Serving Data Right: A Data Steward's Guide to RDM Tool Evaluation

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Abstract. Research Data Management (RDM) is becoming an integral component of modern scientific practice covering all the steps of the research life cycle. As research institutions seek to put the FAIR (Findable, Accessible, Interoperable, and Reusable) data principles of RDM into practice, an increasing number of open-source RDM platforms and tools have emerged to support data collection, sharing, and publication. Selecting a relevant tool based on project and domain requirements is becoming complex, primarily because the existing evaluation methods are disconnected from the practical needs, user roles, and resource constraints. This paper addresses this complexity by introducing a structured, reusable, adaptable, and user-centered framework that includes a guide for the systematic evaluation of open-source RDM repositories across several technical, usability, and operational dimensions. Building on persona focused stakeholder requirements, the framework enables researchers, data stewards, and institutions to identify and compare key selection criteria, aligning tool capabilities with project-specific and organizational needs. Supplementing this framework, this paper provides an evaluation guide that supports researchers and data stewards in making informed, transparent, and context-aware decisions for choosing a specific RDM tool that fits their needs. Following open science, the complete evaluation guide is available for use at: https://github.com/FAIRSpace-Cologne/DataStewardGuides.

Keywords: Research Data Management (RDM), FAIR Principles, Open-Source, RDM Tools, Data Stewardship, Evaluation, Framework, Guide, Checklist, Open Science, Repositories, Research Personas

1 Introduction

The growing focus on open science, reusable data flows, and reproducible research has established Research Data Management (RDM) as a major component of modern scientific practice. Robust RDM ensures that data and research outputs conform to the *FAIR (Findable, Accessible, Interoperable, and Reusable)* principles. These principles aim to strengthen the long-term value, transparency, and integrity of scientific results. While research communities and institutions are working towards adoption of FAIR compliant RDM practices, a growing

ecosystem of open-source RDM platforms such as Dataverse, FAIRDOM-SEEK, and InvenioRDM have emerged to facilitate the curation, sharing, publication, and stewardship of research data. However, this abundance of tools, while beneficial, introduces a challenging question relevant for the RDM community and research projects: *How can data stewards and researchers systematically evaluate and select existing RDM tools against their domain-specific, project-specific, and organizational requirements?*

Existing approaches for software assessment typically only address isolated perspectives for evaluation, such as software quality metrics [1], Software usability scores, FAIR compliance, or narrowly defined domain use cases. An integrated perspective for software evaluation is missing, one that brings the requirements from multiple dimensions together into a coherent, user-oriented framework particularly targeting RDM tools. As a result, data stewards and the RDM community lack structured guidance to select or adapt an RDM tool, that aligns with their disciplinary requirements, organizational resources, and community needs.

This paper addresses the gap by presenting a structured, reusable, adaptable and user-oriented framework for the systematic evaluation of existing open source RDM platforms.

The framework is accompanied by a checklist based *Guide* that enables transparent, context-aware, actionable, and quantifiable assessments of RDM tools across multiple, user-aligned dimensions.

A central characteristic of the framework is its persona-driven design, which brings together the perspectives of key stakeholders into the evaluation process. The framework is organized into multiple dimensions reflecting different perspectives of RDM tool usage, including metadata modeling, interoperability, usability, flexibility, maintainability, and other relevant dimensions. As a result, the framework offers a structured methodology and an adaptable checklist that can be tailored to different organizational settings, resource constraints, and disciplinary contexts.

The main contributions of this paper are as follows:

- Integration of user personas, such as researchers, principal investigators, data stewards, and developers, ensuring that the evaluation criteria map to user stakeholder needs and tasks.
- A comprehensive set of evaluation dimensions covering core RDM tool requirements, e.g. metadata management, data handling, interoperability, community adoption, and sustainability.
- A flexible, holistic, and adaptable comparison criteria supporting assessment across diverse institutional, project, and resource requirements.
- An open-source guide for the structured evaluation of RDM repositories, made available to the community at github.
- A user friendly guide that can be used as a checklist, that facilitates informed decision making across disciplinary and organizational contexts.

The proposed framework provides a methodological practical, and adaptable guide for researchers and data stewards seeking to compare and select RDM tools that align with their scientific objectives and institutional requirements.

