ADVANCING OPEN KNOWLEDGE IN AFRICA THROUGH PERSISTENT IDENTIFIERS AND OPEN RESEARCH INFRASTRUCTURE

COURSE CONTENT

2025

Objectives of the course

- Clearly identify the role of Persistent Identifiers (PIDs) and metadata in supporting African scholarship and open research practices.
- Learn how to use DataCite's metadata and tools effectively to extend the role of PIDs beyond just DOI assignment.
- Explore affordable and practical methods to access and utilize open infrastructure to improve research visibility and accessibility.
- Responsible AI and open research infrastructure
- Identify actionable steps to join DataCite as members, with a focus on affordable solutions tailored for African institutions.
- Discuss success stories of African institutions that adopted DataCite DOI

Module 1

Introduction to Open research infrastructure for visibility and accessibility

Learning objectives

- Define key concepts in open research infrastructure, including persistent identifiers, metadata standards, and FAIR principles.
- Explain the role of DOIs, ORCID, ROR, and open repositories in enhancing research visibility.

Subtopics

1. Introduction
2. Why libraries
3. What are PIDs? Definitions, key concepts and common types of Persistent Identifiers (PIDS) in research (DOIs, ORCID iDs, ROR, ISSN, ISNI, Handle, ARK)
4. Open Research infrastructure

Module 2

Persistent Identifiers (PIDs) and metadata for African scholarship and open research practices

Learning Objectives

- Understand the importance of Persistent Identifiers (PIDs) in scholarly communication.
- Explore how PIDs enhance the visibility and impact of African scholarship.
- Learn about metadata standards and best practices for open research.
- Examine the role of PIDs in research integrity, collaboration, and funding.

Subtopics

a. PIDs in the African Research Ecosystem
b. Implementing and Managing PIDs in Research Workflows
c. Metadata and Open Research Standards
d. PIDs and Open Research Infrastructure
e. Policy and Governance for PIDs in African Research

Module 3

Creating DOIs

Learning Objectives

- Understand what a Digital Object Identifier (DOI) is and explain its role in scholarly communication.
- Distinguish between DOI registration agencies (e.g., DataCite vs. Crossref) and their use cases.

- Understand the DataCite Metadata Schema v4.6, including mandatory, recommended, and optional properties.
- Assess how creating DOIs through DataCite supports knowledge equity, indigenous representation, and multilingual metadata.
- Learn to advocate for DataCite DOI adoption in African libraries and repositories as part of open infrastructure strategy

Subtopics

a. DOIs
b. More about metadata
c. Doing registration agencies
d. Who is DataCite
e. The DataCite metadata schema
f. Markup language for DataCite schema
g. Why DataCite is suitable for African libraries and other documentary and cultural heritage institutions

Module 4 - Responsible AI and open research infrastructure

Learning Objectives

- Explain the principles of Responsible AI and its relevance to research.
- Understand how open research infrastructure supports ethical AI.
- Identify the roles of libraries and information professionals in promoting Responsible AI.
- Apply FAIR data practices to support transparency and accountability.
- Explore how tools like DataCite enable trust and traceability in AI-driven research.
- Outline advocacy and action steps for institutional or regional engagement.

Subtopics

a. Introduction to Responsible AI

b. Roles of Libraries and Information Professionals in Responsible AI
c. Intersection of Responsible AI and Open Research Infrastructure
d. FAIR data and ethical stewardship in the age of AI
e. DataCite and Responsible/Ethical AI Ecosystem

Policy, Advocacy, and Community Engagement
Future Trends and Action Planning

Module 5 - Actionable steps to join DataCite community

Learning Objective

This module will provide practical steps on how to join DataCite community as well as the low-cost options available for African libraries to do this.

a. Membership options
    I. Direct membership vs. joining through a consortium
    ii. African-friendly models: national and regional consortia
    iii. Realistic paths based on institutional size and resources
b. How to get started: Step-by step
c. Low-cost and Low-code solutions
    I. How small or under-resourced institutions can participate
    ii. Using existing repositories, platforms, or partners
    iii. Service providers and support options
d. What happens after joining?Growing in the community
e. success stories of African institutions that adopted DataCite DOI Infrastructure:
    I. Busitema University, Uganda
    ii. CUT, Zimbabwe
    iii. South Africa
    iv. IITA, Nigeria (Pan Africa)
    v. Mekelle University, Ethiopia

Module 1 - Introduction to Open research infrastructure for visibility and accessibility

Discussion Forum

1. Introduce yourself and your institution.
2. What is your understanding of open science?
3. The UNESCO Open Science Recommendation asks Member States to do 7 things. Which of those 7 steps or activities do you think libraries and librarians should take the lead or be a part of? https://www.unesco.org/en/open-science/about

**Participation in this group discussion contributes to a percentage of your final grade. Please don't start a new discussion, please answer the question prompts in this discussion forum. Please answer with as much detail as possible. Use this opportunity to engage with your colleagues by replying to their responses. One-word contributions and replies will not be counted towards your grade.*

Introduction to Open research infrastructure for visibility and accessibility

1. Introduction
2. Why libraries
3. What are PIDs? Definitions, key concepts and common types of Persistent Identifiers (PIDS) in research (DOIs, ORCID iDs, ROR, ISSN, ISNI, Handle, ARK)
4. Open Research infrastructure

Open research infrastructure for visibility and accessibility

1. Introduction

Research is at the root of unabating innovations and advancements that the world is now experiencing in biotechnology, nuclear warfare, information technology and Artificial Intelligence, etc. Research is no longer an esoteric activity but has become recognized as the heart, the fulcrum for birthing innovative solutions that drive inclusive and sustainable development in all sectors of human existence. It is therefore understandable why the UNESCO Open Science Recommendation underscores the need for research processes and outcomes to be open, sharable, and reusable, organized and supported with infrastructure in such a way that provides visibility and accessibility so that everyone can benefit from knowledge for a better world.

Metadata and persistent identifiers (PIDs) are the pillars that support discoverability, integrity, openness and reproducibility in open research infrastructure and open science ecosystems. This course aims to take African library professionals into a clear understanding of PIDs, how to use open, standardized metadata to improve discoverability and interoperability and

how their libraries can leverage on DataCite tools and services toadopt Persistent Identifiers (PIDs) (e.g., DOIs for datasets, ORCID iDs for researchers). Critically, the course will help African librarians recognize how their libraries can utilize PIDs to support African scholarship and promote open research practices.

2. Why libraries?

When it comes to opening up knowledge, data and research as well as the infrastructures that make open and sharing possible, libraries have key roles to play as centres and trusted hubs for research support services, access points for resources. In the past, the focus of most libraries was creating access to information resources.

However, as digital resources continue to grow as well as the understanding of the place of knowledge in driving innovations that lead to sustainable development, it became clear that libraries need to become deeply involved in establishing and maintaining the infrastructure and services necessary for sharing knowledge, enabling collaborations in knowledge creation and reuse as encapsulated in the UNESCO Open Science and Open Educational Resources Recommendations. Libraries began to offer services with institutional repositories, data repositories and the promotion of open access journals and monographs.

In order for libraries to efficiently assist researchers to organize, store, protect, and share their research and research data in accordance with ethical and standardized formats, these professionals need to understand the place of metadata, persistent identifiers and DOIs (Digital Object Identifiers) as

elements that are absolutely essential for creating the needed connections between researchers and their contributions while also providing the pathways and mechanisms for the interoperable sharing of data across systems.

Introducing the use of persistent identifiers (PIDs) and Digital Object Identifier in the workflows of libraries would help the professionals in these institutions to ably create connections between resources and entities thereby promoting the use of FAIR (findable, accessible, interoperable, and reusable) principles for ethical research and knowledge creation.

Again, when library professionals gain deep insights into PIDs, it can become a rallying point for creating standards and awareness about mandatory submission guidelines for Institutional Repositories as well as how such can drive visibility of academic work and research outputs of the academia. This has a high probability of increasing the volume of research from Africa and the rankings of tertiary institutions in the continent as PIDs can play useful roles in the evaluation of institutional repository usage, and other benchmarking activities.

3a. What are PIDs? Definitions and key concepts

An identifier is generally any label or name that is used to uniquely distinguish an entity or item which could be a physical object, a digital entity, or a concept. Generally, URLs or links act as identifiers as they can be used to locate digital content. Nevertheless, they can change or give the 404 notice due to the constant changes in the internet brought on by its expansion

which makes it difficult to perpetuate steady and interminable records of digital objects.

PIDs, or Persistent Identifiers are unique ID numbers or a unique string of characters that go further than distinguishing one digital item or entity from another. They are unique, persistent labels that serve as long-lasting references used to identify and locate digital objects like publications (including journal articles, journals, monographs, presentations, unpublished reports etc), data, software, researchers, scientific samples, funding bodies, or a set of geographical coordinates.

PIDs do not suffer digital attrition as traditional URLs that can break or change. Rather, they are distinctively designed to remain stable over time, even if the underlying data or object changes location or ownership thus, they can remain functional even if the location or web address of the object changes. PIDs are persistent because the links do not rot and do not let libraries and researchers experience the ***"404 Not Found"*** error as they try to locate resources. This is possible because a PID is usually linked to a set of metadata that describes an object rather than to the object itself.

PIDs are valuable machine-readable assets that enable information sharing across systems as different platforms and databases exchange information consistently and unambiguously about digital objects and publications using them. It is a global system of disambiguation that ensures one can reference a particular work or object with no confusion even if there are other works with the same title or other researchers with the same names and initials.

This provides a reliable pathway for tracking citations and attributions, scholarly contributions and allows data reuse.

PIDs can also be used to create networks of linked data that librarians can use to identify other resources/objects associated with a PID. Libraries can also use PIDs to link research components, find related articles and assist researchers identify possible collaborators. This is important as libraries not only provide services that lead to the discovery of information resources that could be any type of digital object, but they also should be able to link such resources to other digital objects such as supporting data, and related research. This will underscore the relevance of library professionals in information retrieval.

Use of PIDs by libraries can assist them to create knowledge graphs of research and creative outputs from their institutions. Furthermore, use of PIDs can help libraries to ensure long-term access to and reliable identification of digital resources they recommend to their user communities. Thus, PIDs can be viewed as stable, machine-readable and human-readable references that allow for consistent and clear identification, verification,and sharing of information about digital objects and content across different systems.

There are different types of PID for various kinds of resources. There are commonly two varieties of PIDs in the research ecosystem: PIDs for objects (publications, data, software, such as URNs, DOIs, ARKs, Handle) and PIDs for people (researchers, authors, contributors, such as ORCIDs, ISNIs).

3b. Common types of Persistent Identifiers (PIDs) in research (DOIs, ORCID iDs, ROR, ISSN, ISNI, Handle, ARK)

The following are the common types of Persistent Identifiers (PIDs) used in research and knowledge creation activities.

a. **Digital Object Identifiers (DOIs)**: This is a widely used PID for identifying scholarly articles (including monographs), datasets, presentations and other research outputs. DOIs are persistent, meaning they remain stable even if the resource's location changes. The DOI assigned to a given research object distinguishes it from other works, including other versions of the same intellectual material. https://zenodo.org/https://datacite.org

b. **ORCID (Open Researcher and Contributor ID):** A unique, persistent identifier for researchers and contributors,that helps to distinguish individuals and link them to their research outputs, creative content and innovations. These PIDs assist institutions and establishments to keep track of the outputs of their employees/researchers/staff and disambiguates between individuals with similar names as each person's work is rightly attributed to him/her https://orcid.org/

c. ROR (Research Organization Registry): A global, open registry for identifying and providing research organizations like universities, institutions, and funding agencies with persistent identifiers. It is the default identifier that is integrated into Crossref DOI metadata, DataCite DOI metadata, and ORCID. *'ROR makes it easy for anyone or any system to disambiguate institution names and connect research organizations to researchers and research outputs'* https://ror.org/.

