' results in conjunction with their confidence to assess results according to the FAIR principles, there seemed to be a change of heart between somewhat and moderately confident (table 4).

%	How confident do you feel today with how you interpret FAIR principles in your research or work?				
	Not at all confident 1	2	3	4	Extremely confident 5
How much do you trust the results of your FAIR assessment(s)?					
1 Not at all	0 %	0 %	0 %	0 %	0 %
2	0 %	20 %	12 %	8 %	14 %
3	0 %	60 %	41 %	25 %	57 %
4	0 %	0 %	41 %	50 %	14 %
5 Very much	0 %	20 %	6 %	17 %	14 %
<i>Total (n)</i>	0	5	17	24	7

Table 4. Cross-tabulation of "How much do you trust the results of your FAIR assessment(s)?" and "How confident do you feel today with how you interpret FAIR principles in your research or work?" (n=53)

To understand if the level of trust in the results of the FAIR assessments varied between 'technical' and 'non-technical' respondents, we used the following approach to categorise them. We classified the respondents as 'technical' if at least one of the domains they had chosen was Engineering and Technology or Information and Computer Sciences or if their role was technical expert/research engineer. This way, 35 respondents can be categorised as technical and 43 as non-technical.

'How much do you trust the results of your FAIR assessment(s)?'	non-technical	technical
1 Not at all	0	0
2	12 %	9 %
3	47 %	23 %
4	26 %	55 %
5 Very much	15 %	14 %
	100 %	100 %
n=56	(34)	(22)

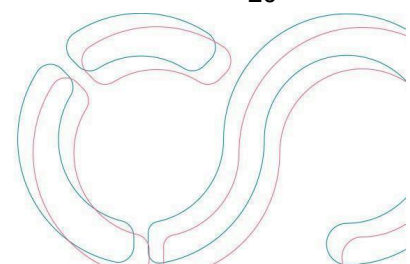


Table 5. Trust on FAIR assessment results by technical/non-technical respondents.

Only 23% of the respondents had published the results of their FAIR assessments. The publication channels were various but the most mentioned were project websites and deliverables, GitHub, Zenodo, presentations, and scientific articles. Twenty respondents elaborated on their concerns about making results public. The concerns included, for example:

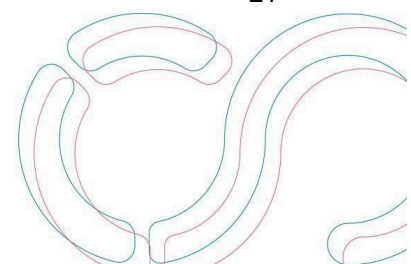
- *“consistency between domains”*
- *“quality of the assessment”*
- *“results are inconsistent between assessments”*
- *“misinterpretation”*
- *“they could be misinterpreted”*
- *“internal assessment”*
- *“no meaningful, resilient, comparable and truly usable information yet”*
- *“no one interested”*
- *“want to publish data and add a “FAIR-metric” badge next to it, won’t publish just the badge”*
- *“We use this as internal procedure and the results with comments are provided to data provider to improve FAIRness of data in order to be preserved and disseminated”*
- *“Self-assessment tools should be used as a mechanism for understanding where we stand, and as a guide to improving the FAIRness levels of the digital objects. Such evaluation shouldn’t be made publicly available as they can harm the project if the proper context and roadmap for improving it are not published or taken into consideration.”*

2.4 FAIR Governance

The FAIR Metrics and Data Quality Task Force is examining various models for the governance of FAIRness assessments and presents options in a discussion paper¹³. The paper was published after the collection of the survey data.

The survey respondents were in favour of some form of FAIR assessment governance to harmonise the interpretation of FAIR by the assessment tools (figure 11), including being supportive of there being a governance body tasked with supporting FAIR assessment activities (figure 12).

¹³ Wilkinson MD, Sansone SA, Méndez E et al. Community-driven governance of FAIRness assessment: an open issue, an open discussion [version 1; peer review: 2 approved with reservations]. Open Res Europe 2022, 2:146 (<https://doi.org/10.12688/openreseurope.15364.1>).



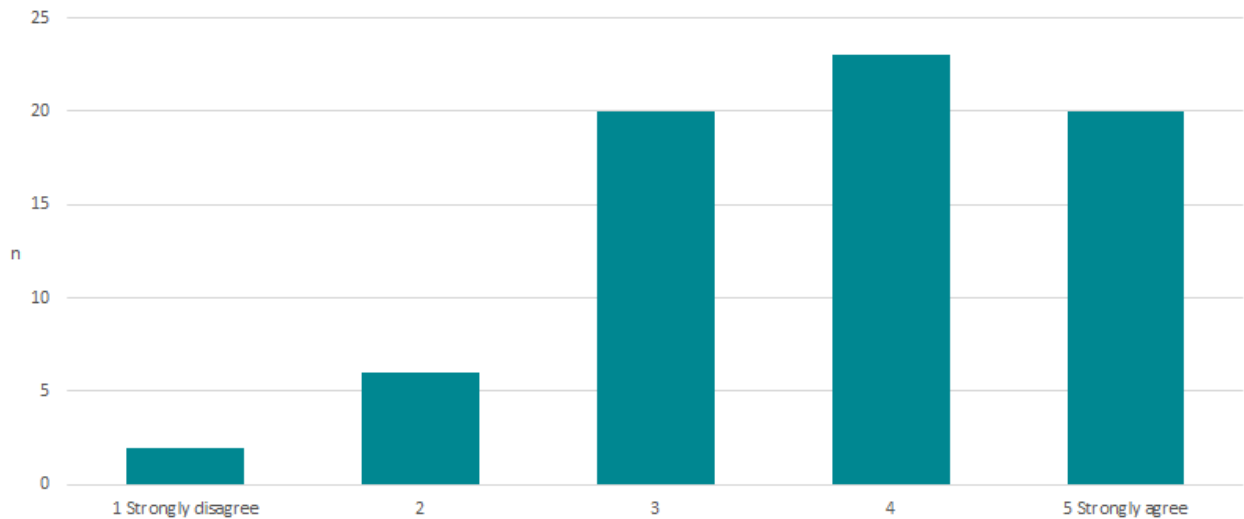


Figure 11. Is FAIR Assessment Governance needed to ensure a common interpretation by FAIR assessment tools (n=71) [1 = strongly disagree, 5 = strongly agree].

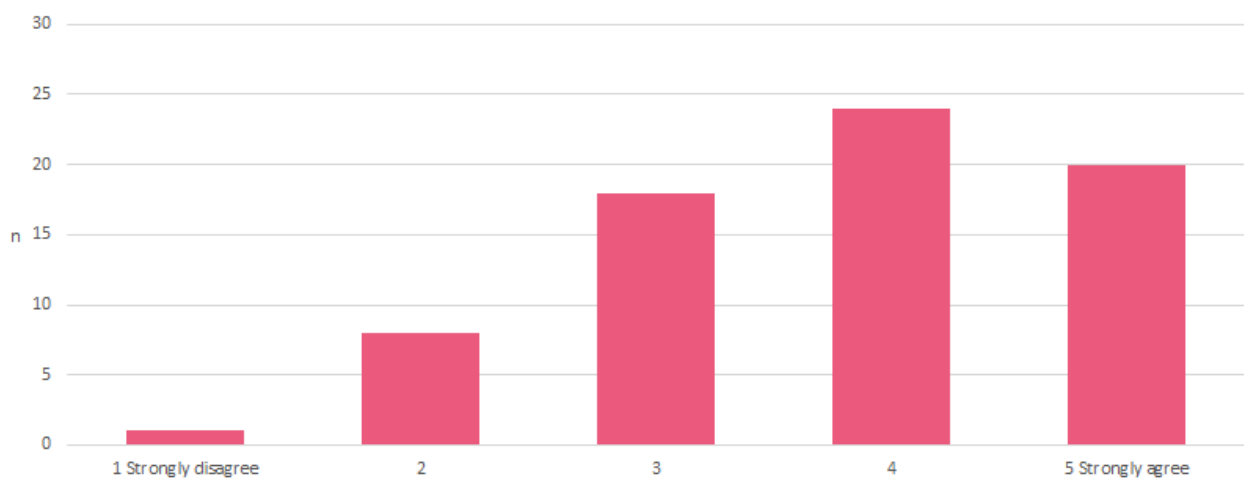
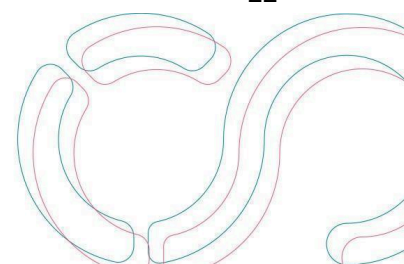


Figure 12. Do you think that a Governance Body could support FAIR assessment activities? (n=71) [1 = strongly disagree, 5 = strongly agree]

Cross-tabulations of data seemed to indicate somewhat more positive attitudes towards a Governance Body by those who had used existing tools. These questions provoked 53 comments in total. The comments covered several themes, as clustered by the authors and shown in Tables 6 and 7 below.

