Umanistica Digitale – ISSN: 2532-8816 – n. 19, 2025
F. Di Donato, L. Provost – *Why isn't FAIR enough? Bringing together methods and values for Open Science uptake*
DOI: http://doi.org/10.6092/issn.2532-8816/20976

Why isn't FAIR enough? Bringing together methods and values for Open Science uptake

Francesca Di Donato

Istituto di Linguistica Computazionale "A. Zampolli", Consiglio Nazionale delle Ricerche, Pisa, Italy
`francesca.didonato@cnr.it`

Lottie Provost

Istituto di Linguistica Computazionale "A. Zampolli", Consiglio Nazionale delle Ricerche, Pisa, Italy
`lottiemiaprovost@cnr.it`

Abstract *[1]

The FAIR principles have emerged as a global standard for Research Data Management but their application has not had the expected impact, especially considering the considerable amount of funding which has been put into FAIR policies. In fact, open research methods have not become the norm, FAIR is still perceived as just another mechanical task for researchers, and quality is still not ensured by the application of the principles. The CARE principles were proposed to complement the FAIR framework, arguing that people and purpose, rather than data and technology, should be at the centre of RDM frameworks. In practice, they have been applied in certain contexts, which we will examine, but their impact has been rather limited. In this article, we will therefore analyse the definition of the Open Science values and principles provided in the UNESCO Recommendation. By doing so, we aim to see if they overlap with the CARE values and principles, and to understand if the latter are useful, and for what. Finally, we note that the UNESCO definition of Open Science already encompasses the values and principles of CARE, while also being broader and more comprehensive. The implementation and practical translation of the FAIR principles into research practices must address an underlying cultural challenge, and this is where the CARE principles can provide meaningful insight, emphasising the importance of starting with context, communities, and their genuine needs. However, these

---

[1] Authors contribution: Conceptualization: FDD; Methodology: FDD; Resources: FDD, LP; Writing Original Draft Preparation: FDD, LP; Writing Review & Editing: FDD, LP; Supervision: FDD. All authors have read and agreed to the published version of the manuscript.

principles are not indispensable, as these considerations are already embedded within the UNESCO Recommendation and, by extension, within the definition of Open Science itself—an ecosystem of practices in which Research Data Management is a foundational pillar.

Keywords: FAIR principles; Care Principles; Open Science; Research Data Management; Research on Research.

I principi FAIR si sono affermati come standard per la gestione dei dati di ricerca a livello internazionale, ma la loro applicazione non ha avuto l'impatto auspicato, soprattutto se si considera l'ingente quantità di finanziamenti che sono stati destinati alla loro applicazione. In effetti, le pratiche della scienza aperta non sono ancora diventate la norma, e l'applicazione dei principi FAIR è percepita dai ricercatori come un'ulteriore attività meccanica; ciò ha inoltre comportato che gli standard di qualità dei dati che ci si attendeva non siano ancora stati raggiunti. I principi CARE sono stati introdotti al fine di integrare il framework dei principi FAIR, a partire dall'assunto che al centro dei programmi per una corretta gestione dei dati della ricerca dovrebbero trovarsi le persone e gli obiettivi della ricerca, piuttosto che i dati e la tecnologia. Nella pratica, i principi CARE sono stati applicati in alcuni contesti che esamineremo, ma il loro impatto è stato piuttosto limitato. Nel presente articolo analizzeremo la definizione dei valori e dei principi della Scienza Aperta resi espliciti nella Raccomandazione dell'UNESCO sulla scienza aperta. In questo modo, ci proponiamo di vedere se tali valori e principi si sovrappongono ai principi CARE e di capire se questi ultimi sono utili e a quale scopo. Nelle conclusioni abbiamo osservato che la definizione di scienza aperta dell'UNESCO comprende in buona parte i principi CARE. L'attuazione e la traduzione pratica dei principi FAIR nelle pratiche di ricerca deve affrontare una sfida culturale, ed è in tale contesto che i principi CARE possono fornire un contributo significativo, nella misura in cui sottolineano l'importanza di partire dal contesto, dalle comunità e dalle loro reali esigenze. Tuttavia, questi principi non sono indispensabili, in quanto tali considerazioni sono già presenti nella Raccomandazione dell'UNESCO e, per estensione, nella definizione stessa di scienza aperta, un ecosistema di pratiche in cui la gestione dei dati di ricerca è un pilastro fondamentale.