AfLIA's ROR ID can be accessed here - https://ror.org/05h39qc65

d. **International Standard Serial Number (ISSN)**: A global identification code made up of 8 digit numbers and characters used by publishers, libraries, information service providers, bar coding systems, and union catalogues, for the identification of serial publications, such as newspapers, journals, magazines and other periodicals in print and electronic formats. Issuance and management of ISSN are handled by registration agencies such as National Libraries. With 93 national centres spread across the globe, the ISSN International Centre has bibliographic details for more than 2.3 million serials. It is also linked to the databases of SCOPUS and DOAJ (Directory of Open Access Journals). Like ISBN which is well known to library professionals, (https://www.isbn-international.org/content/what-isbn/10) and which is also issued through National Libraries, ISSN has been in use as a persistent identifier for a long time https://portal.issn.org/https://www.issn.org/understanding-the-issn/what-is-an-issn/

e. **ISNI (International Standard Name Identifier):** A global, standardized and unique persistent identifier for creators of creative works including novels, musical works, sound recordings and other types of media content as well as all the entities that are involved in the production and distribution process (illustrators, translators, editors, publishers, imprints, data aggregators. https://isni.org/

f. **Handle:** The Handle System is a feature in the architecture of PIDs and is used as the basis for other persistent identifiers like DOIs. Each Handle

identifies a single resource, and the organization which created and/or now maintains the resource. Organisations apply at https://handle.net to receive a prefix to be used for the handle IDs that would be unique to them. Thus, Handle acts as a digital fingerprint, a stable reference point for digital objects including publications, datasets, software, and other research outputs. It typically consists of a prefix (assigned to the owning organization- of the digital object) and a suffix (unique to the resource) separated by a slash.

g. **Archival Resource Key (ARK)**: These are persistent identifiers designed to ensure long-term access to information objects such as digital and physical objects, living beings and groups including companies and orchestras as well as intangible objects such as performances, chemicals, places etc. ARKs persistent identifiers are unique as they have the ability to lead one to the digital object being sought as well as to the descriptions of those objects. *'ARK can be assigned to anything digital, physical, or abstract. That can include things that don't yet exist but to which you need to refer from objects that you're in the process of creating or planning, such as a link from a draft article to a dataset under preparation, or a link from an archived digital letter...'* https://arks.org/about/ark-overview/

4. Open Research Infrastructure

Open Infrastructure fosters collaboration as well as the adoption of open standards, ensuring the transparency, reusability, reproducibility, and long-term sustainability of scientific research. Open research infrastructure is made up of shared digital tools and services that support and enable open science practices. It incorporates a wide range of platforms and repositories

that aid the dissemination, preservation, and accessibility of research outputs, including publications, data, software, and other digital objects. Open research infrastructure supports research, education, and knowledge creation, often with a focus on openness and accessibility. It drives collaboration, promotes open standards, and ensures the transparency, reliability, reusability, and long-term sustainability of scientific research/knowledge. Because it is open, it is mostly community-driven rather than proprietary with centralized control.

The key goals of Open research infrastructure are to:

- provide spaces for researchers to share their work openly,
- promote the open sharing of research data, making it discoverable, accessible, and reusable,
- ensure that research outputs are preserved and accessible for future use
- foster collaboration among researchers and promotes transparency in the research process

Examples

Examples of open research infrastructure include preprint servers that enable researchers to share pre-publication versions of their work such as arXiv e-print archive (*https://arxiv.org)*. The Pan-African e-print archive can be accessed here - *https://info.africarxiv.org* Open data repositories such as Dryad *(https://datadryad.org)* and Zenodo *(https://zenodo.org)*where researchers can deposit, share and preserve their datasets including presentations are also part of the open research infrastructure. Open access

research journals, books and platforms that enable research and knowledge creators to share their works, as well as Persistent identifiers and Digital Object identifiers such as are provided through ORCID and DataCite.

Module 1 Assignment

1. Create an ORCID ID for yourself if you do not have one already. https://orcid.org/

- Find a presentation you had recently made (preferably in Powerpoint) and upload to Zenodo. https://zenodo.org/
- Share the link and the DOI generated by Zenodo
- Share the ROR of your institution if it already exists or go ahead, create one and share https://ror.org/

2. Check and see how many of these authors have ISNI IDs. Do you consider the process for getting ISNI easy? Why not? https://isni.org/page/search-database/

- Ayi Kwei Armah
- Wole Soyinka
- Chimamanda Adichie
- Tayeb Salih
- Alain Mabanckou
- Ngugi Wa Thiong'o
- Buchi Emecheta
- Wangari Maathai
- Helon Habila
- Bessie Heas
- Chinua Achebe
- Mariama Ba
- Sefi Atta
- Mariama Bâ

Further reading for Module 1

- Using Persistent Identifiers https://www.osti.gov/pids/using-pids
- Handle System https://en.wikipedia.org/wiki/Handle_System
- ARK Identifiers FAQhttps://wiki.lyrasis.org/display/ARKs/ARK+Identifiers+FAQ
- Open infrastructure https://openscience.cern/infrastructure

Module 2 - Persistent Identifiers (PIDs) and metadata for African scholarship and open research practices.

Module 2 Forum Discussion
Contribute to the conversation below by following these discussion prompts:

1. How do you handle theses and dissertations in your library?
2. How are datasets for research stored in your country?

**Participation in this group discussion contributes to a percentage of your final grade. Please don't start a new discussion. Rather, answer the question prompts in this discussion forum. Please answer with as much detail as possible. Use this opportunity to engage with your colleagues by replying to their responses. One-word contributions and replies will not be counted towards your grade.*

Module 2 - Persistent Identifiers (PIDs) and metadata for African scholarship and open research practices.

a. PIDs in the African Research Ecosystem
b. Implementing and Managing PIDs in Research Workflows
c. Metadata and Open Research Standards
d. PIDs and Open Research Infrastructure
e. Policy and Governance for PIDs in African Research

a. PIDs in Africa's Research Ecosystem

Persistent Identifiers (PIDs) have evolved over the years in the space of Library and Information Science. For instance, ISBN, the International Standard Book Number, is a unique 12-digit identifier used to identify specific book or book-

like products. ISBN comes at a fee, and it is persistent for the book that it is registered for. Many African literatures have ISBN as their unique persistent identifiers. As the world goes digital, more research outputs also move online. ISBN and other identifiers that are physically assigned have some limitations in terms of persistence and adaptations for online identification, access and dissemination.

An ISBN could be assigned at country level but when such a book or information resource goes online, the rich metadata that could increase the findability, accessibility, interoperability and reusability may not be available. This challenge is observable in African research communities where many journals and ebooks that are open access could not use the legacy identifiers for the online research outputs. Researchers in the region are now learning to embrace online forms of persistent identifiers that add rich metadata to their research outputs.

Research outputs, including text-dominated, tabular-dominated, images, audio, videos as well as cultural artefacts in Africa, are frequently made open access. When referring to open access, we refer to the ability to access research outputs without restrictions. The access could be limited with some conditions that are based on the type of license used. However, in many cases, attribution is always expected for reuse within a research context. When research is open access, one of the incentives for the research output author or creator as well as the co-author(s) is proper attribution with appropriate citation style, which is enhanced with persistent identifiers. Research outputs that are online and open access could be lost or authors

could also be confused. For instance, if a website or repository that hosts or warehouses a journal could not be sustained by the owners, such journal as well as the articles therein, may no longer be available. Even if the articles have links, such a link may return an error 404, which implies that the resource in the link cannot be found.

This is where persistent identifiers become important.

PIDs provide several safeguards for research outputs, research workflows, researchers, and research institutions while also improving discoverability. The example of a discontinued journal or repository above could be mitigated from having a broken link if the resource, in this case, journal, is moved to a new location or repository. This implies that the old URL would no longer be valid.

However, with PIDs, users only access the resource through a persistent link. That persistent link is updated at the backend to reflect the new location of the resource. This process of updating the resource location without breaking the link to the resource ensures that research outputs remain available, regardless of changes occurring at the backend. It promotes accessibility and findability of research outputs. The use of PIDs enhances the discoverability of research outputs. When such work is cited with a persistent identifier, the cited resource becomes discoverable for reuse or access due to the continuous maintenance of the backend that connects the resource location to the persistent identifier. There would not be a broken link except when the persistent identifier is not maintained as explained above.

Leveraging on PIDs and their infrastructure enhances equitable knowledge creation and sharing in Africa which are also integrated into the global research ecosystem. Many local institutions, across the region, have institutional repositories for hosting and sharing knowledge outputs from their institutions. As many that have well implemented PIDs workflow, the knowledge created is accessible beyond the shores of the continent. This decentralised knowledge system has helped increase knowledge generation allowing institutions to take ownership of their research outputs with full integration into global research nexus on their own terms. It is laying a preliminary foundation for simpler metrics beyond the conventional journal impact factor to a richer PID-linked evidence-based impact and contribution measurements.

b. Implementing and Managing PIDs in Research Workflows

It is a great practice to integrate PIDs from the initial stages of the research workflow. A PID-First approach would integrate PIDs right from the Data Management Plan (DMP) stage. A Data Management Plan is a living document that describes the entire research data life cycle from the kick-off, through the research life-span and beyond the end of the research. PIDs would be assigned to every activity as well as data collected during the active period of the research with quality metadata. PIDs would also be assigned to the research outputs after the research completion. The introduction of PIDs from the early stage of research supports provenance while increasing both traceability and reproducibility of the research output.

In this section of the module, we have introduced some concepts or terminologies that would require some clarifications or explanation. We mentioned provenance, traceability, reproducibility, Data Management Plan (DMP) and quality metadata. Metadata would be treated in the next module while we already have an overview of a DMP in the previous paragraph.

- **Provenance** in research refers to the historical record of data which ensures the source of such data is not lost. It tells the verifiable story of where data for a research project comes from.
- **Traceability** refers to the ability to identify, follow and verify the history, location of research data, application methodology, and outputs through persistent links, persistent identifiers, rich metadata and proper documentation. Traceability requires PIDs for integrity check. Traceability leads to Provenance.
- **Reproducibility** ensures a research output can be reproduced by any other researcher with the same result using the same data, method, and software.

PIDs workflow implementation requires a wholesome identification of all important elements and entities in a research ecosystem that require a persistent identifier. This includes PIDs for:

1. **Institutions and funders**: This type of persistent identifier is used to identify a place, an institution, a funder or any organization that's part of the research community. It has standardized and rich metadata that links funding sources and institutional affiliations. A good example of this is ROR (Research Organisation Registry). Others include GRID (Global Research Identifier Database) which was a predecessor to ROR. It is noteworthy that some systems still use GRID

2. **Researchers:** The PIDs here provide unique persistent identifiers to researchers Examples of PIDs for researchers include ORCID (Open Research and Contributor ID), ISNI (International Standard Name Identifier) and ResearcherID as well as Scopus Author ID. It should be noted that both ResearcherID, which is managed by Web of Science and Scopus Author ID, managed by Elsevier, are proprietary. ISNI follows ISO standard while ORCID has more universal adoption in academia due to its open, global and non-profit infrastructure.
3. **Research output**: PIDs for research outputs provide unique and persistent identifiers with rich metadata for all kinds of research outputs, not just data. There are several providers of these identifiers. Some of the most popular include DOI (Digital Object Identifier) provided by DataCite, Crossref, EIDR (Entertainment Identifier Registry used to keep track of movies & TV shows), KiSTI, mEDRA (multilingual European DOI Registration Agency) and many more. Other types of persistent identifiers for research outputs are Handle and ARK
4. **Research activities:** PIDs for research activities are used to enhance the traceability, reproducibility and replicability of research works. A common identifier for research activities is RAiD. Recently, RAiD integrated its system with DataCite to allow the use of DataCite DOI for research activity identifiers.
5. **Projects and Grants:** Persistent identifiers are also provided to projects and grants. This type of identifier enhances the provenance and traceability of research works and the outputs. DataCite provides Grant ID for grants and projects.

c. Metadata and Open Research Standards

A picture photograph of a small colourful bird with a short beak and sparkling eyes could spark more interest to viewers if we know the date the picture was taken, the location where it was taken, the type of camera used, the person that captured the picture and many more attributes that could help a novice to learn more about the bird, beyond the face value. The additional information about the bird is the metadata of that bird, while the bird is the data. So, metadata is the additional information about any data type. The metadata about the bird could be written in different formats by different persons. For instance, someone may call the location a place, another may call it a position, another may call it a country and other types of identifying a location. This could be confusing and may even constitute more of a problem than solving it if there are no standards for defining the metadata tags. It could be written in different languages, which could further worsen the situation. Hence, the need to have free and accessible standards for metadata that would be universal. This is the reason we are focusing on metadata and open research standards in this section.