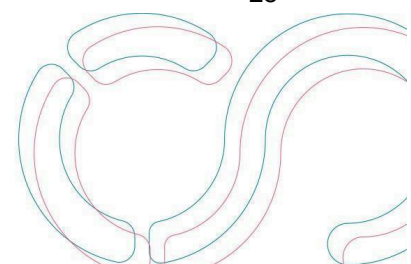
Apart from six respondents who had strong opinions against the need for a body to govern FAIR assessments, some suggested that governance could be centred around the FAIR assessment tools, and many expressed their reservations as well as opportunities found in such endeavour.



Theme	n
Governance Body is not needed	6
Governance of services for FAIR assessments is important	4
Assessment tools should clarify the processes and information leading to FAIR assessment results	3
Collaboration and diversity of expertise to define the governance body	3
Focus on research assessment instead of FAIR assessment to create incentives and rewards mechanisms	2
Domain specific coverage / assistance would be very useful if provided by the body	2
Unclear what Governance for FAIR Assessments is	2
Creation of workflows for FAIR assessments would support governance	1
Fear of simplification of the FAIR principles	1
Opportunities to increase of sustainability	1
In depth knowledge of all sub-principles is limited, hence the governance body would contribute towards addressing this gap	1
Nature of the Governance Body (Recommend vs Mandate) presents different challenges and opportunities	1
Operational challenges might still arise in the Governance Body	1
Research communities could offer better governance instead of such a body	1
Transparency in all aspects concerning the body is important	1

Table 6. The number of comments by the theme to question if FAIR assessment governance is needed to ensure a common interpretation by FAIR assessment tools.

Furthermore, opinions were shared detailing the areas and methods that could be put into practice for the potential governance body to operate effectively, highlighting diversity, collaboration and support as key ingredients.



Theme	n
Experts to contribute in the governance body	3
Encourages the harmonisation of FAIR interpretations	3
Embed the body in existing bodies, e.g. national authorities	2
Provide guidance / support to research stakeholders and communities	2
Collaborates with tools providers	1
Promotes the development of best practices and infrastructures	1
Fear of diverging from the original FAIR principles	1
Ensures objectivity in the FAIR assessment process	1
Ensures accountability	1
Lightweight approach would be better in establishing governance structures	1
Not sufficient to have only a governance body for FAIR assessments	1
Workload of making data FAIR is an obstacle	1

Table 7. The number of comments by theme to question if a Governance Body could support FAIR assessment activities.

Looking at the stakeholders more closely by their role in the Research and Innovation (R&I) spectrum, we see that the respondents believe that all should be involved in the Governance Body, positioning data infrastructure providers, data stewards, ESFRIs/RIs at the top of the list (see figure 13). In addition to the listed options, other mentioned stakeholders included standardisation institutes, assessment tool developers and owners, governance specialists, domain-specific networks, and publishers.

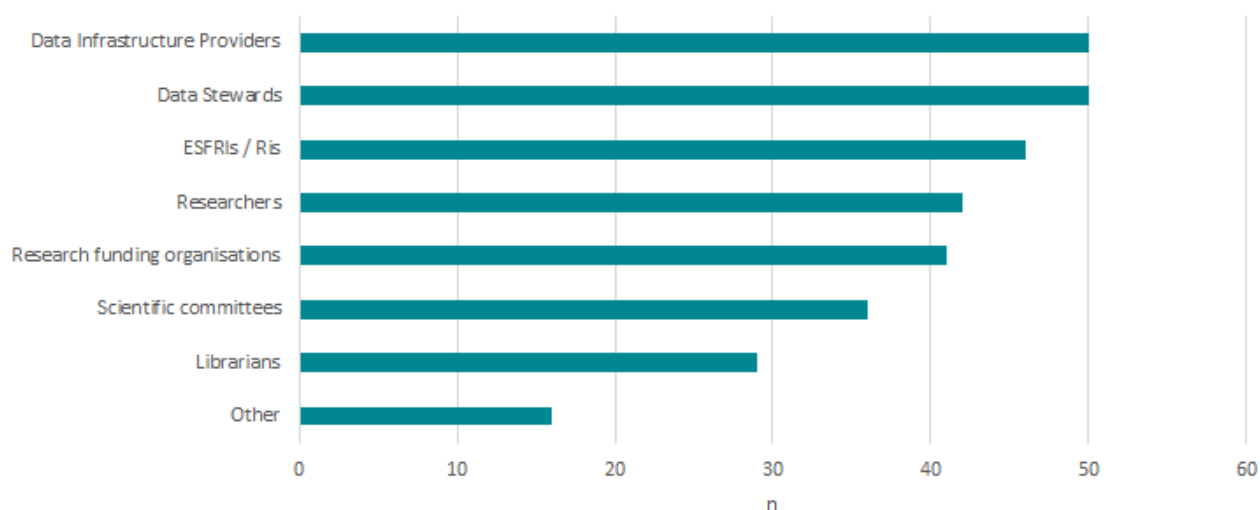
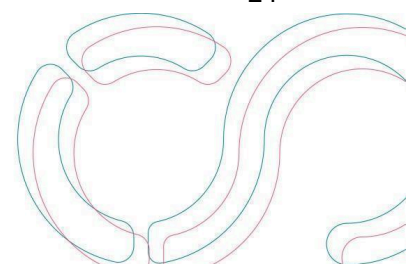


Figure 13. Who should be involved in a FAIR Assessment Governance Body



According to the “Community-driven Governance of FAIRness assessment” position paper, FAIR stakeholders are split into three main groups, each populated by professionals corresponding to more than one role. All respondents were presented with this list of roles and asked to order them from most to least relevant. The options were:

- **“FAIR decision and policy makers:** Funding agencies, Governments, and Publishers. This group encompasses stakeholders requiring access to FAIRification plans, i.e., how the FAIR Principles will be supported and achieved for different digital objects involved in a research process but are not in charge of FAIRifying those digital objects themselves. This group includes funding agencies, governments, and publishers.”
- **“FAIR custodians:** FAIR support stewards & trainers, FAIR repositories, FAIR tools developers and operators, FAIR researchers, and FAIR certification bodies. They correspond to stakeholders that will support FAIR in practice, via FAIR itself research, recommendations for FAIR adopters, or provision of tools making it easier for researchers to produce FAIR research and for those in the first group to assess FAIRness requirements. In this group are FAIR researchers, i.e., researchers whose field of research are the FAIR Principles and elements around them, and FAIR stewards, i.e., data or any other digital object stewards supporting the FAIR Principles.”
- **“FAIR practitioners:** Researchers and research-performing organisations (domain-agnostic), Research software engineers, and Domain-specific research communities. They correspond to professionals directly working on research, including individual researchers and domain-specific research communities, whose responsibility it is to apply the FAIR Principles to their work - both as consumers and producers of data - and utilise services that assist them to achieve this.”

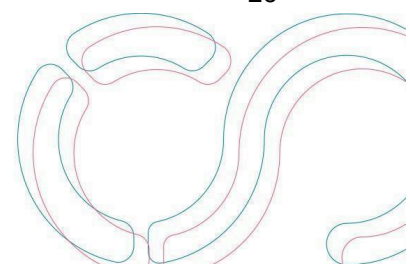
The roles were deemed almost equally relevant, although FAIR practitioners got most first and second places (table 8).

	1st	2nd	3rd	4th	Score
FAIR practitioners	25	32	18	3	3,00
FAIR decision and policy makers	23	24	28	3	2,90
FAIR custodians	24	21	28	5	2,80
Other	6	1	4	67	1,30

Table 8. Respondents' assessment of roles in the FAIR Assessment Governance, ordered from the most relevant to least relevant. The rows show how many respondents ordered the role as 1st, 2nd, 3rd, and 4th. The most relevant (1st) role got 4 points and the least relevant (4th) 1 point; the score is the sum of points divided by the number of respondents.