2 Background and related work

The FAIR data principles (Findable, Accessible, Interoperable, Reusable) provide a widely adopted framework for research data management and stewardship across scientific disciplines. These principles aim to promote research integrity through adding transparency, reproducibility, and efficient reuse of data by both humans and machines. A growing number of open-source RDM platforms have been developed to support FAIR-compliant data and metadata sharing. For example, *Dataverse* [2] is a web-based RDM platform that enables sharing and publishing of research data, alongside annotated metadata. Similarly, *FAIRDOM-SEEK* [3] supports collaborative RDM platform for data, models, and protocols, offering semantic metadata, flexible sharing settings while adherence to FAIR principles. Likewise, *EBRAINS* [4] provides a European digital infrastructure for neuroscience data sharing, simulation, and modeling, *iRODS* [5] (Integrated Rule-Oriented Data System) offers middleware for managing data across distributed storage systems, *Synapse* [6] provides a web-based platform for collaboration and sharing of scientific data, methods, and results, and *Vivli* [7] enables secure, cloud-based sharing of clinical trial data, *Coscine (FDM-NRW)* [8] service, built on iRODS, facilitates FAIR data storage, metadata management, and secure sharing for universities in North Rhine-Westphalia, *InvenioRDM* [9] provides flexible metadata management, search, access control, and community-driven extensions to support FAIR data sharing, and *Gen3* [10] is a microservices-based data commons platform for scalable biomedical data management, offering APIs, metadata services, and user portals for large consortia.

Even though these tools represent just a few of the many FAIR-focused RDM platforms, their increasing number presents a challenge for researchers and data stewards, especially the teams with limited resources.

Selecting an appropriate RDM tool requires considering multiple perspectives in parallel. This includes understanding user needs, organizational objectives, technical constraints, usability preferences, available resources, and domain requirements. These perspectives cover numerous dimensions like interoperability, usability, sustainability, and many others, makes the decision-making process inherently complex and context-dependent.

Only a few of these dimensions can be assessed using established frameworks, such as SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis, or by analyzing existing surveys and reviews of RDM tools [11], [12], [13], [14]. The frameworks presented in the literature are helpful in highlighting common gaps in existing software platforms, but

they generally focus on particular aspects like fragmentation across DMP tools, or review of existing RDM practices. Most evaluations in the literature cover focused perspectives, for example FAIR compliance [15], or data management planning tools [11]. To the best of our knowledge, there is no holistic evaluation mechanism that covers the broader RDM ecosystem and the specific needs, workflows, and resource constraints of users and organizations by specifically targeting user personas.

To address the above mentioned gap, a multidimensional, persona-driven evaluation methodology is desired that can help ensure that the selected RDM tools are not only FAIR compliant, but are also technically capable, aligned with user requirements, institutional requirements, and stakeholder expectations.

3 Methodology

In this section we introduce the methodology proposed for the selection of Research Data Management (RDM) tools. This paper integrates the user personas into the requirements of tool selection and introduces a human-centered approach to improve adoption and effectiveness of the selection process. Traditionally, RDM tools are evaluated driven by compliance requirements hat often overlook users. Personas, representations of user profiles, help bridge this gap by contextualizing users' requirements, available resources, and organizations goals. This approach helps ensure that the selected tools are also usable and relevant. Employing personas in requirements thus transforms RDM from a system-oriented process into a user-driven practice, promoting better engagement and more effective data stewardship.

3.1 Personas

This section explores the key personas critical to successful RDM execution and identifies their core *needs and expectations* from RDM tools, as summarised in Table 1.

Persona	**Primary Use**	**Key Tasks**
Principal Investigator	Oversight	Project creation, permissions, compliance
Research Scientist	Data generation	Upload, annotate, link data
Data Manager	Curation & standards	Metadata curation, quality checks
Collaborator	Data reuse	Search, request access, collaboration
Administrator	Compliance	Reporting, auditing, policy enforcement
Public	Open data access	Browse and download datasets
Developer	Development & maintenance	Install, configure, update platform; fix bugs; develop new features; ensure security and performance

Table 1. Typical user personas for RDM tool/platform

1. ***Principal Investigators / Lead Researchers*** oversee research projects and data management strategy. Their goals for using the framework include, ensuring compliance with funder and institutional data policies, make project data

FAIR and to facilitate collaboration among team members. Some typical tasks of this role in RDM repositories include creation of projects and datasets (if needed), assign permissions and access rights, and monitor data submissions and usage metrics.

2. ***Research Scientists / Data Producers*** generate and handle experimental or computational data. They typically use the system for efficiently storing and organising the research data, annotating data with metadata for discoverability, and sharing datasets with collaborators or publicly when required. Some of the common tasks for this role include, uploading datasets and associated files, provision of metadata for the data, adding links to publications or projects. The might additionally have their domain specific requirements.