Generally, metadata provides a minimum of five (5) mandatory elements. These are: identification, discovery, context, reproducibility and preservation.

- **Identification** ensures objects are provided with unique persistent identifiers (PIDS).
- **Discovery** makes search engines and repositories to find research outputs using sub- elements like title, keyword, author, abstract and so on.
- **Context** uses the ‘wh’ question tags to narrate when, how, why, and who created the object.

- **Reproducibility** keeps the record of the instruments, methods and software version while
- **Preservation** ensures a long-time access to the usability of research outputs.

These 5 elements are the core heart of the FAIR (Findability, Accessibility Interoperability and Reuseability) principle.

Open research standard aligns with the FAIR principle.

Findability relates to how easily researchers can locate relevant research data, code, and information. Key strategies for improving research findability include using unique and persistent identifiers like DOIs andORCID iDs, thus creating rich metadata (descriptive information), and indexing resources in searchable repositories.

Accessibility focuses on use of standard protocols like OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting) is a standard protocol that digital repositories use to share their metadata records through HTTP. It enables services, such as search engines and aggregators, to automatically "harvest" or collect metadata from many different archives, making content more discoverable across the internet. The protocol uses XML over HTTP and requires the Dublin Core metadata format, although other formats may also be supported. Use of APIs (Application Programming Interface, a set of rules and protocols that allow different software programs to communicate and exchange data) as well as an open access policy.

Interoperability involves the use of common vocabularies and schemas. It is the capability for different systems, software, and datasets to exchange, combine, and interpret information with each other, ensuring that the data

retains its essential meaning and is usable across various platforms and for different purposes. This process relies on standardized or common formats for data documentation, including the use of common data elements and unambiguous metadata to remove hindrances in information exchange. This makes collaboration, accuracy as well as reproducibility better.

Reusability encourages clear licensing for all outputs.

Other entities have also attempted to express the same principle in other forms. For instance, W3C PROV which provides a standard for describing provenance, OPEN AIRES Guideline which provides metadata and interoperability standard for repositories in Europe as well as Schema.org/JSON-LD

d. PIDs and Open Research Infrastructure

Now that we have some understanding about PIDs, metadata and open research standards, we need to have a fair knowledge about open research infrastructure. Open research infrastructure refers to sets of technology tools, services, protocols, standards and software contributing to the research lifecycle - from collaboration and experimentation through data collection and storage, data organization, data analysis and computation, authorship, submission, review and annotation, copyediting, publishing, archiving, citation, discovery and more. If we consider the roles of PIDs, which are:

- Provision of identity and attribution to the research community, including the research outputs, research work, research workflow, research organizations, researchers, funders, software, and all

instruments used for research activities to ensure appropriate attributions

- Ensuring provenance and traceability of research workflows and linking the inputs with the outputs. Inputs here refers to all objects and subjects involved in the research activities such as the researchers, instruments, funders, methodologies, and data, while outputs refer to publications, datasets generated, and software.
- Enhancing interoperability by connecting all research activities, tools, and entities involved through the adoption of the FAIR principles that promote open standards, and connecting diverse systems like repositories, funders, publishers, authors and data.
- Promoting reusability of research outputs with appropriate licenses and enhancements of citations, thus improving trust in the research ecosystem.

So, PIDs, inadvertently, cannot be separated from open research infrastructure when we are considering open access. In open access as well as open science, PIDs infrastructures are sustained through open research infrastructures. It means that a DOI will require an open infrastructure for it to be discoverable. In this case, the open infrastructure would be a repository. Open research infrastructure largely relies on community-governed and non-proprietary systems. It is the community-led approach of open infrastructure that makes the associated PIDs acceptable, accessible, trusted, and sustained.

The future of PIDs lies in Linked Open Data (LOD) along with metadata that is driven by AI. The result is a transformation to how research data is discovered, connected, and reused.

e. Policy and Governance for PIDs in African Research

Persistent Identifiers (PIDs) including PIDs for researchers (a common example of this is ORCID), PIDs for publications and datasets (common one includes Handle, DOI, ARK), PIDs for organizations and places (the most common here is ROR), and PIDs for workflows and projects (RAiD is well known for this) are the foundation to trust in the context of interoperability of African research. It is important that institutions and funders make the use of PIDs mandatory requirements throughout the research lifecycle.

PIDs should be provided to grant applications, ethics approvals and workflows, data management plans, repositories, repository deposits, reports, and publications. This enhances reproducibility, traceability, discoverability, supports provenance and attribution, promotes measurable and accurate impact assessment, and removes ambiguity, while promoting a FAIR-compliant open-science ecosystem.

In terms of governance, PIDs adoption and implementation should be a national and cross stakeholder model. The government should encourage national research councils along with higher education commissions to set mandates and incentives while universities and research institutions implement them in repositories. Regional networks like NRENs, and library consortia can provide shared services as well as training while it is expected that global PID providers supply standards and infrastructure. It is a good

idea to establish national or regional PID consortia which could help lower cost barriers, promote local support, and standardise metadata practices. Appropriate policy should be formulated to address privacy and data-protection compliance, equitable participation, and transparent governance followed by appropriate roadmaps and community oversight. Monitoring may use open dashboards to track PIDs coverage, metadata quality, and reuse. If well implemented, the policy and governance measures ensure a measurable, resilient and inclusive PIDs system for African research.

Module 2 Assignment

Task1.
In your own words, define the following terms:
A. Provenance
B. Traceability

Task 2.
In one paragraph, explain the difference between a legacy persistent identifier like ISBN and a modern online identifier like DOI.

Task 3.
In not more than a paragraph while using the example of a website broken link (error 404) as given in this module, explain when a DOI is referred to as being persistent

Further reading for module 2

Project Data Management Planning Michener, William. (2018). Project Data Management Planning. 10.1007/978-3-319-59928-1_2.

Owango, Joy &Ksibi, Nabil. (2025). Introducing Africa PID AllianceEnglish: Implementing PID for Indigenous Knowledge and Cultural Heritage in the Emerging FDO Ecosystem. Open Conference Proceedings. 5. 10.52825/ocp.v5i.1430.

https://doi.org/10.48550/arXiv.2204.114

Module 3: Creating DOIs

Module 3 Forum Discussion

Contribute to the conversation below by following these discussion prompts:

Below is an infographic from Aljazeera. The image captures the winners of Nobel Prize by country. Please note that;

- It mentions only the top countries by continent that have won the prize
- It covers 1901 -2020
- Potential Nobel Prize winners are considered for the quality, depth, and breadth of their research/work OR the impact of their activities.

Haddad, M. (2021, October 8). *Infographic: Nobel prize winners 1901-2021.* Al Jazeera.https://www.aljazeera.com/news/2021/10/7/infographic-nobel-prize-winners-1901-2021

Below are tables of African Nobel Prize winners

Table 1 - Peace Prize Winners

Name	Country	Year	Contribution
Albert Luthuli	South Africa	1960	Anti-apartheid activism
Anwar Sadat	Egypt	1978	Camp David Accords
Desmond Tutu	South Africa	1984	Moral leadership against apartheid
Nelson Mandela	South Africa	1993	Reconciliation and democracy
F. W. de Klerk	South Africa	1993	Ending apartheid
Kofi Annan	Ghana	2001	UN leadership and peacebuilding
Wangari Maathai	Kenya	2004	Environmental activism
Ellen Johnson Sirleaf	Liberia	2011	Women's rights and peacebuilding
Leymah Gbowee	Liberia	2011	Mobilizing women for peace
Tunisian Dialogue Quartet	Tunisia	2015	Democratic transition post-Arab Spring
Denis Mukwege	DR Congo	2018	Advocacy for survivors of sexual violence

Table 2: Literature Prize Winners

Name	Country	Year	Contribution
Wole Soyinka	Nigeria	1986	First Black African Literature laureate
Naguib Mahfouz	Egypt	1988	Arabic literature and social realism
Nadine Gordimer	South Africa	1991	Anti-apartheid literature
J. M. Coetzee	South Africa	2003	Postcolonial themes and humanism
Abdulrazak Gurnah	Tanzania	2021	Colonialism and displacement narratives

Table 3: Science & Medicine

Name	Country	Year	Category	Contribution
Max Theiler	South Africa	1951	Medicine	Yellow fever vaccine
Allan Cormack	South Africa	1979	Medicine	CT scan development
Ahmed Zewail	Egypt	1999	Chemistry	Femtochemistry
Sydney Brenner	South Africa	2002	Medicine	Genetic code and cell lineage

1. *What do you notice from the AlJazeera infographic?*
2. *What struck you most from Tables 1 to 3?*
3. *What role do you think open research infrastructure especially, persistent identifiers can play in bringing more research from Africa to global notice?*
4. *How can your library play a significant role in elevating research from your institution to the global stage?*

**Participation in this group discussion contributes to a percentage of your final grade. Please don't start a new discussion. Rather, answer the question prompts in this discussion forum. Please answer with as much detail as possible. Use this opportunity to engage with your colleagues by replying to*

their responses. One-word contributions and replies will not be counted towards your grade.

Creating DOIs

a. DOIs
b. Understanding Metadata
c. DOI Registration Agencies
d. Who is DataCite?
e. The DataCite Metadata schema
f. DataCite Metadata schema language
g. Why DataCite is suitable for African libraries and other documentary and cultural heritage institutions

3a. DOIs

Digital Object Identifiers (DOIs) are unique names assigned to research outputs and other information resources that are online. They represent an established international information standard, and a growing number of publishers, libraries, and other information providers now use it to identify the resources in their holdings uniquely. Each DOI is accompanied by rich metadata which speaks about the content of the work to which the DOI is assigned, who published it and the license under which it is made available.

"DOIs are actionable on the Internet: when put in URL form (http://dx.doi.org/{DOI}), these strings automatically redirect to an online landing page that offers information about the research object. Sometimes, the landing page contains a link to the resource itself. Where the resource is not online, the landing page indicates where to find it. For example, a DOI assigned to a physical resource such as a print book, a museum specimen, or

a scientific sample will specify the repository or collection where the resource resides." CODATA-RDA

Resources that are assigned DOIs tend to be more discoverable and are likely to be used and cited by others. This is because the identifier is persistent as it is maintained and preserved even when the URL of the content it identifies changes. It is said that the DOI is basically a guarantee to always supply information about the knowledge resource associated with it. However, it should be noted that not every knowledge resource that has a DOI is Open Access as this depends on the restrictions and licenses put in place by the creator/author or owner of the resource.

In registering or minting a DOI, the metadata is included. This is critical and each DOI Registration Agency (DataCite, CrossRef etc) has totally different metadata schemas with mandatory and optional data elements.

3b. More about Metadata

Metadata is data about data. It describes or provides information about other data so that the data can be better understood, managed, or discovered thus transforming raw data into usable, searchable and meaningful knowledge. A standardized metadata framework makes data discoverable as such a framework ensures that metadata is machine-readable, and can be used to search and find data through interoperability. Also, it supports preservation, reuse, scholarly integrity and accountability in research through DOIs.

- Metadata can be **Descriptive** when it provides information such as the title, author, subject and keywords of a knowledge resource for making content visible and retrievable.

- It can be regarded as **Structural** when it defines how components relate, for example, chapters in a thesis, and tables in a dataset. This is vital for repositories handling complex research outputs or multilingual collections. It supports version control, and logical grouping.

- Metadata can also be **Administrative** when it includes the origin, creation date, rights, file format, and lifecycle of a resource thereby ensuring long-term accessibility and integrity, even as technologies evolve. This is the key to ethical stewardship for indigenous knowledge and digitized archives.

- Also, Metadata can be **Technical** when it includes details about how data was created or encoded, software version of a methodology used etc. A standardized metadata schema, such as Dublin Core, Crossref, and DataCite, includes all these aspects.