The open-ended comments provided further insight into how respondents think that some roles could contribute to governance activities:

- “From practitioners for practitioners - in an agile and slim setup”



- “concrete implementations will remain the actual job of FAIR custodians, but FAIR users and FAIR beneficiaries like policymakers should be aware of FAIR assessment consistency and challenges”
- “I don't know what this question even means; however, again, the funders have to provide the teeth.”
- “Not sure what a FAIR custodian exactly means. Therefore I cannot sort this in a meaningful order.”
- “it is critical to get researchers involved so that FAIR is not something forced on them”
- “first the vision, then the policies, then the practice: start from use cases”
- “standard setting institutions need to enter the framework”

The FAIR Governance Body should be trusted, adequately skilled but also appropriately scoped, broadly representative, and sustainable (see Figure 14). ‘Arms-length’ seemed to be an unfamiliar concept to the respondents.

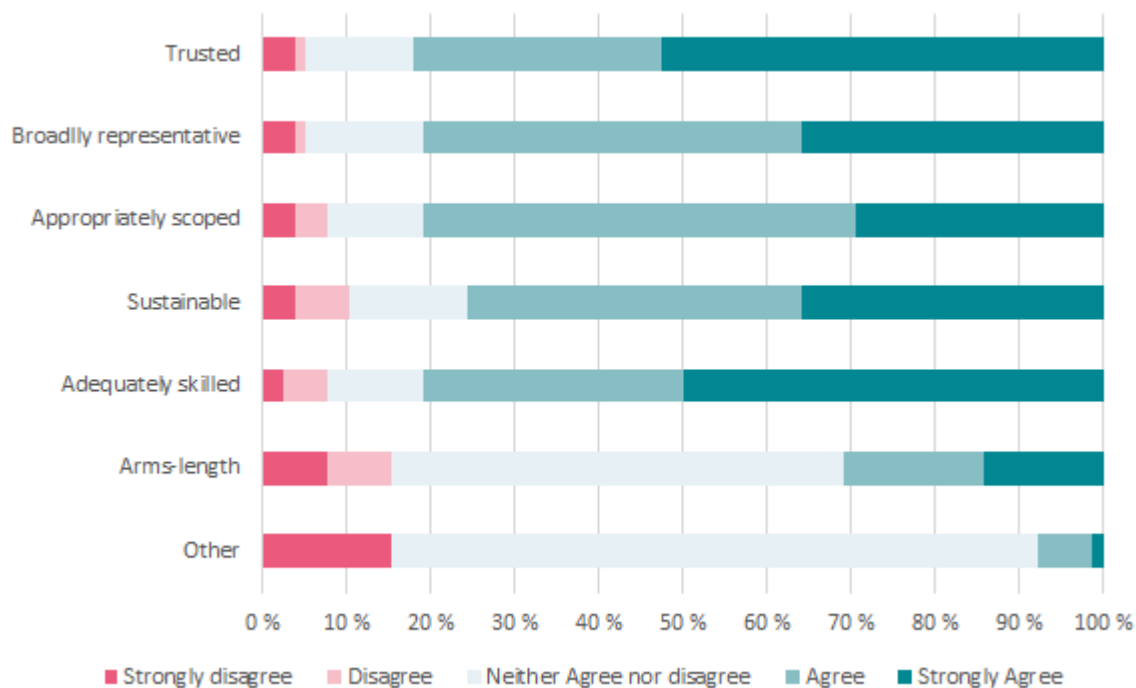
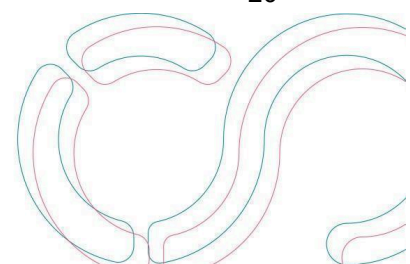


Figure 14. Respondents' opinions on the desired attributes for a Governance Body as they are expressed in the White Paper for the FAIR Assessment Governance.

The most effective way to get the respondents to apply changes to increase the FAIRness of their practices is through funding (see figure 15). Support and guidance would also be beneficial. This is a rather self-evident result, but it is worth noting for future activities.



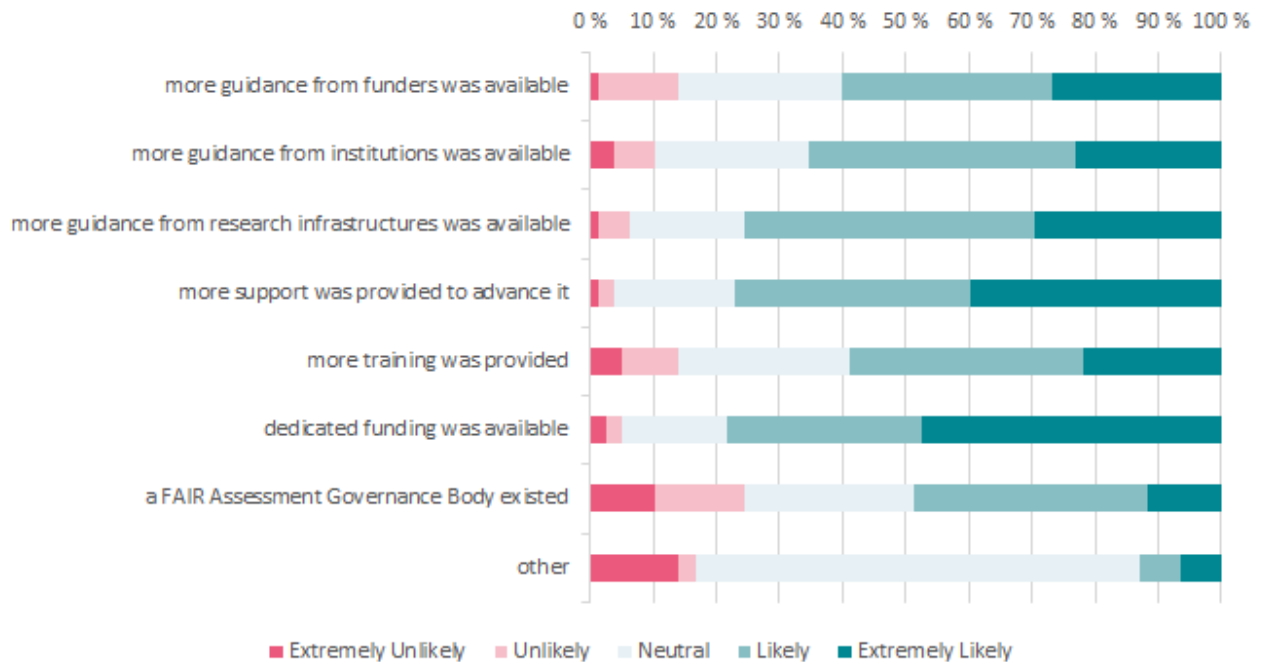
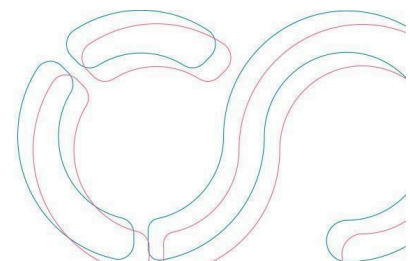


Figure 15. How likely would the respondents apply changes to increase the FAIRness of their practices if various incentives were in place?

The comments reflected the importance of funding and also mentioned job security for researchers and legal changes as enablers of FAIR:

- “colleagues who call their stuff “FAIR”, when it is really “FA” should know better and won’t do better until funding is contingent on doing that last mile of “IR””
- “FAIR is extra work for researchers who anyway are overloaded with tasks. Without a proper strategic approach, backed up by substantial financial and structural investments, the FAIR vision for (European) data is not going to happen soon [...] the European funding organisations lack proper knowledge on what it means to implement machine-actionability. There is a severe underestimation of resources required. As the effort is huge, only few have the interest and are in the position to adjust workflows.”
- “job security for early-career researchers also plays a big role as to how much time and effort people are willing to invest in making sure their data is FAIR”
- “legal change in copyright and broadening the TDM [text and data mining] exception and exception for preservation and sharing for reproducibility (extremely unlikely)”
- “led by the relevant subject-specific community”
- “better tooling”

2.5 The evolving landscape: FAIR, CARE, TRUST principles



The survey concentrated on the FAIR (Findable, Accessible, Interoperable, and Reusable) principles that stress the importance of making data accessible to discover, access, and utilise. FAIR prioritises metadata quality and data sharing to enhance data's visibility and usability and machine actionability, ensuring it can be effectively employed for various purposes. In addition, we wanted to grasp the community's opinions on the [CARE](#) and [TRUST principles](#) that have emerged to understand their current adoption and need for metrics for assessment. The CARE (Collectable, Accessible, Reusable, and Expendable) principles focus on the ethical dimensions of data management. They highlight responsible data collection, broad accessibility, encouraging data reuse, and considering data's lifespan, including potential deletion, to uphold ethical and privacy standards. TRUST (Transparency, Responsibility, User focus, Sustainability, and Technology) principles cover responsible data stewardship encompassing transparency in data handling, responsibility in data stewardship, user-centric data design, data sustainability, and appropriate technology. While FAIR-CARE-TRUST frameworks have distinct emphases, they collectively contribute to responsible and effective data management in their respective ways.