Parole chiave: Principi FAIR; Principi CARE; Scienza aperta; Gestione dei dati di ricerca; Ricerca sulla ricerca

1. Introduction

Defined in 2016 by a group of scholars (Wilkinson J. et al. 2016) [19], the FAIR principles have emerged as a global standard in the space of a few years. Intended to be a high-level tool which provides operational principles that can be applied and implemented in different contexts, the principles detail how research data should be managed across the research lifecycle in order to be Findable, Accessible, Interoperable and Reusable (i.e. FAIR). The FAIR principles are understood as the qualities that data and, by extension, digital objects stemming from and used for research, should have in order to accelerate research, facilitate large scale machine analysis, and to ensure the transparency, reproducibility and societal benefits of research (European Commission 2018, 8) [6].

Following the FAIR acronym, the principles are grouped into four macro-categories.[2]

1. *Findability:* Humans and machines need to be able to search for and discover research data easily. The automatic discovery of datasets and research products is enabled when

---

[2] The FAIR principles are described in detail by the GO FAIR initiative: https://www.go-fair.org/fair-principles.

complete, accurate, and machine-readable metadata accompany the data and follow existing standards, when available. Persistent Identifiers (PIDs) must be assigned to data, metadata and research objects to allow for their long-term unambiguous identification. Finally, to ensure long-term preservation, datasets and accompanying metadata must be stored in a publicly accessible and searchable trusted repository.

2. *Accessibility:* Humans and machines should be able to freely access data, and to know who can access it, when, and how. The data and metadata should be accessible and retrievable through their PID, using a standard communication protocol, such as HTTP or HTTPS. It should be noted that *Accessible data* does not imply that the data is open. Rather, it means that if data has access conditions, these are clear to both humans and machines. Therefore, the protocol for accessing the data should be open, free and universal and allow for a prior authentication and authorisation procedure, when required. Even when the data is no longer available, the metadata can and should remain accessible.
3. *Interoperability*: Humans and machines need to be able to understand, interpret and integrate data with other data. To do so, the data and metadata should be described following recognised, often disciplinary, community standards for formats, specifications and vocabularies. Context should be provided through the use of qualified references[3] to relevant datasets and metadata, so as to create meaningful links between metadata resources. Data is interoperable when both humans and machines can interpret data exchanged between different systems or organisations, which plays a key role in supporting interdisciplinary scientific research.
4. *Reusability*: Humans need to reuse data for future research. Effective data reuse allows researchers to reproduce experiments, verify scientific findings and build their work on previous analyses. To facilitate the reuse and combination of research data in different contexts, both data and accompanying metadata should be thoroughly described according to community standards, and accompanied by rich documentation. Extensive data documentation includes contextual information such as data provenance and processing, and a clear data usage licence which indicates to machines and humans the conditions under which the data can be used.

Each of the macro-principles contains technical-operational rules. For example, for a resource to be findable it needs to have a Persistent IDentifier (PID), such as a DOI for objects and an ORCID id for authors. For a resource to be accessible, it must be deposited in a trusted repository; and for data to be interoperable, it should adopt common vocabularies. It is important to note that today, there are available tools that make the application of these rules almost automatic. For instance, by appropriately depositing digital resources in certified trusted repositories, researchers can ensure that their research outputs are more FAIR compliant. Namely, by using an open repository such as Zenodo, researchers can make their work FAIR.[4]

---

[3] A qualified reference is a cross-reference that explains its intent. Qualified references help create meaningful links between (meta)data resources, for example by clarifying how a dataset builds on, or complements another. See principle I3.