Within the African context, metadata can be a pathway for knowledge equity. It can be used by libraries, repositories, archives and museums to 'localize' cataloguing by adding descriptions that highlight hitherto unacknowledged knowledge systems.

3c. DOI Registration Agencies DOI minting is managed by Registration Agencies (RA) authorized by the International DOI Foundation which is the international, not-for-profit organization that oversees the global framework for DOIs that identify and manage digital content permanently and reliably. The Foundation maintains the DOIsystem with the ISO standard: ISO 26324:2022 (Information/documentation Digital Object Identifier System) which is recognized globally in publishing, knowledge, data management,

and open science infrastructures. It also provides the technical infrastructure for resolving DOIs to URLs or metadata and defines standardized metadata frameworks for describing digital objects. Importantly, the DOI Foundation has members known as Registration Agencies (RAs).

These are the organizations authorized to assign DOIs and manage metadata for their user communities. These agencies pay membership fees and have representation in the DOI Foundation's governance. Most of the RAs serve a specific sector or geographic region while others provide services globally for their user communities. Also, each agency serves specific sectors or content types, offering tailored metadata services and infrastructure. Here are some of the major RAs, their areas of focus and the communities that they serve.

Major DOI Registration Agencies

Agency	Focus Area	Ideal For
Crossref	Scholarly publishing (journals, books, proceedings)	Publishers, academic journals, societies
DataCite	Research data, articles, books, theses, software, grey literature	Repositories, libraries, research institutions, archives, and museums
mEDRA	Multilingual European content	European publishers and institutions
JaLC	Japanese academic content	Japanese universities and publishers
EIDR (Entertainment Identifier Registry)	Film, TV, and entertainment metadata	Global (media and entertainment industry)
OP (Publications Office of the EU)	Official EU publications and documents	European Union
BSI Identify	Standards and technical documentation	United Kingdom
CNKI	Chinese scientific and technical content	Chinese research organizations
KISTI	Korean scientific information	Korean institutions and repositories
ISTIC	Chinese technical standards and publications	Governmental and technical bodies
Airiti	Chinese-language academic publishing	Asian publishers and research platforms

Crossref and DataCite are considered to be among the top-tier Registration Agencies under the International DOI Foundation. They have distinct strengths and serve different communities and purposes within the scholarly communication ecosystem. Here is a tabular presentation of their features.

Major features of DataCite and Crossref

Feature	DataCite	Crossref
Primary Audience	Repositories, libraries, archives, universities, archives, museums, research institutions	Publishers, Journals, scholarly societies
Content types	Research outputs including Datasets, Reports, Articles, books, theses, software, images, grey literature	Journal articles, books, conference papers, reports
Mission	Make all research data, outputs(journal articles, books etc) persistently accessible, citable and usable	Provide persistent linking and citation infrastructure for traditional research publications/scholarly content
Metadata depth	Rich support for research data, including geolocation, funding, translation and relations	Strong focus on citation metadata, contributor roles (CRediT), and versioning
Identifier Support	ORCID, ROR, ISNI, Wikidata	ORCID, ROR, ISNI, Wikidata
DOI Registration	Yes	Yes
Citation tracking	Robust	More robust
APIs & Integration	REST API, Fabrica, Metadata Store	REST API, Metadata Search, Crossmark, Similarity Check
Membership	Institutional, often via consortia	Publisher-based, with tiered pricing

The two RAs are complementary. For Crossref, a publisher assigns DOIs to journal articles so that citations are trackable across publishing houses. Crossref is most suitable for organizations whose primary focus is publishing scholarly articles, books, or conference proceedings, and those seeking citation tracking and publishing infrastructure.

It is most useful for supporting scholarly publishing and robust citation metrics. For DataCite, a repository or a library assigns DOIs to datasets, research outputs, theses, indigenous knowledge etc, to make them citable and discoverable. Nevertheless, the two RAs collaborate closely to link data and publications through the Scholi (Scholarly Link Exchange) initiative, and exchange metadata metadata through APIs, and common DOI infrastructure and resolver.

d. **Who is DataCite?**

DataCite is a global not-for-profit organization that provides open infrastructure to support the identification, citation, discovery, and reuse of research outputs. It was founded in late 2009 by organizations from six countries (including the British Library, California Digital Library, the National Research Council of Canada, TU Delft, TIB Germany, etc.). It is a DOI registration Agency that provides persistent identifiers (DOIs) and accompanying metadata framework for research outputs including datasets, theses, software, grey literature, and other non-traditional scholarly materials.

Published articles, reports and books have been used for communicating research findings research for centuries. Nonetheless, they provide only a fraction of the information required to fully understand, evaluate or reproduce findings for sustainable innovations or discoveries. The UNESCO Open Science Recommendation supports open science infrastructure that promotes access to the underlying information of research, as well as the mechanisms to connect research design, data, and the analytical tools that are used to generate reported outcomes of research with the main purpose of evaluating, replicating and/or building on research for sustainable development. DataCite provides persistent identifiers, specifically Digital

Object Identifiers (DOIs), for research data and other research outputs. Its primary goal is to make outputs from the entire research cycle more discoverable, citable, and reusable by helping the research community locate and identify them with confidence. DataCite services and tools include a rich and extensible metadata schema, a Commons which is a discovery portal for exploring registered research outputs, Fabrica for managing DOIs and metadata and APIs for integration with platforms including ORCID, ROR and WIkidata.

DataCite is also a global community with members such as libraries, data centres, people and organizations that support the research lifecycle, and researchers who have come together as a network to shape, share and promote open research.

e. The DataCite Metadata Schema

The Schema is a comprehensive framework for describing and citing research outputs, especially non-traditional like datasets, theses, software, and cultural materials. It is a structured set of metadata properties used to register DOIs (Digital Object Identifiers) for research outputs**.** The schemadefines a broad set of properties that are used to describe research outputs when minting DOIs. These properties which are grouped within 3 levels of obligation are generic and tailored to fit every discipline.

- **Mandatory properties:** These are essential for creating a valid DOI record that uniquely identifies and makes a resource to be properly

attributed, and discoverable. They five core fields are; Identifier, Creator, Title, Publisher, PublicationYear

- **Recommended properties** are not strictly required for DOI registration, but they're strongly encouraged to improve discoverability, interoperability, and citation quality. For African libraries and repositories, these fields are especially useful for representing diverse knowledge outputs with rich context. They include Subject, Contributor, Date, Language, Resource Type, Alternate Identifier, Related Identifier, Size, Format, Version, Rights, Description (abstract, summary)
- **Optional properties** are those that enrich the metadata record but are not required for DOI registration. These fields allow institutions—especially libraries and repositories—to add contextual depth, interoperability**,** and cultural relevance to their records. These properties include geolocation that can help situate indigenous knowledge or community-based research, funding reference, related item for rich linking between theses, datasets, translations, and oral histories, size, version, event, and custom attribute which can be used to include local vocabularies, language codes, or cultural tags among others

For African libraries, repositories, and knowledge institutions, the DataCite schema offers a unique opportunity to represent diverse knowledge systems in a globally interoperable way.

f. Markup language for DataCite schema

In creating metadata that accompany a DOI, markup languages are used. DataCite uses XML and JSON. XML, or Extensible Markup Language, is a markup language that defines rules for encoding documents in a format that is both human-readable and machine-readable. It is used to store, transmit, and reconstruct data, and unlike languages like HTML, it does not have predefined tags; instead, you define your own tags to describe the data. It is text-based and self-descriptive. This makes it flexible for exchanging data between different applications, systems, and platforms. XML supports a hierarchical data structure, which is useful for representing complex relationships in data.

This is an example;

<book>

<title>Voices Are Power</title>

<author>Johnson Asagba</author>

<year>2021</year>

<publisher>Public Libraries Online</publisher>

</book>

JSON (JavaScript Object Notation), is a human-readable, and text-based format for storing and exchanging data. It is widely used to transmit data between a server and a client and is built on two universal data structures: collections of name/value pairs (objects) and ordered lists of values (arrays). It is less verbose than formats like XML, as it does not require end tags. It is

supported by many programming languages, simplifying data exchange between different systems and platforms.

JSON is built on two core structures:

·**Objects**: Collections of key-value pairs, wrapped in { }

·**Arrays**: Ordered lists of values, wrapped in [ ]

Here's a simple example

```
{
  "name": "Noelita",
  "role": "Administrator",
  "interests": ["Open science", "Wikidata", "Knowledge equity"]
}
```

JSON is especially useful for structuring **metadata** for DOIs, digital repositories, and linked data and interfacing with APIs (like ORCID, DataCite, or Wikidata). We will learn this more as African libraries get signed on to DataCite.

g. **Why DataCite Is suitable for African Libraries and other documentary and cultural heritage institutions**

DataCite is considered ideal for institutions managing research, research data, digital archives, or open repositories, especially those focused on preservation and accessibility such as libraries that seek to strengthen the research visibility of their parent institutions and play definitive roles in entrenching Open Science. It can be integrated into the cataloguing, and preservation workflows of libraries/Institutional Repositories or museums. It is inclusive as it offers more flexibility for non-traditional scholarly content.

Much of Africa's scholarly and research output, particularly datasets, theses, reports, and institutional publications are largely underrepresented in global discovery systems due to limited use of persistent identifiers (PIDs) such as DOIs (Digital Object Identifiers). DataCite can provide the infrastructure and standards to make research data and other scholarly resources findable, accessible, interoperable, and reusable (FAIR) as its services and tools are deeply aligned with UNESCO's Open Science Recommendation (2021). Libraries can use DataCite to assign DOIs to datasets, theses, grey literature, and institutional outputs, to ensure global findability and long-term access.

Most African universities already have repositories (often on DSpace, EPrints, or Invenio). These platforms can easily integrate with DataCite's APIs or Fabrica interface to mint DOIs for theses and dissertations, research data and project outputs, institutional reports, policy briefs, and conference papers. DOIs from DataCite make repository content discoverable globally (e.g., in DataCite Commons, OpenAIRE, and Google Scholar).

DataCite's schema supports;

-Multilingual metadata

-Geolocation and coverage dates

-Relations between objects (e.g., thesis → dataset → publication)

-Integration with ORCID, ROR, and Wikidata

This makes it easier for African libraries to build interoperable, linked open data ecosystems.

Unlike Crossref, which is mostly publisher-driven, DataCite's model fits libraries, and repositories. It integrates seamlessly with platforms such as **DSpace, Invenio,** and custom-built repositories using **REST APIs,** and semantic web tools. This empowers libraries, to serve as local DOI service points within universities or consortia as they manage metadata, assign DOIs, and train lecturers and researchers. It also builds local capacity while giving libraries a central role in minting DOIs locally**,** maintaining control over their metadata, and generally, being key professionals in research data management (RDM).

DataCite allows for consortial membership, as a regional body such as AfLIA can become a consortium lead with National library Associations as members. Libraries as member institutions at the national level could then register DOIs through that consortium, often at reduced prices cost and with shared technical support. Furthermore, DataCite offers free or low-cost training, technical support, and community-building along with its membership. This will ensure that African librarians learn not just how to mint and use DOIS, but also become co-creators of global open infrastructure.

Again, DOIs ensure that even if a repository moves servers or changes URLs, the persistent identifier remains valid. This increases trust for African research.

DataCite Commons also offers metrics and discovery tools, which help measure impact and demonstrate institutional visibility for global rankings.