About half of the respondents had heard of the CARE and TRUST principles (see Table 9). Only 10% of all respondents had designed or performed assessments based on them. When asked to specify, the respondents mentioned TRUST self-evaluation of a data repository, lightweight assessment based on TRUST and CARE, CoreTrustSeal certification, and assessment of projects based on CARE.

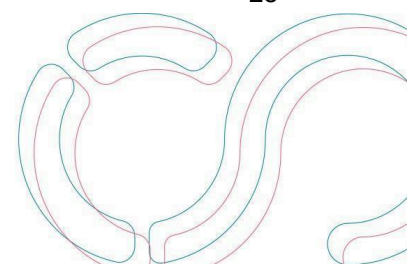
% (n=78)	Yes	No
Heard of the CARE principles	49 %	51 %
Heard of the TRUST principles	46 %	54 %

Table 9. Share of respondents that had heard of the CARE and TRUST principles

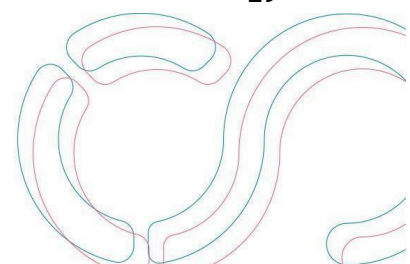
The respondents were also asked if the CARE and TRUST principles need equivalent attention to the FAIR principles for assessment. Less than half of the respondents (46.2%) answered this question, and on a scale of 1 (strongly disagree) - 5 (strongly agree), most chose the middle option, and the average was 3.3, so there was no strong preference either way.

In the final question, we asked about any other thoughts about FAIR assessments, landscape or practices, and in total, 21 respondents provided their thoughts and reflections on the technical readiness of the current ecosystem, the challenges that are still prevalent in the scientific sector, and the limitations in terms of designated workflows and roles distribution across involved stakeholders to adopt best practices.

- "Open Science paradox"
- Promote adoption of FAIR principles from a business rather than academic perspective:



- Who runs the FAIR metrics: the single producer, the repository, the repository aggregator? Clear the roles and levels of implementation to make it easier for researchers.
- Focus on the practices of implementing FAIR principles that are easily digestible by researchers not to complicate them, but instead make aware and reward
- Reliability of data
- Infrastructure elements:
 - The role of repositories and large-scale reuse of harvested information
 - Keep TRUST for repos and large infras and embed FAIR principles for machine accessibility of the repository descriptions and content (also to FAIR assessment tools)
 - Other services/mechanisms to enable FAIR
 - Governance
 - Training
- CARE for ethics of data use complement FAIR, but can the community support machine actionability?



3. Discussion

In this section, we delve into the key themes and considerations that emerged from our FAIR assessment practices and stakeholder perspectives analysis. These insights shed light on the current state of FAIR metrics implementation and offer valuable directions for future research and policy development.

We received a relatively low number of responses, which could be attributed to the following:

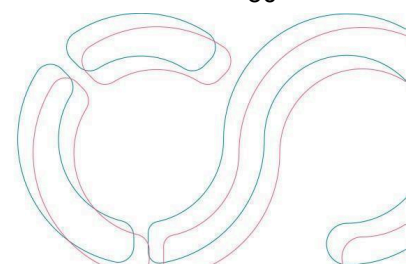
1. **Scope of FAIR Evaluations:** FAIR principles and FAIR assessment tools are still emerging practices. Though awareness of the FAIR Principles is rising, FAIR assessment remains uncommon in the research community, thus we might expect lower participation from a community that has limited awareness of FAIR assessment tools.
2. **Outreach and Awareness:** The survey may not have reached a sufficiently broad audience. If the outreach was limited in scope or awareness about the survey was not widespread, this could have resulted in a lower response rate. This limitation is significant to acknowledge as it might affect the generalizability of the findings.
3. **Complexity and Understanding of FAIR Principles:** The survey findings suggest a mix of confidence and uncertainty in interpreting FAIR principles. This complexity might have deterred potential respondents who need to become more familiar with or confident in their understanding of FAIR assessments.

Given these considerations, it is advisable to be cautious when generalising about the research community based on this survey. While the responses provide valuable insights, especially in identifying challenges, trust levels, and the need for more transparent governance structures in FAIR assessments, they represent a specific segment of the academic community engaged with FAIR principles. The findings should be indicative rather than definitive, pointing towards areas for further exploration and outreach to broaden the understanding and application of FAIR principles in the broader research community.

3.1 Stakeholders

All respondents were asked to identify the stakeholder category they belong to so that any patterns relevant to their roles and capacity are captured and analysed. Because we received responses from service providers and service users, we tracked their differences and took the necessary measures to limit bias in our analysis. In addition, stakeholder categories and roles were proposed for the potential FAIR Assessment Governance Body. Still, these do not regard respondents' capacity per se, although, admittedly/unavoidably, someone might favour their role. Our key observations can be found below.

3.1.1 Capacity and perceptions



Overall, the knowledge base of the respondents was identified to be rather strong, in the sense that they are well aware of FAIR indicators and can thus interpret the results of the tools in a useful way despite the known issues and challenges.

Data quality experts are among the respondents exuding the highest confidence over their FAIR interpretations for assessment. This is to be expected, as FAIR principles support quality elements of data management, and experts dealing with data quality naturally appear to be more competent in relevant frameworks. At the same time, it seems unorthodox that respondents who regulate policies expressed higher confidence than respondents who apply best practices in their research/practice. For example, publishers and policy/decision makers exude higher confidence than others, while data users, standard makers, and data producers are more likely to feel reserved in their perceptions. Particularly because the former have less practical experience than the latter, it is more likely that responses might be prone to a potential knowledge gap on the FAIR implementation and FAIR for assessment challenges across groups of stakeholders.

Regarding trust, the levels are significantly higher for respondents of technical background and position, with more than half trusting the results somewhat more. In contrast, non-technical respondents get a more neutral position in their answers. However, there seems to be an agreement in the percentages of respondents from both sides who feel strongly that they trust the FAIR assessment results.

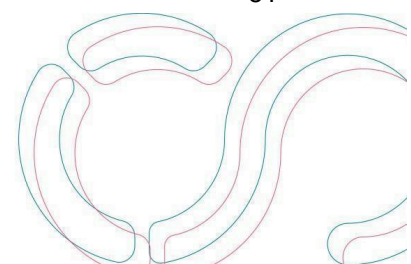
3.1.2 Governance

Although our survey launched before the White Paper on FAIR Assessment Governance¹⁴ was published, we included descriptions and references that explained the envisioned framework. Responding to that, community-governed FAIR assessment is favoured by respondents, with slight emphasis given to the role of practitioners in this schema. Still, it is not prioritised as the most important element to drive change in the current landscape. On the contrary, a governing board is found far below other factors, namely funding, support and guidance expected by existing bodies, i.e. funders, institutions, and infrastructures.

3.2 FAIR assessment tools, outputs, and results

The survey aimed at understanding the behaviours and perceptions of the research community using FAIR assessment tools but also captured the input of a few tool providers. We defined tools very broadly to include practices from the design or application of FAIR metrics to the use or development of assessment tools. Hence they may vary from software to checklists and questionnaires. The following findings provoke new topics for discussion with the Open Science community. They can be also consumed as feedback by FAIR assessment tool providers to strengthen their workflows and research support.