3. ***Data Stewards / Research Support Staff*** support researchers in managing data, ensuring standards and best practices are being followed. Their goals are to maintain data quality and consistency in the repository and projects in general, to ensure that the datasets are FAIR-compliant, and to help with long-term preservation. Their typical set of tasks include, curation of metadata, defining metadata schemas, ensure alignment with standards, review dataset submissions, and to provide guidance on RDM policies and standards for individual projects.

4. ***Collaborators / External Researchers*** are the users that can access shared data for research collaboration. They typically use the system to discover and reuse relevant datasets, to contribute to collaborative projects without owning the primary data. Their typical tasks include searching and download of datasets, requesting access to restricted data, or they can comment or provide feedback on shared datasets (if enabled).

5. ***Institutional Administrators / Compliance Officers*** may use these repositories to monitor institutional data compliance and reporting. They aim to ensure research outputs meet institutional and funder requirements, and to track usage and sharing metrics. Although less likely to be used in open settings, the typical tasks for this role can include generation of reports on dataset submissions and usage, auditing access and permissions, and to ensure sensitive data handling complies with regulations.

6. ***General Public / Citizen Scientists*** (*Optional*) can access openly shared research data. They might use the repository to discover datasets for education, outreach, or independent research. Typical tasks of this role are to browse and download open datasets, or to explore metadata and associated publications.

7. ***Developer / Maintainer*** is the person responsible for installing, configuring, maintaining, and extending the RDM tool. This person ensures that the system runs reliably and securely, may develop new features or customize the platform for institutional needs, or to fit domain-specific data types and workflows. This person is responsible for fixing bugs and handle software updates, while enabling scalability and interoperability with other systems. The typical tasks of this role include installation and configuration of the platform, monitoring of the system health, logs, and performance metrics. Developer is also responsible to develop new modules, plugins, or integrations with other tools

and systems, and might take the support role for resolving technical issues.

3.2 Persona Based Requirements for RDM Tool Evaluation

The roles and personas introduced in the previous section have mostly distinct expectations and requirements as with respect to their tasks associated with such a tool. Taking from these key tasks and related expectations, this section shows a high-level evaluation methodology that reflect the practical needs of these personas. This assessment mechanism introduces a human-centered perspective that contrasts with conventional, standards-driven evaluations, such as those guided by ISO, or SUS frameworks. A summary of the desirable features by each role is provided in Table 2.

Table 2. Evaluation criteria for RDM tools by user persona.

Persona	**Key Evaluation Criteria**
Principal Investigator (PI)	Easy to generate reports; clear project overview dashboards; compliance with funder/institutional policies.
Research Scientist / Data Producer	Easy to upload and organize data; intuitive interface; ability to annotate data with metadata; support for linking datasets, models, or experiments.
Data Manager / Data Steward	Easy to add and edit metadata; support for controlled vocabularies and standards; data quality validation; ability to curate, review, and enrich datasets.
Collaborator / External Researcher	Easy data discovery and search; clear access permissions; ability to download or reuse datasets; support for commenting or collaboration.
Administrator / Compliance Officer	Audit trails and logs; reporting capabilities; user and permission management; compliance with policies and regulations.
Public / Citizen Scientist	Access to open data; intuitive browsing and search; metadata clarity.
Developer / Maintainer	Easy to install and configure; modular and extensible architecture; well-documented APIs; stable and secure system; easy to troubleshoot and update.

3.3 Evaluation Dimensions

In this section, we organize the expectations and requirements of the previously described user roles and personas into several evaluation dimensions. This structured dimension based evaluation approach enables researchers, data managers,

and other stakeholders to evaluate any RDM tool in a consistent and purpose-driven manner. At the same time this helps ensuring alignment with the project requirements, and institutional policies. The dimensions described below correspond directly to the persona based evaluation and usability criteria summarized in Table 2.

1. Usability. Usability is foremost criteria for any software solution, it covers the intuitiveness, clarity, and overall user experience (UX) of the tool across different roles. Key sub-criteria include user documentation, availability of interfaces to support different roles, and the ease of performing basic tasks such as adding data, metadata editing, publishing, and user access management. Usability evaluation methods include heuristic evaluations by experts, empirical user testing with representative personas, and standardized methodologies like System Usability Scale (SUS) [16]. The evaluations include task completion rate, error rate, and user satisfaction. User interviews can further capture perceptions, frustrations, and improvement suggestions. Practical challenges of assessing usability of a system include limited availability of trained evaluators, resource constraints for iterative refinement, and the limited availability of open-source usability assessment tools. This feature is equally relevant for all personas.