Module 3 Assignment

Part 1: Metadata Mapping Exercise

Choose **three** of the following resource types:

- A postgraduate thesis from your institution
- An oral history recording in a local language
- A digitized archival photograph
- A dataset on indigenous medicinal plants

For each resource:

1. Identify appropriate metadata elements using the **DataCite schema** (found here: DataCite Metadata Schema Documentation
2. Draft a metadata record (minimum 10 fields) including:
    - Title, Creator, Subject, Description, Date, Language, Format, Rights, Identifier, Coverage
3. Reflect and make notes of not more than 200 words on:
    - Which fields were challenging to populate and why
    - How cultural context influenced your metadata choices

Part 2: Metadata Policy Brief

Write a 1–2 page policy brief for your library leadership proposing a **metadata strategy** that:

- Advocates for the use of persistent identifiers (e.g., DOIs via DataCite)
- Promotes multilingual and culturally sensitive metadata

- Aligns with **FAIR principles** and **knowledge equity**
- Suggests training or capacity-building initiatives for staff

Further reading

https://groups.niso.org/higherlogic/ws/public/download/17446/Understanding%20Metadata.pdf

https://www.doi.org/

https://www.doi.org/the-community/existing-registration-agencies/

https://www.crossref.org/community/datacite/DOI

https://info-africarxiv.ubuntunet.net/datacite-pid-infrastructure-in-africa/

Module 4 - Responsible AI and open research infrastructure

Module 4 Discussion Forum

- Where do you see AI already affecting discovery, cataloguing/metadata, research evaluation, or student services? Identify one potential risk (e.g., bias, privacy leakage, explainability) and one benefit.
- How can African libraries participate in implementing continental and national frameworks (e.g., AU data/AI initiatives, national data-protection laws) and the UNESCO Recommendation on the Ethics of AI (2021)? https://unesdoc.unesco.org/ark:/48223/pf0000381137

**Participation in this group discussion contributes to a percentage of your final grade. Please don't start a new discussion. Rather, answer the question prompts in this discussion forum. Please answer with as much detail as possible. Use this opportunity to engage with your colleagues by replying to their responses. One-word contributions and replies will not be counted towards your grade.*

Responsible AI & Open Research Infrastructure

- Roles of Libraries and Information Professionals in Responsible AI
- Intersection of Responsible AI and Open Research Infrastructure
- FAIR data and ethical stewardship in the age of AI
- DataCite and Responsible/Ethical AI Ecosystem
- Policy, Advocacy, and Community Engagement
- Future Trend and Action Planning

Introduction to Responsible AI

According to IBM, Responsible AI (RAI) involves the consideration of a broader societal impact of AI systems and the measures required to align these technologies with stakeholder values, legal standards and ethical principles. Research discovery, curation, evaluation, teaching and reuse are being reshaped today by Artificial Intelligence (AI).

The alignment of Artificial Intelligence (AI) systems with stakeholder values, legal standards, and ethical principles, including safety, fairness, privacy, transparency, accountability, human oversight, and environmental stewardship is called Responsible AI (RAI). Open research infrastructure (ORI) such as repositories, persistent identifiers (PIDs), shared metadata schemas, and open Application Programmable Interfaces (APIs) provides the provenance, attribution, and interoperability needed to make AI enabled research trustworthy, visible, and reusable in open science.

Africa has diverse research systems spanning bandwidth constrained campuses, rapidly digitising universities as well as world class labs. Libraries in Africa can bridge these contexts by providing shared services, common metadata practice, and multilingual support so that outputs from any region can be findable, attributable and reusable. Open research infrastructure (ORI) ensures local control over data while connecting to global knowledge networks.

Module aim. Equip library and information professionals to embed RAI into everyday services while leveraging PIDs—ORCID iDs (people), DOIs (datasets, software, articles), ROR IDs (organisations and places), RAiDs (projects and workflows) to express machinereadable lineage from data, software/model, publications to policy and practice.

Why libraries?

Libraries and information services are at the core of trust in research and knowledge stewardship. Beyond access provision, they design and run repositories, data services, and policy workflows that ensure openness with integrity.

Core service catalogue.

- Repository & CRIS operations: mandate PIDs at deposit (ORCID sign in; DOIs for datasets/software; ROR affiliations; RAiD for projects); enforce versioning; maintain landing pages with rights/licences.
- Data & metadata governance: Libraries curate all research ecosystem documentation including methods, instruments, ethics approvals, licence selection, consent language, retention & deletion timeline. They also coordinate Data Access Committees (DACs) for controlled data access.
- Algorithm transparency: Libraries maintain an algorithm register for AI used in discovery, analytics, chatbots, or student services which include purpose, data sources, limitations, human oversight, and feedback channels.
- Training & literacy: RAI awareness; Datasheets for Datasets and Model Cards; PID onboarding; DMP support; multilingual materials.

- Procurement & due diligence: require transparency on training data and model lineage; privacy/security controls; audit rights; exit strategies and interoperability with PIDs.

Maturity roadmap (quick).

1. Foundational: repository exists; start collecting ORCID iDs; pilot dataset DOIs.

2. Developing: ROR normalisation; software DOIs; relations (IsDerivedFrom, Cites); basic algorithm register.

3. Advanced: DAC in place; full PID graph coverage; RAI policy; dashboards for PID coverage & metadata quality; regular audits and red-teaming for higher-risk AI tools.

Skills compass - Metadata & identifiers, licensing & data-protection basics, API literacy, stakeholder engagement, and bilingual/multilingual outreach.

2. Intersection of Responsible AI and Open Research Infrastructure

Provenance & accountability. PIDs and relations (e.g., IsDerivedFrom, IsSupplementTo, IsVersionOf, Cites) make machine readable chains connecting datasets, software/models, articles, contributors, funders, and institutions.

RAI by design workflow (libraryled).

1. Plan: in DMPs, commit to PIDs, licences, consent, and access governance; identify sensitive/community data.

2. Collect: document methods, sampling, instruments, bias risks; assign ORCIDs to contributors.

3. Curate: deposit data/software with DOIs; add ROR affiliations; add related Identifiers to link inputs/outputs and versions.

4. Disclose: create Datasheets and Model Cards; register algorithms used in services.

5. Govern: run DACs where needed; monitor usage; maintain de-identification guidance; refresh licences as contexts change.

6. Evidence: publish PID-graph-driven dashboards to show lineage, reuse, and funding links—support assessment without tracking individuals.

Example scenario. Repository chatbot suggests theses and datasets. The library's algorithm register lists model type, training data sources, known limitations, and human review steps; repository records show dataset/software DOIs and Cites relations from these.

3. FAIR/CARE stewardship for AI data and models

FAIR in practice.

- Findable: rich metadata; DOIs; ORCID/ROR/RAiD links; keywords and discipline vocabularies.
- Accessible: stable landing pages; clear access statements; protocols for controlled data.
- Interoperable: community schemas (DataCite, CodeMeta), open formats, multilingual abstracts/keywords.
- Reusable: explicit licence (CC BY/CC0 or restricted); detailed methods; provenance via related Identifiers; limitations documented.

CARE in practice.

- Collective Benefit: articulate societal value; support local reuse.
- Authority to Control: respect community governance; consult community representatives.
- Responsibility: mitigate misuse; publish contact points and takedown paths.
- Ethics: consent for secondary use; cultural privacy; avoid extractive data practices.

Licensing choices. Prefer open licences when safe; for sensitive datasets, use restricted licences with DAC approval, usage logging, and time-bound access.

Access governance models. Open · embargoed · registered access · safe-haven/secure enclave. Libraries document the model and the approval workflow.

Quick template prompts. Datasheets: Motivation · Composition · Collection Process · Pre-processing · Uses/Misuses · Distribution · Maintenance. Model Cards: Intended Use · Factors · Metrics · Ethical Considerations · Caveats.

4. DataCite and the ethical AI ecosystem

Implementing DOIs (step by step).

1. Enable creation of DOI for datasets, all publications, artifacts, and software (through a consortium or repository platform).

2. Capture, at least, minimum metadata (title, creators with ORCID, publisher/repository, publication year, resource type) and recommended metadata (contributors/roles, funding, rights/licence, methods, geocoverage, language, descriptions).

3. Add relatedIdentifiers: dataset ↔ software (e.g., software IsDerivedFrom dataset); article/preprint Cites dataset/software; new versions use IsNewVersionOf/IsPreviousVersionOf.

4. Ensure landing pages resolve, contain machine-readable metadata, and include contact and rights statements.

Integration patterns. ORCID OAuth for sign-in and claim; ROR normalisation of affiliations; RAiD where project tracking exists; export APIs for national portals.

Why this matters for RAI. Provenance reduces ambiguity, supports audit and reproducibility, and enables fair credit across multi-country collaborations.

5. Policy, advocacy, and community engagement

Below are sample policy clauses that could strengthen Responsible AI (RAI) in institutions.

Model policy clauses (samples).

- PID mandate: “All deposits must include ORCID for contributors, ROR for affiliations, and a DOI for datasets/software where applicable.”
- Provenance: “Deposits must include relatedIdentifiers expressing derivations, versions, and citations.”
- RAI safeguards: “AI deployments that influence discovery, ranking, analytics, or user support must be registered in the algorithm register with model/data lineage, limitations, oversight steps, and a contact point.”

- Access governance: “Sensitive data require an access model (registered/DAC/enclave) with documented approvals and retention/deletion schedules.”

Procurement checklist (AI tools). May include:

- Model transparency,
- training-data sources,
- security & privacy controls,
- logging/audit access,
- interoperability (export, PIDs),
- localisation (language support), and
- exit strategy.

Governance setup. Establish an AI/Data Governance Board (library, research office, IT, legal, ethics, community rep where relevant); publish minutes and change logs; run annual reviews and red-team exercises for higher-risk tools.

Metrics & dashboards. PID coverage; % records with licences/funding/relations; number of datasets/software with DOIs; ORCID adoption; DAC turnaround; algorithm-register entries; reuse indicators (citations, links in policy/clinical/education outputs).

Module 4 Assignment

1. Prepare an 8-slide presentation covering ANY of the following topics:

    a. What responsible AI means in the context of libraries and how librarians can act as stewards of AI adoption in research and education.
    OR

b. Highlight the unique role of librarians as mediators between technology, researchers, and the public

OR

2. Select one scenario (e.g., AI search, AI-powered cataloguing, plagiarism detection tools, or predictive analytics in library services) and prepare a maximum of 8-slide presentation to;

a. Describe the AI-enabled technology and its intended use

b. Identify potential risks (bias, privacy concerns, exclusion)

c. Suggest mitigation strategies that librarians could implement

Further reading for Module 4

- CARE Principles for Indigenous Data Governance - https://www.gida-global.org/care
- DataCite Metadata Schema & guidance - https://schema.datacite.org/ (schema site) and https://support.datacite.org/docs/datacite-metadata-schema (docs)
- Datasheets for Datasets (paper & template): https://arxiv.org/abs/1803.09010arXiv
- FAIR Principles (GO FAIR) - https://www.go-fair.org/fair-principles/
- Model Cards (guides/examples): https://modelcards.withgoogle.com(guide) and the paper: https://arxiv.org/abs/1810.03993Google Model Cards+1
- Open Infrastructure (reference hub): https://openscience.cern/infrastructure
- ORCID (people IDs): https://orcid.org/ORCID

- Research Organization Registry (ROR): https://ror.orgResearch Organization Registry (ROR)
- RAiD (Research Activity Identifier): https://raid.org(overview) and https://raid.org/what-is-raid (what is RAiD).Raid+1
- UNESCO Recommendation on the Ethics of AI (2021) (https://www.unesco.org/en/articles/recommendation-ethics-artificial-intelligence(official overview). PDF: https://unesdoc.unesco.org/ark:/48223/pf0000381137)
- UNESCO Open Science Recommendation (2021) - https://www.unesco.org/en/open-science/about
- WACEN: https://wacren.net/en/news/libsense-develops-a-roadmap-for-implementing-persistent-identifiers-in-africa-re-ecosystem/

Module 5 - Actionable steps to join DataCite community

Forum Discussion

1. What differences did you note between the DataCite schema and the regular cataloguing and classification of digital materials in your library?
2. Do you see the DataCite schemas being robust enough for your collections? Do you envisage it serving as a digital assets register?