¹⁴ Wilkinson MD, Sansone SA, Méndez E et al. Community-driven governance of FAIRness assessment: an open issue, an open discussion [version 1; peer review: 2 approved with reservations]. Open Res Europe 2022, 2:146 (<https://doi.org/10.12688/openreseurope.15364.1>)



3.2.1 Tools

It is notable that the providers of the two most mentioned tools, i.e. F-UJI and FAIR evaluator, did not participate in the survey. In the “Apples to Apples” report it was identified that even when working side-by-side, it was challenging to get the assessment tools to work in a common way - the complexity of metadata harvesting is sufficiently high that different choices are made at numerous steps in the process. In addition, some tools, such as DSW, might not serve solely the purpose of FAIR assessments but rather incorporate FAIR metrics in their workflows. The survey also showed that trust levels between the used tools did not pose significant differences.

Overall, respondents have more trust in their abilities to interpret the FAIR principles to assess data and other outputs than in the FAIR assessment tools which present expected inconsistencies due to the topic’s evolution: 45% don’t feel confident with the results of the tool. This might justify that those who performed manual assessments were less likely to perform multiple assessments, as well as that only 6% of respondents had performed only automated assessments.

3.2.2 Types of assessed outputs or entities

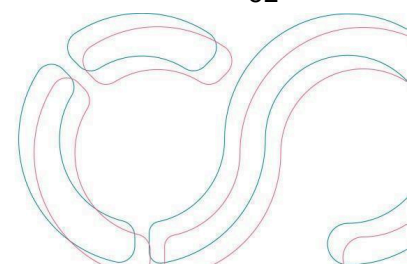
Although most responses concerned (meta)data assessments, it is encouraging to see efforts being made to trial FAIR assessments on other types of outputs or entities, such as software, DMPs, repositories, workflows, standards, etc. On the one hand, this opens up the space for knowledge exchange with tools providers focused on (meta)data which can share lessons learnt and errors found in the process. On the other hand, given that the FAIR principles were primarily introduced for data, the challenge of how they can be applied to different outputs arises, which might drive different metrics and solutions (such as the example of the FAIR-TLC metrics for repositories). In addition, based on what we know of what the tools actually support, it seems likely that many who had replied ‘data’ or ‘repositories’ might actually have been assessing ‘metadata’ because that is what e.g. F-UJI and FAIR Evaluator currently assess.

3.2.3 Sharing assessment results

It is not common practice for the results of the FAIR assessments to be published. But, the 28 respondents who have published their results clarified that their scope was to share papers referring to their FAIR assessment activity as a use case to enrich their FAIRness policies, practices, and tools. Others feel that this information shouldn’t be shared as it is part of an internal process, it might be misinterpreted and might not be interesting for researchers.

This debate creates the opportunity for closing the FAIR assessment lifecycle by defining when FAIR assessment results can be made openly available or remain closed and making the results of those assessments FAIR themselves to be findable, accessible, interoperable, and reusable, even though they might not be open.

3.3 FAIR practices adoption



The survey revealed that to drive changes in respondents' FAIR practices, there should be adequate funding, support, and guidance available to them. That also applies to the tool providers and the domains represented to allow them to overcome the challenges of first, FAIR principles interpretation and second, FAIR metrics standardisation.

Life or health sciences strongly represented are dealing with heterogeneous data (from molecular to remote sensing) with big challenges considering metadata and interoperability issues when some other communities (like astronomy, chemistry, or metrology) are not represented even if they have a longer practice in data sharing and interoperability practices. This will have to be taken into account in future studies/surveys.

3.3.1 Awareness

The following points present opportunities to increase the levels of FAIR awareness for adoption among the research community:

- **Data quality vs FAIR data**

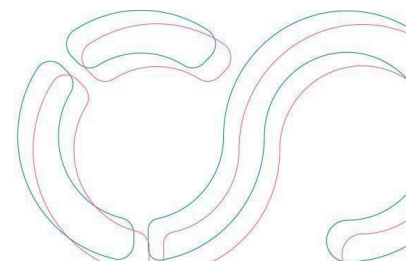
We observed that the terms “Data quality” and “FAIR data” were sometimes used interchangeably by respondents. Data Quality and FAIR Principles are related concepts, but they are different. Data quality is concerned with the overall condition and accuracy of data. In contrast, FAIR principles are concerned with the metadata and infrastructure that make data assets more discoverable, accessible, interoperable, and reusable. While they are related and often complementary, they address different data management and usage aspects. Data quality ensures the reliability and integrity of data, while FAIR principles enhance its accessibility and usability in a broader context.

- **Expectations vs reality**

The majority of respondents specified that their FAIR assessments targeted FAIR data compliance. About 40% of respondents specified that they assessed repositories. However, from the *“FAIR Assessment Tools: Towards an “Apples to Apples” Comparisons”*, we know that the tools currently only support FAIR assessments at the metadata level and that repositories are crucial for supporting proper metadata provision. While FAIR data assessment looks at the inherent qualities of the data, FAIR metadata assessment focuses on the accompanying information that describes the data. Both assessments are critical for making data assets findable, accessible, interoperable, and reusable, in line with FAIR principles, but they target different aspects of data management.

3.4 EOSC adoption

From all the FAIR assessment tools identified in the survey, F-UJI was mentioned most times by respondents. The tool was developed and funded by EOSC projects, namely the FAIRsFAIR and FAIR-IMPACT. Thus, it is positive to see that the research community follows the EOSC project outputs as well as that there is a collaboration between projects and grants, such as via EOSC-FUTURE, which can facilitate the EOSC tools adoption.



4. Conclusions

With the caveat of a moderate 78 responses, from which 61 capture the FAIR assessment parts of the survey, it was pointed out that there is knowledge and confidence in interpreting the FAIR principles as a concept, yet concerns remain about interpretations and assessment criteria. Many have used multiple tools to assess their artefacts against the FAIR principles because the results left them with concerns about how the tools interpret FAIR in different contexts and domains, what the criteria used for assessment are, and whether, at the end, they are valid so they can use them effectively to increase their FAIRness.

Our survey findings reveal consistency in perceptions between tool users and tool providers. Notably, tool providers prioritise the interpretation of the FAIR principles in different contexts / domains, and the scalability of assessment as challenges to be addressed in the short-term.

F-UJI and the FAIR Evaluator are used more than other solutions, probably because, among other things, they offer both manual and automated assessment workflows, provide scores at the level of every sub-principle (F.A.I.R) and as an aggregated score, and present the results as qualitative and quantitative outcomes and/or narratives. Overall, tool providers that give more options in the assessment process and the results seem to be favoured even though their adoption is still limited by the community. The reported inconsistencies in the FAIR assessment results are caused by adaptations on the metrics, even though all tool providers use the FAIR Data Maturity Model as a basis. Additionally, from the responses it is unclear if and what (open) standards are incorporated in the development (e.g. vocabularies) and documentation (e.g. metadata) of FAIR assessment tools.

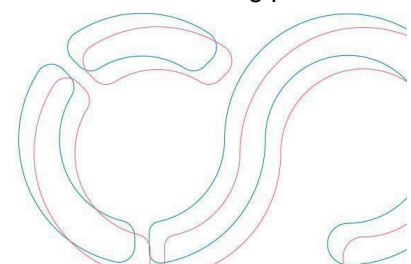
Most FAIR assessment tool users are data stewards or curators and service or data providers. They report to use them primarily to assess data, metadata, and repositories. In some cases, they compare the results assessed by data producers with those derived by data curators. Managers are more concerned about the validity of results, probably because they need tools that support their administrative overload and policy compliance.

Assessments on the CARE and TRUST principles are not established practices (only 10% had performed one). Still, the latter is used more frequently, targeting repositories through self evaluations also linking to CoreTrustSeal certification.

Navigating the path ahead underscores the areas where interventions are needed for EOSC to fulfil its vision towards the “Web of FAIR data and services”. On that, we propose a set of recommendations to be taken up by the respective stakeholders.

4.1 Research Communities

Establishing a FAIR assessment infrastructure is pivotal for advancing research practices and promoting data interoperability. To prepare a robust FAIR assessment infrastructure, clear governance structures must be in place, delineating the roles and responsibilities of different



stakeholders. Adequate training programs are essential to equip stakeholders with the necessary skills to implement and maintain FAIR principles. It is imperative to recognize various entities' distinct roles in this process, from data producers to repository managers. Researchers emerge as the ultimate beneficiaries to leverage the tools and methods provided, empowering them to conduct more efficient and impactful investigations.

Collaborative case studies between communities/domains and tool providers could prove instrumental in mitigating challenges associated with implementing FAIR principles, fostering a synergistic environment that propels scientific progress.