[4] Findable: a PID is attributed to the deposited resource, giving it a unique identifier and making it easier to discover. Accessible: the resource is licensed under CC-BY-4.0, access conditions are clear and are included in the metadata. Interoperable: certified trusted repositories use

The European Commission (EC) has included FAIR data management among the mandatory practices in research proposals since the eighth framework programme, and specific conditions are detailed in the Model Grant Agreement that European funding beneficiaries are requested to sign (European Commission 2024) [7]. The Commission also requires for data to be stored in trusted certified repositories. In addition, the Council has recently adopted the Data Act, a new law on fair access to and use of data (European Parliament and European Council 2023) [8]. These prescriptions complement the mandate on Open Access (OA), which has been mandatory in European funding programs for years, and is historically the first pillar of Open Science (OS).

Regarding the impact and permeation of these principles and mandates in real research practices, it should be noted that, immediately before the pandemic, the data were still alarming, with significant discrepancies between the policies in place and their actual application (European Commission 2018, 32; van Reisen et al. 2020) [8] [14]. Realising this has led to increased pressure from funders towards the adoption of the FAIR principles, correct research data management practices and, more generally, of Open Science practices. Nevertheless, studies estimating the effective reuse of datasets indicate that this practice is not yet commonly adopted by researchers, and that data in this regard are incomplete and not easily quantifiable by researchers themselves (Krūminas et al. 2022) [12]. In fact, despite substantial EU funding[5] precise data on the number of FAIR datasets currently available in Europe are still missing; meanwhile, the costs incurred by not having FAIR data at our disposal are clear (European Commission, 2018) [5].

One of the issues may lie in the perception that researchers have of these requirements as additional bureaucratic and mechanical procedures - new obligations added on top of the others, which only complicate the practice of research. This perception may be the reason behind the low impact of the FAIR principles in terms of effective reuse of data. As a matter of fact, in practice, we are unable to estimate the actual reuse of scientific information.

According to Leonelli, in the definition and vision of Open Science promoted by research funders, starting with the EC "research is portrayed as encompassing a succession of stages – typically going from research design and data collection to analysis and publication – each of which generates outputs worth sharing" (Leonelli 2023, 18) [13]. As an effect of this, "the OS system supported by European institutions tends to focus mostly on institutional diversity and technocratic solutions. The emphasis is first and foremost on developing and promoting tools and infrastructures, such as international consortia, interoperable infrastructures and standards

---

standardised metadata schemes, allowing for improved compatibility across platforms and disciplines. Citation rules are also included in the metadata to ensure correct linkage and attribution. Reusable: resources deposited in editable formats are easier to reuse and adapt. Additionally, making the timestamp of the last update visible ensures users are aware of the version history, thereby facilitating long-term reuse. While we acknowledge that using a certified trusted repository does not fully achieve FAIR compliance, the example provided through the use of Zenodo is intended to show that FAIRness can be approached by following simple steps. A more detailed approach to the steps involved in making digital objects FAIR, and more specifically learning materials, is outlined in the SKILLS4EOSC FAIR-by-design methodology: https://www.skills4eosc.eu/resources/fair-by-design-methodology.

[5] To name only the European Open Science Cloud (EOSC)-related projects, funding amounts to around 300 million euros (the figure has been calculated by adding together the funding allocated under the Horizon 2020 and Horizon Europe programmes in the INFRAEOSC calls), while research on the potential impact of EOSC at the national level is growing (Doumuchel et al., 2024). Estimates are better with regard to OA, also considering that the obligation to publish OA was introduced longer ago.

to make data findable and reusable. The European Open Science Cloud (EOSC), a highly ambitious effort to coordinate access to European research data infrastructures, is a good illustration of such trends." (Leonelli 2023*,* 41) [13].

Nonetheless, there have been and there are several attempts within the scientific community to consider Open Science as a method and set of practices, supported by communities with shared values and principles. An example is the work developed by the FORCE11 working group on Scholarly Commons, active in 2016-2020, in which, from a set of principles, a set of rules is derived. The community of researchers (i.e. the scholarly commons) and other interested parties have to adhere to these in order to identify minimum viable Open Science workflows. According to this framework, the envisioned commons is about scholarly objects being open, FAIR and citable, but also about participation, independence from external reward systems, and independence from specific (technical) systems, platforms and business models (Bosman et al. 2017) [1].