**Participation in this group discussion contributes to a percentage of your final grade. Please don't start a new discussion. Rather, answer the question prompts in this discussion forum. Please answer with as much detail as possible. Use this opportunity to engage with your colleagues by replying to their responses. One-word contributions and replies will not be counted towards your grade.*

Understanding DataCite Membership

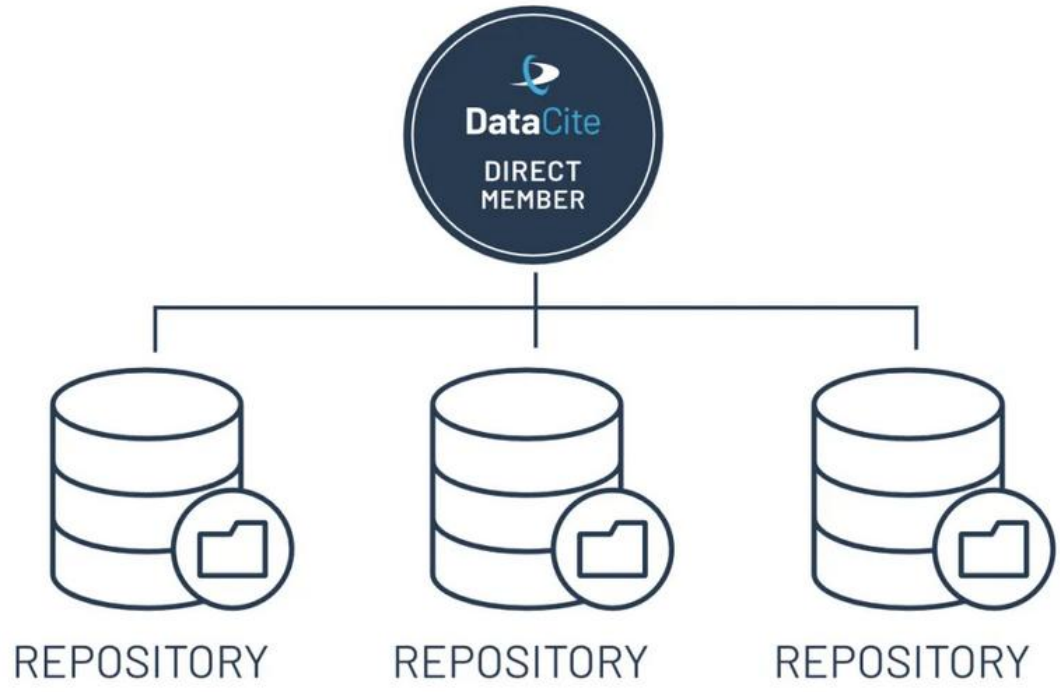
a. Membership options
    I. Direct membership vs. joining through a consortium
    ii. African-friendly models: national and regional consortia
    iii. Realistic paths based on institutional size and resources
b. How to get started: Step-by step
c. Low-cost and Low-code solutions
    I. How small or under-resourced institutions can participate
    ii. Using existing repositories, platforms, or partners
    iii. Service providers and support options
d. What happens after joining?Growing in the community
e. success stories of African institutions that adopted DataCite DOI Infrastructure:
    I. Busitema University, Uganda
    ii. CUT, Zimbabwe
    iii. South Africa

iv. IITA, Nigeria (Pan Africa)
v. Mekelle University, Ethiopia

A. Membership options

DataCite is global community that shares a common interest: to ensure that research outputs and resources are openly available and connected so that their reuse can advance knowledge across and between disciplines, now and in the future. As introduced in module 3 of this course, DataCite is a membership governed organization. The organization has different membership types. These are:

I. Direct Member - This type of member supports DataCite's mission and is an organization that works with one or more repositories within their organization. The repositories are under the same administrative structure as the organization.



Ii. Consortium Lead - A consortium is a group of like-minded organizations that have come together to collectively participate in DataCite's community and governance activities and use DataCite's DOI services. Consortia are generally located in a single country or subject-based. Organizations within a consortium can work with one or more repositories. The consortium lead serves as the voting member for this membership type and it represents the interest of the consortium within DataCite.

The guidelines for consortium membership are detailed below:

A consortium is composed of five or more organizations that are under different administrative structures.

- Consortia should consist of a minimum of five organizations, including the consortium lead. New consortia are expected to reach this number in one year.
- All future Consortium Organizations should either be within one geographic region OR subject area.
- One organization within the consortium is designated the Consortium Lead and fulfills a range of responsibilities.
- Consortium Leads can distribute costs across the Consortium Organizations as per their own policies and structures.

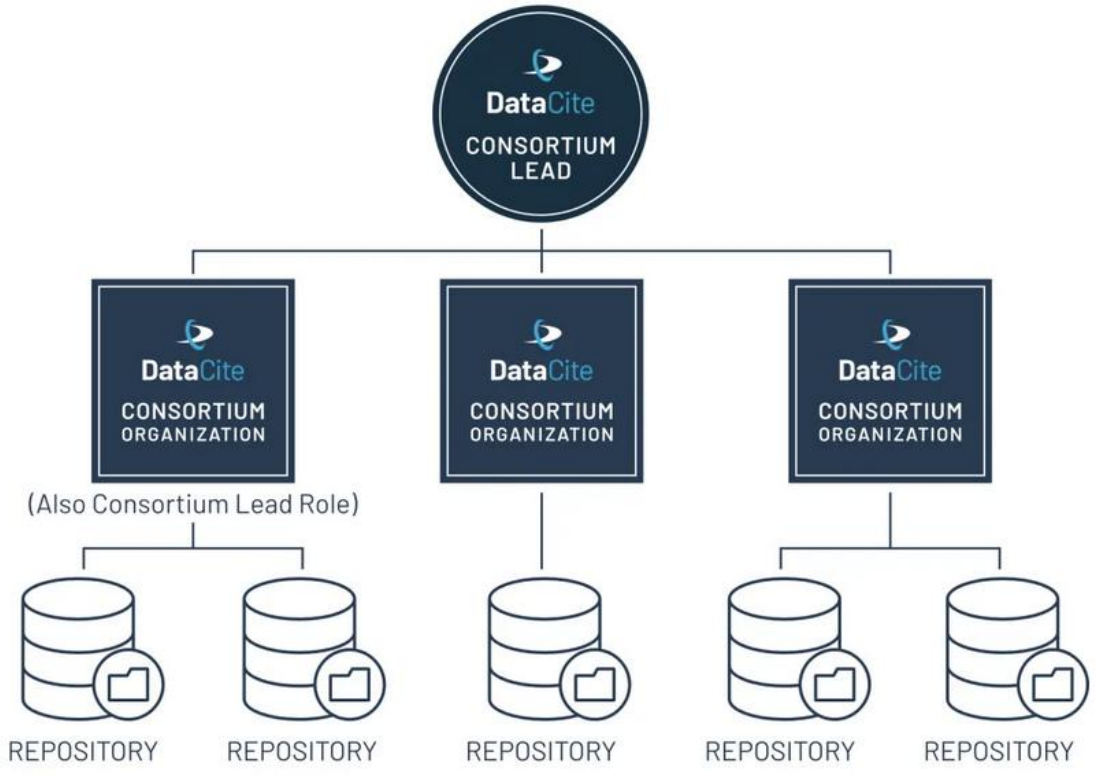


Diagram of consortium membership

Iii. This type of member supports DataCite's mission and wants to collaborate with DataCite and/or be part of DataCite's governance. This member does not register DOI.

a. Fee Model

Membership Fee

DataCite's strength is rooted in its active membership. DataCite's global community of members includes data centers, libraries, government agencies, research institutions and more. Members are the voting body of the organization and establish the vision and strategy, set the fee structure, and

vote or stand for theExecutive Board. Membership is open to all organizations that share DataCite's research sharing mission. Membership fees support DataCite's goal to enable the discovery and reuse of research outputs in a global transition to Open Science.

Annual Membership Fee: 2.000€

This fee applies to Direct Members, to a Consortium as a whole, and to Supporting Member organizations.

Service Fees

DataCite's DOI Services are available to members for an additional service fee. Our robust infrastructure provides a simple and effective method of DOI creation and management; thereby enabling discovery, access, sharing, tracking, and citation. DataCite's user-facing services: indexed content, help-desk, support site, and a metadata schema – support a range of diverse content types (data, text, images, software, samples, and more).

Each Direct Member or Consortium Organization that makes use of DOI registration services will pay an annual service fee. This fee consists of two components: an ***Organization Fee*** and a tier-based ***DOI Fee***.

Organization Fee

The organization fee for non-profit organizations is **500€ per year**. This fee includes all the repositories and prefixes needed by an organization to follow best practices.

DOI Fee

There are several tiers for the number of new DOIs registered annually. The tiers accommodate different types of organizations and align with the cost impact. The DOI fee is based on the total number of DOIs registered in the previous calendar year across all repositories of an organization. In the first year the DOI fee is based on an estimate of DOIs the organization is planning to register from the start date until December 31st.

Annual DOI range	Tier	Organization Fee	DOI Fee	Annual Service Fee
0 – 1.999	Tier 1	500€	0,80€ per DOI	500€ + 0,80€ per DOI
2.000 – 10.000	Tier 2	500€	1.600€	2.100€
10.001 – 100.000	Tier 3	500€	2.500€	3.000€
100.001 – 250.000	Tier 4	500€	3.500€	4.000€
250.001 – 1.000.000	Tier 5	500€	8.500€	9.000€
1.000.001 – 2.000.000	Tier 6	500€	13.000€	13.500€
2.000.001 – 5.000.000	Tier 7	500€	18.500€	19.000€
5.000.001 – 10.000.000	Tier 8	500€	25.500€	26.000€

b. Membership options

DataCite membership comes at a fee. The fee model and membership type are determined by DataCite existing members annually.

I. Direct membership vs. joining through a consortium

Direct members pays membership fee, and the service fee. Recall that the service fee has two components, the organization fee and the cost of the DOI created but cannot have any member under it. A consortium lead also pays the same fees as the direct member. However, a consortium lead can have

consortium members under its structure. A consortium member is a unique institution or entity which is managed by a consortium lead. All the described membership types have the ability to create unlimited repositories and DOIs.

The table below summarizes the various membership type and fee model.

Membership Type	**Direct**	**Consortium**	
Description		**Consortium Lead**	**Consortium Member**
Membership Fee	✓	✓	✗
Organizational Fee	✓	✓	✓
Have sub-members	✗	✓	✗
Tiered- DOI fee/create unlimited DOI	✓	✓	✓
Create unlimited Repositories	✓	✓	✓
Participate in DataCite Governance	✓	✓	✗

Table showing the summary of DataCite membership and fee models

ii. African-friendly models: national and regional consortia

Considering the membership models described earlier, the consortium membership type is friendlier for national and regional entities. It allows nationals or regional associations the opportunity to be a DataCite member with each member institution having the potentials of creating as many repositories needed as possible. This model also promotes cost-sharing, collaborative governance as well as customised support that address common challenges within African institutions like limited funding, unequal

institutional capacity for technical, infrastructure and resource management as well as promoting regional relevant open science infrastructure.The model encourages the pooling of resources and encourages smaller organisations to access DOI services without incurring the full financial burden.

iii. Realistic paths based on institutional size and resources

To ensure equitable participation of African research communities in the global open science community, a realistic pathway that will cover challenges like cost and funding, staff capacity, infrastructure availability and technical capacity is recommended. That model is the consortium model.

b. How to get started: Step-by step

Becoming a DataCite member requires structured process for intending institutions with adequate planning. For AfLIA members, we will consider the consortium path. The steps below highlights the important steps to follow.

- Need assessment: Conduct a need assessment for DOI by your institution. Identify the type of research outputs generated by your institutions such as dataset, journals, theses, dissertations, artifacts, designs among others. Review DataCite mission against your institutions mission for research outputs and data sovereignty.
- Decide membership type: Decide the best type of membership that suits your institution, whether direct, consortium lead or consortium organisation. For consortium organisation, you have to join an existing consortium lead.