4.2 Service Providers and Research Infrastructures

Science and scholarly communication is essential during the different stages of the scientific process and among the different actors involved in them. To increase the impact of our activities, we should delineate the nuances of FAIR data and FAIR metadata assessments. Tool providers could support this activity by explicitly specifying the type(s) of assessment(s) their tools support along with the limitations in reaching the FAIR assessment goals.

Another factor that would increase trust in FAIR assessment tools is the transparency of the assessment process, specifically emphasising the constituents of the tools that can increase trust, addressing challenges expressed by users, and incorporating open standards into workflows.

Advocating for a more 'FAIR way' of disseminating the FAIR assessment results is of equal attention. This involves initiating discussions on the file formats, metadata, and protocols for their exchange and ensuring their discoverability in designated locations.

Moreover, investigating the capacity of current tools to incorporate supplementary assessment principles, such as CARE and TRUST, is a relevant area for further exploration.

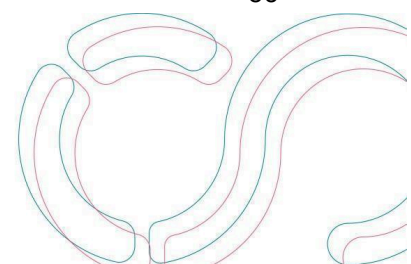
4.3 Research Funders

Due to a lack of research funders answering our survey, we have no picture of their behaviours and perceptions of FAIR Assessments. This should be further explored in the future, especially for FAIR assessment governance and increased awareness on the implementation and meaning and value of metrics of the FAIR principles for assessment.

4.4 EOSC

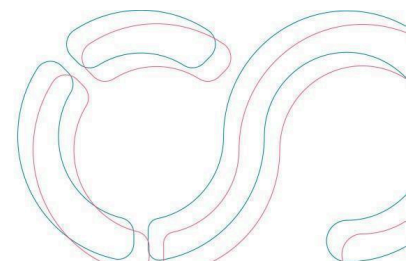
To foster community adoption, we need to be able to show where 'FAIR Data' and 'Data Quality' intersect and deviate. This could become the basis of a deliverable that the new mandate of the EOSC-A FAIR Metrics and Data Quality Task Force could undertake.

While celebrating the progress of EOSC adoption, our gaze should extend beyond to advocate for shared markets over monopolies or oligopolies. Enhancing the effectiveness of assessment tests through harmonisation is crucial. Additionally, when tool providers collaborate in developing benchmarks, EOSC should embrace and actively promote such partnerships.



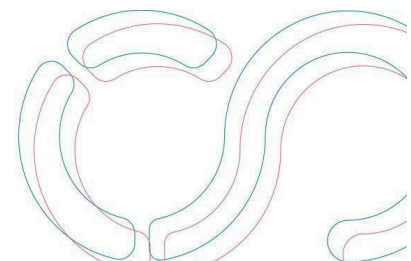
Finally, this report will inform future work in the EOSC Association Task Force and the new Open Science Trails - OSTrails project activities. [OSTrails](#) aims to advance processes and instruments for Planning, Tracking, and Assessing scientific knowledge production beyond state-of-the-art, working with various national and thematic contexts and stakeholders, improving existing infrastructure, and connecting key components to enable an operational, open and FAIR EOSC ecosystem.

Acknowledgements: We would like to thank Paola Ronzino who supported the dissemination activity of the survey by sending out emails and reminders, and all Task Force members for sharing the survey within their own networks.



References

- [1] Wilkinson MD, Dumontier M, Aalbersberg IJ, Appleton G, Axton M, Baak A, et al. The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data*. 2016;3: 160018. doi:10.1038/sdata.2016.18
- [2] Haendel, Melissa, Su, Andrew, McMurry, Julie. FAIR-TLC: Metrics to Assess Value of Biomedical Digital Repositories: Response to RFI NOT-OD-16-133 | Zenodo. doi:10.5281/zenodo.203295
- [3] Romain D, Laurence M, Alison S, Sarah S, Mogens T, Mohamed Y, et al. Implementing FAIR in data sharing: who are the actors and their responsibilities? Poster presented at; 2020 Mar 30. doi:10.5281/zenodo.3743946
- [4] dos Santos Vieira B, Bernabé CH, Zhang S, Abaza H, Benis N, Cámara A, et al. Towards FAIRification of Sensitive and Fragmented Rare Disease Patient Data: Challenges and Solutions in European Reference Network Registries. 2022. doi:10.21203/rs.3.rs-1572508/v1
- [5] FAIR Data Maturity Model Working Group. FAIR Data Maturity Model. Specification and Guidelines. 2020 Jun. doi:10.15497/rda00050
- [6] [European Commission, Directorate-General for Research and Innovation. Six Recommendations for implementation of FAIR practice by the FAIR in practice task force of the European open science cloud FAIR working group. LU: Publications Office of the European Union; 2020. Available: https://data.europa.eu/doi/10.2777/986252](https://data.europa.eu/doi/10.2777/986252)
- [7] Hong NC, Katz DS, Barker M, Lamprecht A-L, Martinez C, Psomopoulos FE, et al. FAIR Principles for Research Software (FAIR4RS Principles) | RDA. 2021. doi:10.15497/RDA00065
- [8] Goble C, Cohen-Boulakia S, Soiland-Reyes S, Garijo D, Gil Y, Crusoe MR, et al. FAIR Computational Workflows. *Data Intelligence*. 2020;2: 108–121. doi:10.1162/dint_a_00033
- [9] Castro LJ, Katz DS, Psomopoulos F. Working Towards Understanding the Role of FAIR for Machine Learning. *PUBLICO*; 2021. doi:10.4126/FRL01-006429415
- [10] Papadopoulou, E., Bardi, A., Kakaletis, G. et al. Data management plans as linked open data: exploiting ARGOS FAIR and machine actionable outputs in the OpenAIRE research graph. *J Biomed Semant* 14, 17 (2023). <https://doi.org/10.1186/s13326-023-00297-5>
- [11] Peters-von Gehlen, K., Höck, H., Fast, A., Heydebreck, D., Lammert, A. and Thiemann, H., 2022. Recommendations for Discipline-Specific FAIRness Evaluation Derived from Applying an Ensemble of Evaluation Tools. *Data Science Journal*, 21(1), p.7. DOI: <https://doi.org/10.5334/dsj-2022-007>
- [12] Nordling, J., Mihai, H., Meerman, B., Alaterä, T., Kleemola, M., & Livenson, I. (2022). D4.3 Report on Nordic and Baltic repositories and their uptake of FAIR. Zenodo. <https://doi.org/10.5281/zenodo.6880904>
- [13] Schwanitz, V.J., Wierling, A., Biresseoglu, M.E. et al. Current state and call for action to accomplish findability, accessibility, interoperability, and reusability of low carbon energy data. *Sci Rep* 12, 5208 (2022). <https://doi.org/10.1038/s41598-022-08774-0>
- [14] Sun, C., Emonet, V., Dumontier, M., A comprehensive comparison of automated FAIRness Evaluation Tools. *CEUR Workshop Proceedings* (2022). <https://ceur-ws.org/Vol-3127/paper-6.pdf>
- [15] David, R., Richard, A. S., Connellan, C., Lauer, K. B., Chiusano, M. L., Goble, C., Houde, M., Kemmer, I., Keppler, A., Lieutaud, P., Ohmann, C., Panagiotopoulou, M., Raza Khan, S., Rybina, A., Soiland-Reyes, S., Wit, C., Wittner, R., Andrade Bueno, R., Marsh, S. A., ... Ewbank, J. (2023). Umbrella Data Management Plans to integrate FAIR data: Lessons from the ISIDORE and BY-COVID consortia for pandemic preparedness. *Data Science Journal*, 22. <https://doi.org/10.5281/zenodo.7520086>



Appendix 1

'FAIR Assessment Survey' of the EOSC-A FAIR Metrics and Data Quality Task Force

Fields marked with * are mandatory.

The [EOSC Association](#) (EOSC-A) has introduced Task Forces as a mechanism to bring the research community together and collectively work towards EOSC implementation at all levels across commonly identified data topics.

According to the [FAIR metrics and Data Quality Task Force Charter](#), it will implement the proposed FAIR metrics for EOSC by assessing their applicability across research communities and testing a range of tools to enable uptake. Recommendations will be made to update metrics and adopt tools as appropriate. In addition, the group will undertake a state of the art to understand measures of data quality, conducting several case studies to identify common features and dimensions to define an approach for EOSC.