2. Metadata Management. Metadata management evaluates the system's support for creating, updating, and standardizing metadata across domains and data types. Sub-criteria include metadata enrichment support, custom metadata fields, integration with standardized vocabularies or ontologies, compliance with metadata standards (e.g., Dublin Core, schema.org, etc). These features are more relevant for data stewards but also benefit other personas. The evaluation considers flexibility in defining and extending schemas, quality of metadata curation, linkage to related datasets, publications, or other resources, and the ability to support FAIR principles in practice. While existing frameworks such as FUJI [17] or OMQAF [18] assess metadata quality, they do not measure how well a tool enables metadata usage.

3. Data Handling. Data handling covers the complete life cycle of datasets, including creation or uploading, viewing, updating, deletion, and searching. Key sub-criteria include methods for data upload (including large file and API support), searchability (full-text, faceted, advanced filters), browsing ease, versioning, linking datasets to other sources, deletion and retention management, publishing workflows, and granular access control. These features are of particular interest to data producers and data managers. For data publishing, features like DOI support, provenance tracking, and linking with external repositories or data sources are also relevant.

4. Interoperability. Interoperability is the data exchange among different platforms serving different data types, or different stages of research data life cycle, it evaluates the ability of the system to integrate data from different platforms and accross standards. This includes criteria like API availability (e.g. REST, GraphQL), integration with identity providers (ORCID, LDAP), compliance with data exchange standards, and import/export support for standardized formats. Interoperability ensures that metadata and data from multiple systems

can be searched, accessed, and integrated across diverse workflows using different tools and systems (e.g. RedCap[1], OMERO[2], Electronic Lab Notebooks (ELN). This enables robustness and help avoid altering existing workflows, and in the longer run, making the tool more sustainable. These features directly influence developers tasks, while being particularly useful for researchers that are data producers, managers, and collaborators.

5. Extensibility and Maintenance. Extensibility and maintenance assess the long term resources required for running the tool. This dimension covers the basic requirements like installability and portability of a tool, in addition to its modularity, and adaptability. Sub-criteria include installation and configuration complexity, monitoring and logging support, clarity of technical documentation, modular design, developer friendliness, and support for developing custom plugins and workflows. These dimensions help evaluate the long-term usability, sustainability, and maintainability of the system relative to available resources. These features are relevant for developer as well as manager roles.

6. Governance and Compliance. Governance and compliance dimension focuses on mechanisms ensuring secure, accountable, and policy-compliant use of the system. Sub-criteria include versioning and provenance tracking, auditing and logging of changes, policy enforcement (data retention, embargo, sharing, licensing), FAIR reporting, and support for managing and enforcing given policy requirements. These set of features help ensure that the data management processes align with institutional and funder regulations. These features are relevant for administrators and useful for compliance and data governance.

7. Performance and Security. Performance and security capture system reliability, scalability under load, and robustness of security measures. Sub-criteria include uptime, secure authentication and authorization, encryption, data integrity, and backup/recovery capabilities. Together, these ensure both operational resilience and protection of sensitive research data. These features are relevant for developers, as well as administration and security.

8. Adoption and Integration. Adoption and integration measure the system's proven use and ease of integration into existing infrastructure. Sub-criteria include institutional and domain adoption, ease of adapting the platform for specific disciplines or data types, and community trust and maturity. High adoption and integration capabilities indicate maturity and long-term sustainability. These features may be of more interest to principal investigators and administrators.

9. Community and Sustainability. Community and sustainability evaluate long-term viability and support. Sub-criteria include deployment model (cloud, on-premises, hybrid), open-source licensing, active development, community support (forums, issue trackers), and sustainability planning such as future roadmaps and institutional backing. Selection of tools with strong community engagement, and ongoing support are more likely to remain maintainable and relevant over time. These features are of interest to all the user roles.

[1] https://project-redcap.org/
[2] https://www.openmicroscopy.org/omero/

Table 3 provides an overview of these dimensions together with example evaluation criteria and indicators that cover a particular dimension, providing a blueprint to be used for evaluation. These dimensions can be assessed either qualitatively or quantitatively, based on existing supporting evidence or specific evaluation criteria (e.g. SUS score for usability testing, stress testing for scalability, etc.). This structured approach allows researchers to systematically evaluate RDM tools based on their specific project, institutional, and domain requirements. This evaluation framework supports informed decision-making for tool adoption. Importantly, the outlined evaluation criteria are flexible and optional, allowing for complete adaptation based on project, domain, and resource needs, while remaining relevant, robust and actionable. The goal here, is not to provide an exhaustive list, but a holistic evaluation guide to help RDM teams and Data Stewards select the best-aligned tools.