- For Consortium Lead, Complete Inquiry form. Reach out to support@datacite.org for further inquiry about the form
- For consortium member, reach out to the consortium for legal documentation. This document will be provided by the consortium lead. IN most cases, it mimics the type of agreement the consortium lead has with DataCite. However, it is not uncommon for consortia to had their regional or need specific conditions in agreements.
- Signing of agreement: There must be a sign-off by both parties and invoice to kick off the membership.
- Notification period: DataCite notifies all her voting members about a new intending member. The notification period is 30 days during which members are allowed to express their willingness or concern (this rarely happen) for the new intending member to be part of DataCite as a member.
- Account set up: Once the invoice has been paid and the 30 days notification is over and the new member has been approved by the DataCite members, the account is setup in DataCite's Fabrica. Fabrica is the name of DataCite's DOI system.
- Onboarding: A formal onboarding process is organised for the new member. DataCite staff will reach out to formally welcome the new member and go through a series of onboarding activities including indepth introduction to DataCite tools and services, how to access various APIs, integrations systems, dashboards for reports, creating DOI and other relevant knowledge needed to maximise DataCite tools, services and community engagements.

- Capacity building: New members will be able to access various training programmes organised by DataCite. They will also be able to participate in certification programmes with a globally recognised certificate. Members will keep getting invites to attend various DataCite physical and online events to promote community engagements, networking and collaborations among members.
- Monitor and report: It is important to monitor the new system and ensure DOI and associated metadata are created correctly. Reports on DOI visibility for any research output, including downloads,citations, views and many more, can be accessed for further actions.

c. Low-cost and Low-code solutions

DataCite offers lower entry point for institutions with limited funding and technical capability.

I. How small or under-resourced institutions can participate - Organisations with funding and technical concerns can join DataCite through the consortium organisation model. The organisation becomes a member under a consortium lead. For instance, if there are 10 small organisations that cannot afford to be direct members, they can form a consortium and share the annual 2,000 euro while each pay their respective cost of DOI created and a 500 euro organisation fee.

ii. Using existing repositories, platforms, or partners - For small institutions that cannot afford a membership, Zenodo may be an option. Zenodo (by CERN) is an open repository based in Europe. Institutions and individuals can register and deposit their research

outputs in the repository at no cost. Free DOIs are provided for the deposited research outputs. AfricArvix or OSf (Open Science Framework) offer free preprints deposition while Figshare allows free individual account but some fees for institutions.

d. What happens after joining? Growing in the community

DataCite members can join various groups within the DataCite community such as Community Engagement Steering Group (CESG), Services and Technology Steering Group (STSG), Regional Expert Group, Metadata Working Group, and Harvesters Interest Group. This allows members to contribute and share regional concerns that would help build a more robust and listening community. Members can participate in various DataCite Connect, meetings, conferences, initiatives and trainings. Members can track metrics to see the impact of their research outputs using DataCite Commons

e. success stories of African institutions that adopted DataCite DOI Infrastructure

The case studies in this sections highlight how various institutions across Africa adopted DataCite DOI

I. **Busitema University, Uganda**

Busitema University is a multi- campus university based in Uganda. The institution is a beneficiary of DataCite's Global Access Fund (GAF) in 2024. The institution joined DataCite and integrated their repositories with DataCite's DOI infrastructure. The institution uploaded 471 various research outputs and had 47 citations within a year with more than 840 views and over 325 downloads.

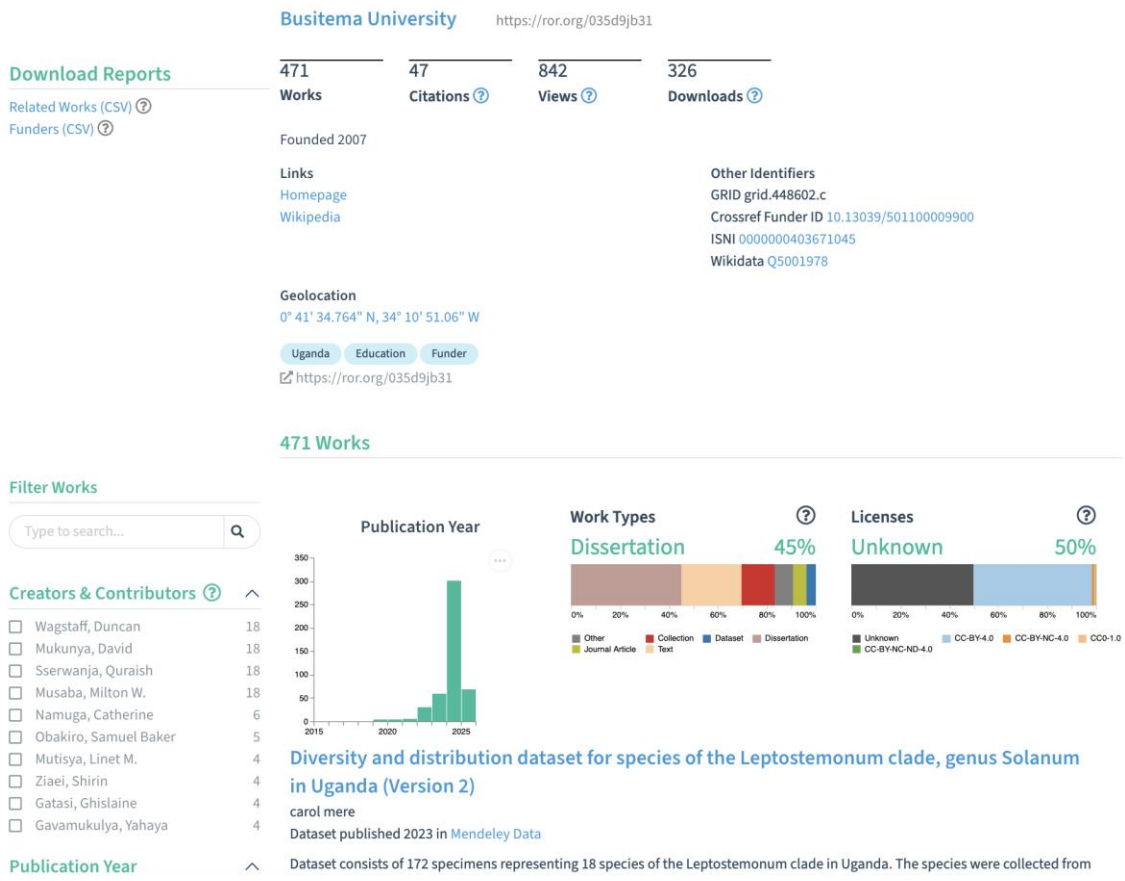


Diagram showing Busitema University's metrics - taken on 17th October 2025

ii. CUT, Zimbabwe

Chinhoyi University of Technology (CUT) recently joins DataCite in 2025 through Zimbabwe University Library Consortium which is a beneficiary of DataCite's Global Access Fund (GAF). The institutional focus more on data preservation while it plans to integrated text dominated repository later.

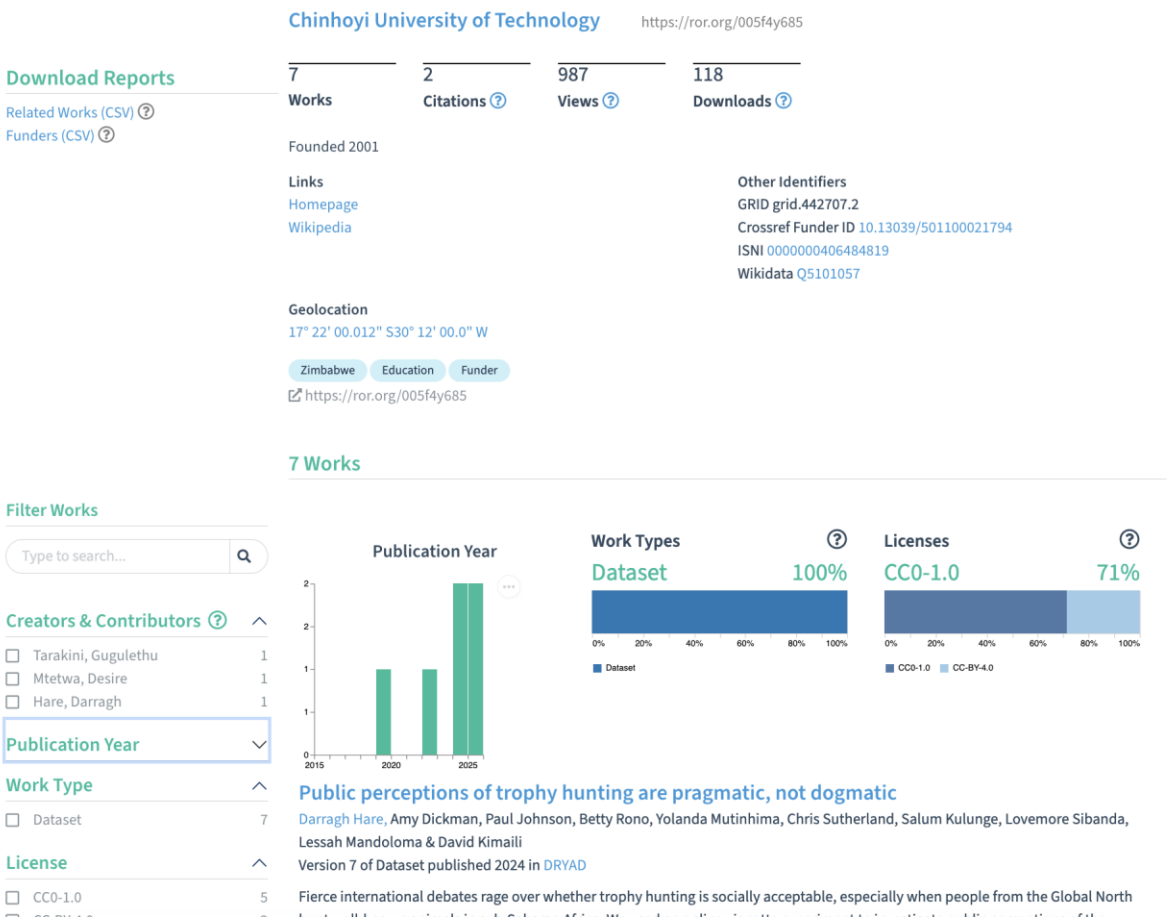


Diagram showing CUT dashboard from DataCite Commons - taken 17th October 2025

iii. South Africa

In South Africa, several institutions joined DataCite either through the Figshare consortium, UbuntuNet Consortium or as direct member. South Africa's institutions leverage strongly on DataCite DOI to improve their research outputs visibility, get up-to-date metrics that consider details beyond citation, including downloads, views, funders type and many interesting reports. University of Cape Town is one of the top University with over 173,000 research outputs that are findable with DOI. (See the diagram below). The institution leverages on DataCite DOI to improve its visibility globally.