This survey regards the activities performed specifically for FAIR metrics to support harmonisation of FAIR assessments' results across service providers and promote a community driven approach to FAIR governance.

The data collected will be sent to the EC's survey tool EUSurvey. The privacy statement of EU survey is here: <https://ec.europa.eu/eusurvey/home/privacystatement>.

By answering you agree to take part in this survey sent to you by the [FAIR Metrics and Data Quality Task Force](#). The data collected will be used to provide feedback on the EOSC Association and EOSC related projects, and their analysis will be made available to the community afterwards.

Estimated time to finish the survey: 15-30 minutes.

About You

Name of organisation

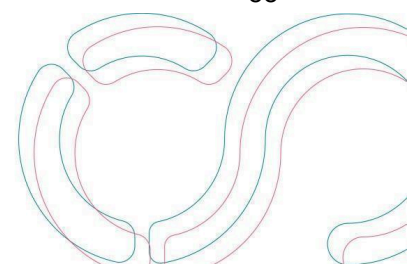
Please add full name of organisation.

* Type of organisation

- Academia / research, including Library
- Government / public services
- IT consultancy / development
- Large Enterprise
- Policy / funding agency
- Press and media

1

38



- Small and Medium Enterprise
- Other

Role in the organisation

EOSC project(s) involvement

Add all EOSC related projects that you have been / are involved in, separated with comma.

*** Discipline / Domain represented**

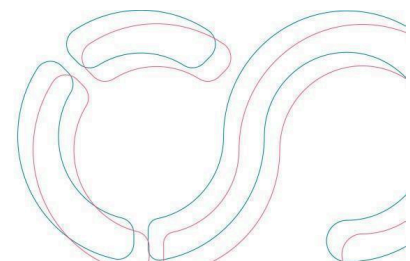
- Medical and Health Sciences
- Biology and Life Sciences
- Metrology
- Earth Sciences
- Astronomy
- Chemistry
- Engineering and Technology
- Social Sciences
- Law
- Humanities and the Arts
- Library Sciences
- Information and Computer Sciences
- Agriculture and Veterinary Sciences
- Theology
- Education
- Other

Please specify

*** In what capacity are you responding in this survey?**

If you are a researcher, you may produce, provide, consume, enhance and / or use data, other research outputs and FAIR assessment tools. Please choose the option(s) that best describe your everyday work.

- Data producer
- Data steward or custodian or curator
- Data user
- Data quality practitioner
- Publisher
- Service or data provider
- Policy / decision maker
- Standard maker
- Funder
- Other



Please specify

Application of the FAIR Principles for Assessment

- * Have you applied the FAIR principles for assessing data, software or any other research outputs and digital objects?

That includes practices from the design or application of FAIR metrics to the use or development of assessment tools. FAIR Assessment tools may vary from software to checklists and questionnaires. For the rest of this questionnaire, we will refer to these as "assessment tools", or just "tools".

- Yes
- No

- * Has someone else applied the principles for you / supported you in your FAIR assessment?

- Yes
- No

- * What type artifacts / digital object(s) or entities did you design / perform the FAIR assessment(s) for?

- Data
- Metadata
- Software
- Repository/ies
- Service(s)
- Publication(s)
- Training material
- Data Management Plan(s)
- Workflow(s)
- Protocol(s)
- Other

Add other digital object

- * What was the purpose of your FAIR assessments?

- Self-assessment of your own records
- Assessment of third-party records
- Comparison of your own records with third-party records

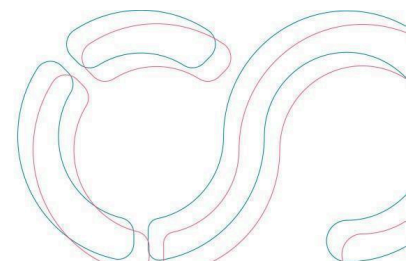
Please specify the scope and objective(s) of your FAIR assessment(s)

- * Did you perform the FAIR assessment(s) on one artifact/digital object/entity or on a collection of artifacts/digital objects/entities (or both)?

Please provide more details on the volume of records and repetitions of your assessment (e.g. up to hundreds of repetitions).

3

40



* Did you design / perform manual or automated assessments?

- Manual assessment
- Automated assessment
- Combination of manual and automated assessment
- Other

Please specify other type(s) of assessment

* Did you perform multiple assessments for the same (kind of) artifact (s)/digital object(s) or entity(ies)?

- Yes
- No

Please specify / provide more details on the comparison that you performed

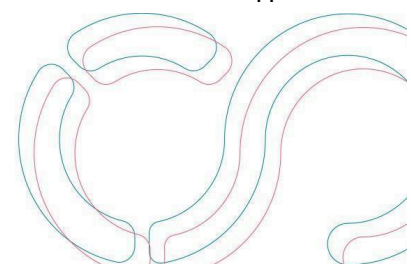
Please explain any deviations observed between the assessment results performed on the same (kind of) digital object(s)

Did the results leave you with confidence in the assessment?

* What are the biggest challenges that you faced when applying the FAIR principles for assessment? (Order the list items from bigger to smaller challenges)

Use drag&drop or the up/down buttons to change the order or [accept the initial order](#).

- Other challenge(s)
- Concerns about the interpretation of the FAIR principles, in your context/domain, by the assessment tool
- Scalability of performed activity
- Validity of results
- Quality/readiness of data/outputs to be assessed
- Understandability of assessment criteria/mechanism, their applicability and relative importance



Please specify

* Did you use an existing tool(s) to perform your FAIR assessments?

You may find a list of FAIR assessment tools or tools that embed FAIR assessors in their workflows here: <https://fairassist.org>

- Yes
- No

Please specify / provide name and URL of the tool(s)

Did you use multiple tools to perform your assessment?

- Yes
- No

Were the outputs from those tools consistent?

- Yes
- No
- Somewhat

Please comment on your perception of the utility/accuracy of each tool (positive and negative)

Do you believe you understand why different tools give different evaluations?

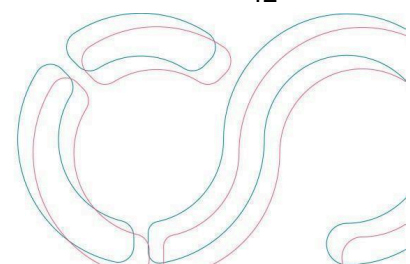
What remedy would make you more comfortable?

Please comment on your perception of the utility/accuracy of each tool (positive and negative)

What would your concerns be if you discovered that different tools provide inconsistent evaluations?

* Did you develop your own tool to assess FAIRness?

- Yes
- No



* Please specify / provide name and URL of the tool and its documentation, or if these are not available, a general overview of the functionality of the tool you developed

* Did you use / adapt the FAIR Maturity Model for your assessments?

The FAIR Maturity Model defines a set of indicators, their priorities and evaluation methods for the evaluation of the FAIR principles to be used as a common approach across assessment methodologies (<https://zenodo.org/record/3909563#.Ytp6v3ZBy5c>).

- Yes
 No

Please specify / provide details on any adaptation performed

Were you aware that this set of FAIR Maturity indicators existed?

* Does the designed / developed tool incorporate open standards in its workflows?

- Yes
 No

Please list any type of documentation of open standards used

* What kind of feedback did the FAIR assessment tool provide?

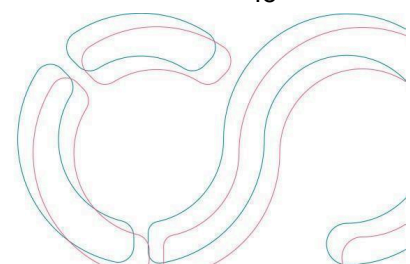
- Qualitative score
 Quantitative score
 Narrative feedback
 Other

Please specify

* How was the evaluation score provided?

- Separate for each sub-principle
 Aggregated result per top-level principle (F.A.I.R.)
 Aggregated result for all principles (total FAIRness)
 Other

Please specify



* How were the results of the FAIR assessment delivered?

- On screen
- Exported file(s)
- Email
- In person or with data stewards/consultants
- Other

Please specify other forms

How much do you trust the results of your FAIR assessment(s)?

* Did you publish the results of the assessment?

- Yes
- No

Where did you publish them?

* Do you plan on publishing them in the future?