4 Results

Following open science principles, the evaluation *guide* is made publicly accessible via GitHub: https://github.com/. This evaluation framework is originally developed to support research data management (RDM) tool selection within the institute. It has helped in streamlining the decision-making processes, by addressing requirements from different stakeholders and supporting the identification of a tool with functionalities that align with project-specific requirements, and team goals including practicality, maintenance, extensibility, and resource constraints. The *guide* has subsequently been applied in multiple research projects, where it has proven to be a valuable resource for both researchers and data stewards. The accompanying *guide* provides a comprehensive, accessible, and adaptable approach to RDM tool evaluation that can be effectively employed by RDM teams across heterogeneous research environments. Its open availability promotes broader uptake, domain-specific adaptation, and community-driven enhancement by the research data management community, thus positioning it as a reusable and evolving resource.

5 Discussion

The proposed framework offers a structured evaluation mechanism that integrates multiple perspectives across different dimensions, covering requirements from different personas, in a comprehensive, robust, and actionable manner. The framework builds on the assumption that the tools under consideration already fulfill the fundamental RDM requirement of FAIR data access, and develops its evaluation criteria around this basis. Furthermore, this work does not aim to redefine existing evaluation standards but extends them to integrate different perspectives for selection and evaluation of an RDM tool. Existing methods provide either generic or too focused assessment criteria, while our method proposes persona-specific requirements, covering numerous dimensions like usability, metadata, performance, data handling, and governance that are relevant

Dimension	Example Criteria / Indicators
Usability	User interface intuitive across different roles; ease of dataset upload and organization; easy search and browsing; advanced and faceted search options; auto completion.
Metadata Management	Flexibility to define and extend metadata schemas; support to add different types of data, and ability to connect with domain ontologies and controlled vocabularies; metadata standardization and FAIR compliance; metadata enrichment and curation tools; linking datasets with publications or models.
Data Handling	Uploading, editing, versioning, linking, deleting, and publishing data; access control and permissions; dataset citation (DOI support); handling of large or sensitive datasets; provenance tracking.
Interoperability	API availability (REST, GraphQL); import/export of data in standard formats; integration with external services (e.g., ORCID, DOI registries, institutional repositories).
Extensibility & Maintenance	Modular and configurable architecture; ease of customization and plugin development; installation, configuration, and monitoring tools; well-documented APIs; ease of software updates; scalability and maintainability.
Governance & Compliance	Role-based access control; user and group management; audit trails and logs; compliance and policy enforcement; FAIR compliance reporting; data retention and licensing support.
Performance & Security	System reliability and uptime; scalability under load; secure authentication and authorization; encryption and data integrity; backup and recovery capabilities.
Adoption & Integration	Proven adoption across institutions, domains, and regions; ease of integration into institutional IT infrastructure; community use, and maturity.
Community & Sustainability	Open-source license; active community and contributor engagement; transparent governance; roadmap and regular release cycles; comprehensive documentation; long-term sustainability, and institutional support.

Table 3. Evaluation dimensions for systematic comparison of open-source RDM tools

to not only data stewardship and FAIR data practices, but also to organizational goals and resources. With the stakeholder-oriented view, it is a generic evaluation model, that helps in aligning technical evaluation criteria with the requirements within the RDM ecosystem, while providing a context-aware and comprehensive evaluation mechanism. The framework and the associated guide enables identification of strengths and weaknesses across RDM tools, supporting evidence-based, actionable decision-making. It is important to note that some di-

mensions mentioned in the list might require tradeoffs. For example, optimizing for rich and flexible metadata may reduce ease of use, or deployment, and increasing flexibility for developing new features can contradict with a centralized development roadmap.

6 Conclusion

This paper successfully addresses the fragmented nature of existing software assessment by introducing a structured, user-centered evaluation framework specifically designed for open-source Research Data Management (RDM) tools. The key contribution lies in integrating disparate assessment methods into a single, comprehensive view, driven by the practical requirements and tasks of specific user personas (e.g., Data Stewards and RDM teams).

This integration translates user needs into a set of multiple, interconnected evaluation dimensions that unify established principles of software quality, usability, and compliance. The resulting framework accompanying *guide* provides an evaluation that is holistic, robust, actionable, and context-aware.

In conclusion, this paper offers a comprehensive, reusable, and adaptable guide for RDM tool evaluation, enabling organizations and projects to make informed, transparent, and systematic decisions regarding the selection and hosting of an open source RDM platform.

7 Acknowledgement

This research is part of the BETTER REAL-WORLD HEALTH-DATA DISTRIBUTED ANALYTICS RESEARCH PLATFORM project funded by the European Union (GA 101136262), the DFG SFB 1607, Project 501530074 (BM, TV, CC, MN), and ARTICYST, funded by the Open Science Clusters' Action for Research and Society (OSCARS) project under GA 101129751.

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