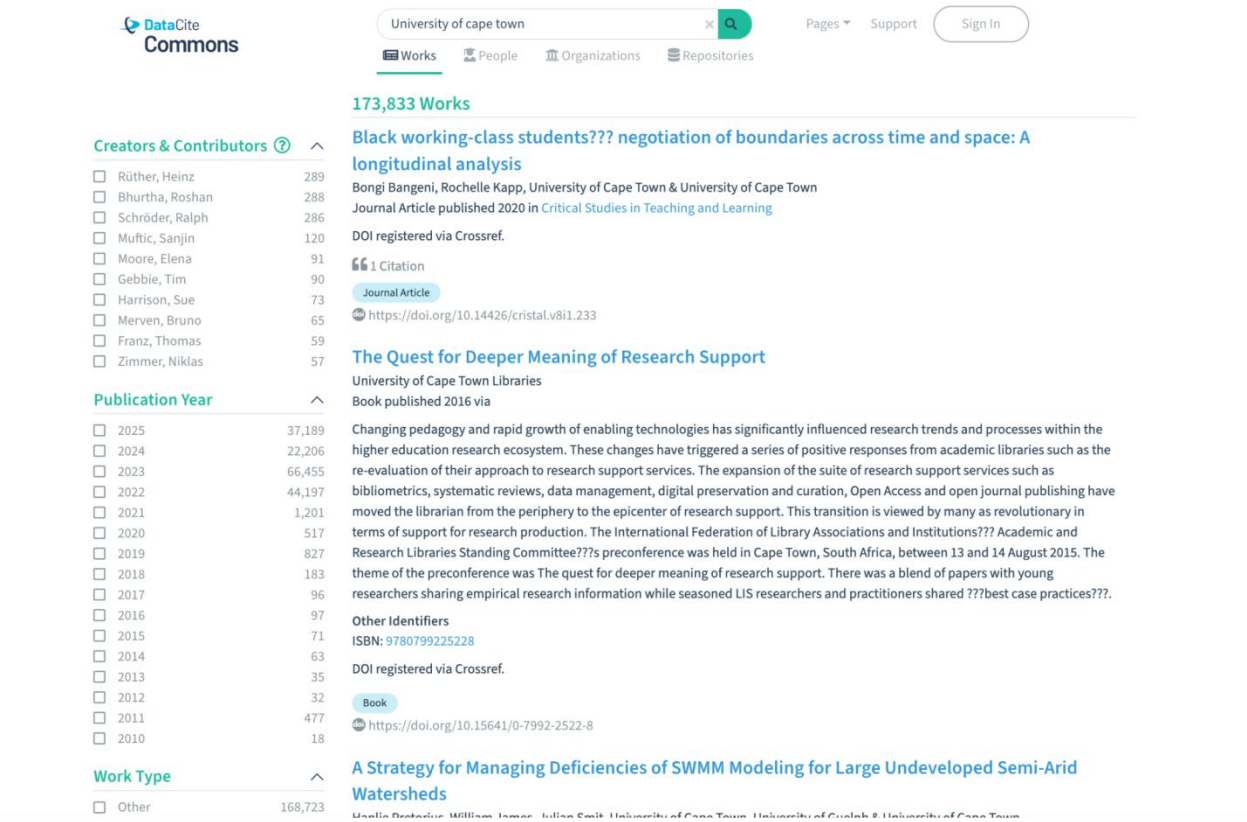


Diagram showing research outputs with DOI from the University of Cape Town - taken 17th October 2025

iv. IITA, Nigeria (Pan Africa)

IITA is Pan Africa Research Institution and a member of CGIAR. CGIAR is the world largest collection of research institutions spread across all the continents of the world. IITA joined DataCite in 2017 principally to improve the visibility of their research data. The institution developed an institutional repository as a main collection point (warehouse) for other research databases such as Cassavabase, Yambase, Musabase, Enterprise Breeding System, among others. Data accessed through the institutional repository are auto assigned DOI through a complex integration systems between the institutional repository and all the research databases. The institutional leverages on CKAN for its repository and integrate it with DataCite's Fabrica

for an enriched DOI and metadata seamless integrations. Additionally, IITA integrates its domain specific metadata schema called CGcore V2 with DataCite metadata schema to provide an enriched data reuse, provenance and attribution.

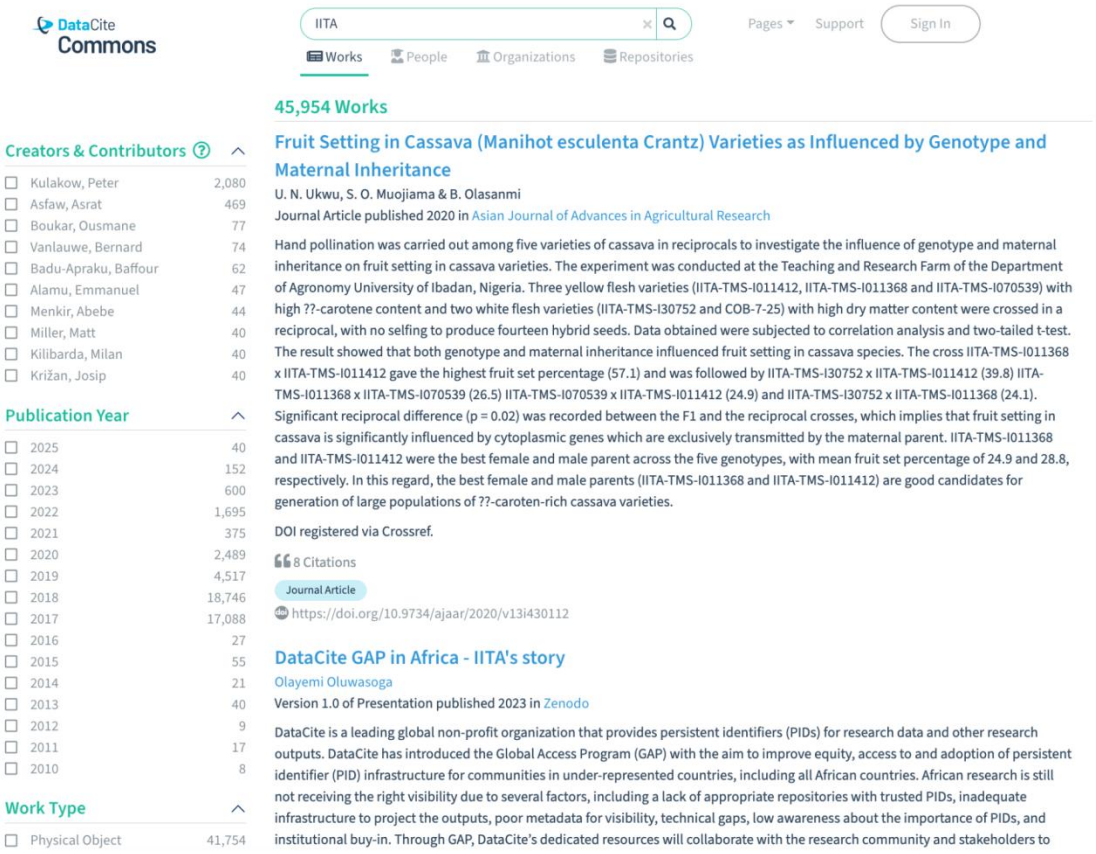


Diagram showing works from IITA as seen in DataCite's Common - taken on 17th October 2025

v. Mekelle University, Ethiopia

Mekelle University started the first consortium lead in Ethiopia recently in 2025. The institution has published 100% publications with DataCite DOI, promoting open science. Mekelle was a beneficiary of DataCite Global Access Fund (GAF) in 2024. The institution is leading Ethiopia to join DataCite membership. The institution has initiated initiatives to increase awareness

about open science and PIDs in the country and furthering the integration of PIDs into workflows.

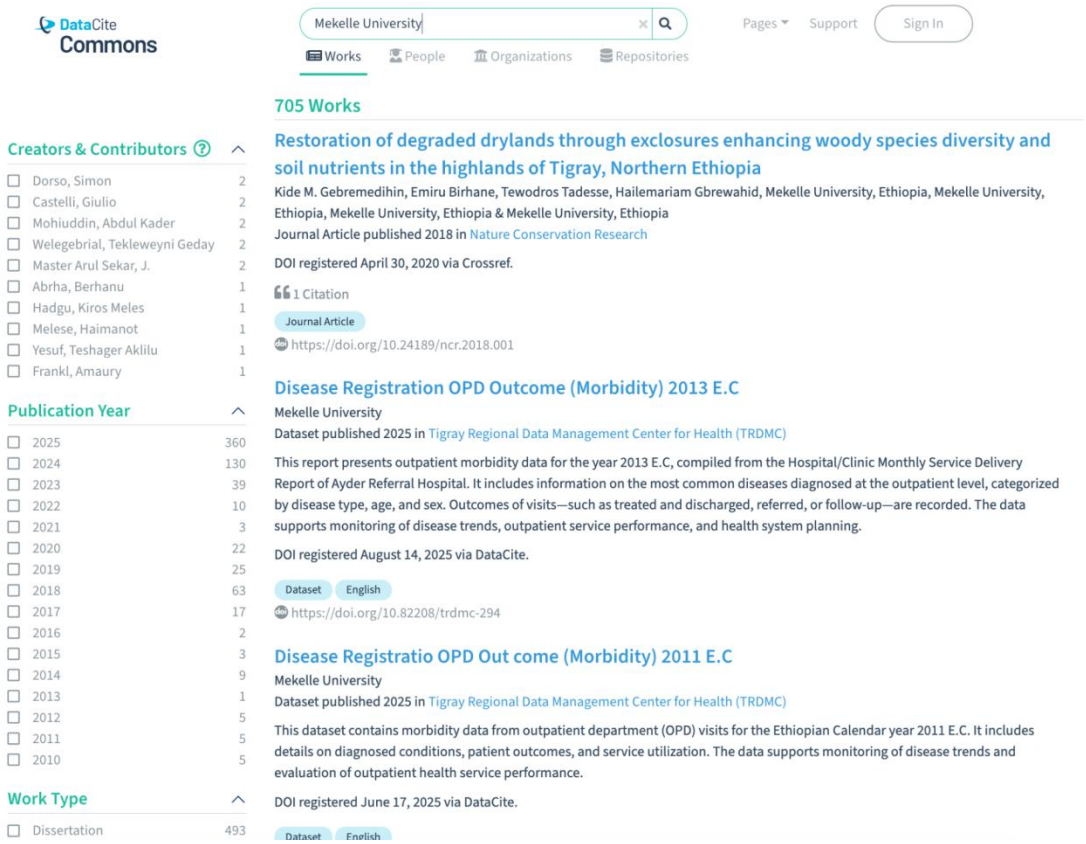


Diagram showing works from Mekelle University as seen in DataCite's Commons - taken on 17th October 2025

Module 5 Assignment

Assignment 1: Membership Pathway Quiz

Objectives:

a. Assess the understanding of DataCite's membership pathway including available membership options, fee models and appropriate pathway for African institutions.

b. Stimulate self-assessment of institutions for the appropriate fit for a DataCite membership.

Instruction:
Complete the multi-choice questions based on module 5 and write a brief reflection based on the quiz.

Quiz:

1. DataCite has a membership pathway for institutions with limited funding by not paying for the membership fee through a consortium.
   True [ ] False [ ]
2. Which membership will be ideal for a group of African universities in the same region or country, with limited funding but wishes to retain DataCite membership benefits?
   (a) Direct (b) Consortium (c) Partnership
3. In the step-by-step guide, what is the first action or step that an institution or organisation must take when planning to join DataCite?
   (a) Sign Agreement (b) Need Assessment (c) Fee Payment
4. For an institution that cannot afford to join DataCite but wishes to have DOI in a third party free platform (meaning the institution has no control over their works), name a low-code platform that could be a good choice?
5. What is the name of the tool or system that DataCite provides to members for DOI management?
   (a) DataCite's Commons (b) Zenodo (c) Fabrica

Assignment 2 - Theory

Objective:

a. Evaluate the understanding of local or indigenous consortium and the values associated for African institutions

Instruction:
Your response should be an average of 150 words for assignment 2.

Question:
Discuss the benefits of either creating a regional consortium for a group of African institutions or joining an existing consortium like UbuntuNet for an African institution.

Further reading for module 5

Become a DataCite member - https://datacite.org/become-a-member/
DataCite fee model - https://datacite.org/fee-model/
DataCite community initiatives:
CESG - https://datacite.org/community-groups/cesg/ ,
Regional Expert Groups - https://datacite.org/regional-expert-groups/
STSG - https://datacite.org/stsg/
Metadata Working Group - https://datacite.org/metadata-working-group/
Harvesters Interest Group - https://groups.google.com/a/datacite.org/g/harvesters-interest-group/about?pli=1
DataCite support documentation - https://support.datacite.org/
IITA and DataCite's DOI impact - https://datacite.org/blog/datacite-use-cases-around-the-world-iita/ and https://www.slideshare.net/slideshow/make-your-research-visible-and-create-more-impact-using-datacite-dois/250811398
DataCite in Ethiopia - https://zenodo.org/records/15131904 , https://datacite.org/global-access-program/gaf2025infrastructure03/ , https://www.mu.edu.et/index.php/ethiopian-doi-consortium
DataCite in South Africa - https://zenodo.org/records/8128828 ,
CUT and DataCite - https://datacite.org/blog/advancing-research-through-datacites-global-access-fund-zimbabwe-university-libraries-consortium-zulc-zimbabwe/
Busitema University, Uganda and DataCite - https://datacite.org/blog/advancing-research-through-datacites-global-access-fund-busitema-university-uganda/ , https://news.busitema.ac.ug/dr-fredrick-kiwuwa-lugya-receives-datacite-global-access-fund-promote-open-scholarship-and-open