- Yes
- No

Please specify how and where you plan to make the results of your assessments available

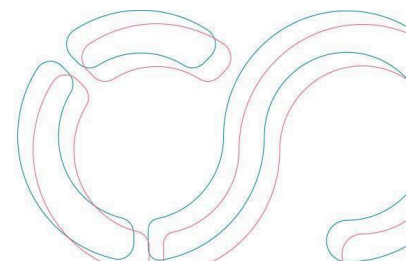
What are your concerns about making your assessment results public?

FAIR Assessment Governance

In your opinion, is FAIR Assessment Governance needed to assist in ensuring a common interpretation by FAIR assessment tools?

The need for governance around Web technologies and standards is not unique to FAIR and has been addressed by a wide range of internationally-scoped organizations, whose outputs need to be trusted by both academic and commercial stakeholders. The FAIR Metrics and Data Quality Task Force is examining various models for the governance of FAIRness assessments.

Please specify



Do you think that a Governance Body could support FAIR assessment activities?

Please specify

* Who should be involved in a FAIR Assessment Governance Body?

- Research Funding Organisations
- European Strategy Forum on Research Infrastructures (ESFRIs) / Research Infrastructures (RIs) to represent different domains
- Librarians
- Data Stewards
- Scientific committees
- Researchers
- Data Infrastructure providers
- Other

Please specify

* How relevant and applicable are the following roles in a FAIR Assessment Governance Body? (Order the list items from most to least relevant and applicable)

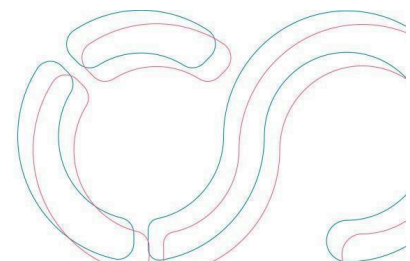
According to FAIR Assessment Governance community discussions, FAIR stakeholders are split into 3 main groups each populated by professionals corresponding to more than one roles. Below, three main groups are explained:

- FAIR decision and policymakers: Funding agencies, Governments, Publishers. This group encompasses stakeholders that will require access to FAIRification plans, i.e., how the FAIR Principles will be supported and achieved, for different digital objects involved in a research process but are not in charge of FAIRifying those digital objects themselves. This group includes funding agencies, governments, and publishers.
- FAIR custodians: FAIR support stewards & trainers, FAIR repositories, FAIR tools developers and operators, FAIR researchers, FAIR certification bodies. They correspond to stakeholders that will support FAIR in practice, also via research on FAIR itself, recommendations for FAIR adopters, or provision of tools making it easier for researchers to produce FAIR research and for those in the first group to assess FAIRness requirements. In this group, there are FAIR researchers, i.e., researchers whose field of research are the FAIR Principles and elements around them, and FAIR stewards, i.e., data or any other digital object stewards supporting the FAIR Principles.
- FAIR practitioners: Researchers and research-performing organizations (domain-agnostic), Research software engineers, Domain-specific research communities. They correspond to professionals directly working on research, including individual researchers and domain-specific research communities, whose responsibility it is to apply the FAIR Principles to their work - both as consumers and producers of data - and utilize services that assist them to achieve this.

Use drag&drop or the up/down buttons to change the order or [accept the initial order](#).

☰ FAIR decision and policymakers

☰ FAIR custodians



☰ FAIR practitioners

☰ Other

Please specify

What attributes would you expect the FAIR Assessment Governance Body to have?

From Wikipedia: The arm's length principle is the condition or the fact that the parties of a transaction are independent and on an equal footing. Check more: https://en.wikipedia.org/wiki/Arm's_length_principle

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree
* Trusted	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Broadly representative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Appropriately scoped	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Sustainable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Adequately Skilled	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Arms-length	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify

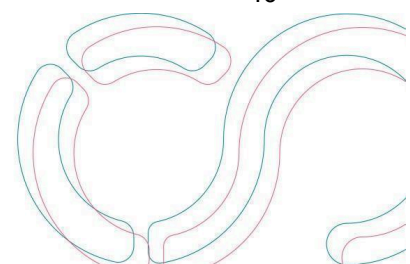
Compared to the status quo, what would be the cost/benefit of establishing a body for the Governance of FAIR assessment?

Personal Reflections

How confident do you feel today with how you interpret FAIR principles in your research / work?

How likely would you apply changes to increase the FAIRness of your practices if:

	Extremely Unlikely	Unlikely	Neutral	Likely	Extremely Likely
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* more guidance from funders was available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* more guidance from institutions was available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* more guidance from research infrastructures was available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* more support was provided to advance it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* more training was provided	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* dedicated funding was available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* a FAIR Assessment Governance Body existed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify

* Have you heard of the CARE principles?

The [CARE Principles for Indigenous Data Governance](#) are people- and purpose-oriented, reflecting the crucial role of data in advancing innovation, governance, and self-determination among Indigenous Peoples. The Principles complement the existing data-centric approach represented in the 'FAIR Guiding Principles for scientific data management and stewardship' (Findable, Accessible, Interoperable, Reusable).

Yes

No

* Have you heard of TRUST principles?

The [TRUST Principles for digital repositories](#) provide a common framework to facilitate communication with all stakeholders, providing repositories with guidance to demonstrate transparency, responsibility, user focus, sustainability, and technology.

Yes

No

Do you think these need equivalent attention to the FAIR principles for assessment?

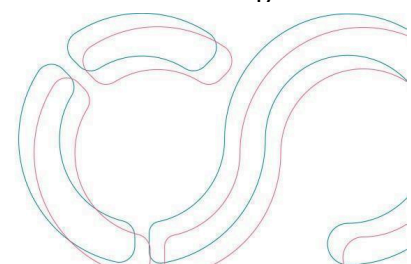
* Have you designed / performed any assessments based on the CARE and / or TRUST principles?

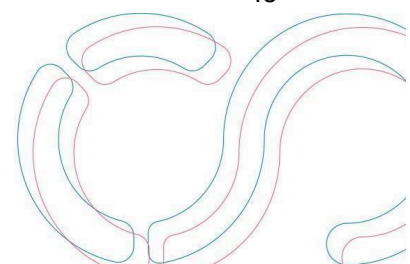
Yes

No

Please specify

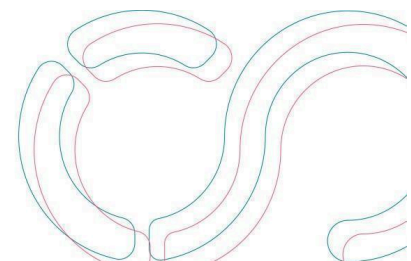
Do you have any other thoughts about FAIR assessments, landscape or practices?





Appendix II

Name of tool	URL	Organisation
Checklist for Evaluation of Dataset Fitness for Use	https://doi.org/10.15497/rda00034	WDS/RDA
CLARIN Curation Dashboard	https://curation.clarin.eu/	CLARIN
Curation application for PHI-base	https://canto.phibase.org/	PHI-BASE community
Data Stewardship Wizard	https://ds-wizard.org/	ELIXIR NL and ELIXIR CZ
FAIR checker	https://fair-checker.france-bioinformatique.fr/	IFB (ELIXIR-FR)
FAIR Data Self Assessment Tool	https://ardc.edu.au/resource/fair-data-self-assessment-tool/	ARDC
FAIR Enough	https://fair-enough.semanticscience.org/	Maastricht University
FAIR Evaluator	https://fairsharing.github.io/FAIR-Evaluator-FrontEnd/	FAIRmetrics.org
FAIR Validator	https://www.openaire.eu/openaire-guidelines-for-literature-institutional-and-thematic-repositories	OpenAIRE
FAIR-Aware	https://fairaware.dans.knaw.nl/	FAIRsFAIR project (DANS)
FAIR-TLC: Metrics to Assess Value of Biomedical Digital Repositories	https://zenodo.org/records/203295	Monarch Initiative and the TransMed NCATS Data Translator projects
FAIRplus Dataset Maturity (DSM) Model	https://fairplus-project.eu/	FAIR Plus project
FAIRshake	https://fairshake.cloud/	NIH Data Commons partners
F-UJI	https://www.f-ujl.net/	FAIRsFAIR project (PANGAEA)



howfairis	https://github.com/fair-software/howfairis	Netherlands eScience Center
metaxreader	https://github.com/CSCfi/metaxreader	CSC
O'FAIRe	https://hal.archives-ouvertes.fr/lirmm-03630233	AgroPortal Project (supported byINRAE / U. Montpellier)
RDA SHARC IG templates	https://zenodo.org/record/3922069	RDA