Another recent example which has had significant impact are the CARE (Collective Benefit, Authority to Control, Responsibility and Ethics) principles for Indigenous Data Governance published in 2020 as a set of principles providing guidance for indigenous data governance and use, which aim to correct the merely technological viewpoint of FAIR by adding political, historical, social context (Carroll et al. 2020) [2].

Mentioned in the G7 OSWG Recommendations of 2023 which, among the next steps for action include "promote research management and data governance practices in line with the FAIR (Findable, Accessible, Interoperable, Reusable) and CARE [...] principles" (G7 Science Ministries 2023, 2) [9], the principles have raised considerable international attention.

2. The CARE principles

The aim of the CARE principles is to build on the FAIR principles for data management and to include the values and principles of preexisting declarations and founding documents from indigenous communities (which are more focused on context, i.e. on people and purpose) into new principles for data steward practices related to indigenous data.[6]

The principles stem from the need and tension for indigenous communities to

1. protect their rights and interests in indigenous data; and
2. support open data, machine learning, broad data sharing and big data initiatives.

From the four overarching principles of CARE derive twelve guiding principles - reported below - which outline how data governance and management should be carried out from the

---

[6] In 2017, academics and practitioners of the Research Data Alliance (RDA) International Indigenous Data Sovereignty Interest Group (IG) highlighted the growing tension between supporting open science and open data, and protecting indigenous peoples' rights and interests in data. In an Indigenous-led workshop hosted by the RDA IG at the International Data Week 2018 Conference, participants carried out a comparative analysis of indigenous and mainstream data frameworks and identified three main categories of principles: people oriented, purpose oriented, and data oriented. They found that indigenous frameworks tended to be more oriented towards people and purpose, while mainstream ones overall focused on data (Carrol et al, 2020a).

perspective of indigenous peoples, and define the rights, interests, and concepts to employ to ensure indigenous control over data governance and reuse.

Collective benefit

The design and operation of data ecosystems should ensure that indigenous peoples can derive benefit from the data. Collective benefits include inclusive development and innovation, better governance and engagement of citizens, and equitable outcomes for indigenous peoples. Benefits increase when data ecosystems are built to support: the use and reuse of data by indigenous nations and communities; the use of data for policy-making and assessment purposes; and the generation and use of data that aligns with community values.

C1 For inclusive development and innovation: Facilitate indigenous innovation, value generation, and local self-determined development processes by supporting indigenous peoples' use and reuse of data.

C2 For improved governance and citizen engagement: Data should improve planning policy-making, and service delivery for indigenous communities, and foster better engagement between citizens, institutions, and governments. Open data is used in an ethical manner, with the aim to improve transparency and decision-making processes.

C3 For equitable outcomes: Taking into account that indigenous data are grounded in community values, any value created from such data should equitably provide benefits to indigenous communities and support their aspirations to wellbeing.

Authority to control

Following the vision of the *United Nations Declaration on the Rights of Indigenous People* (UNDRIP) (United Nations 2007) [18] — a non-binding framework adopted in 2007 by the United Nations General Assembly which sets out the rights of indigenous peoples to self-determination, cultural preservation, land, and resources, and to participate in decision-making on matters affecting their rights— this second aspect of CARE highlights the need to recognise indigenous peoples' rights and interests in indigenous data governance, and to empower them to have authority to control and govern such data. Indeed, indigenous data governance allows indigenous peoples and governing bodies to determine how themselves, their lands, territories, resources, knowledges, and geographical information are represented and identified in data ecosystems. Therefore, indigenous peoples must determine data governance protocols, and be actively involved in data management stewardship and decision-making for indigenous data held by non indigenous bodies.

A1 Recognising rights and interests: Recognise the collective and individual rights of indigenous peoples to free, prior and informed consent in the collection and use of indigenous knowledge and data, and in developing policies and protocols for data collection.

A2 Data for governance: Ensure that indigenous peoples and communities' right to access indigenous data that is relevant to their worldviews and supports self-determination and self-governance is respected.

A3 Governance of data: Ensure that indigenous peoples' right to develop cultural governance protocols for indigenous data is respected and that they are the ones to lead the stewardship and access to such data.

Responsibility

The people working with indigenous data should ensure that they nurture respectful relationships with indigenous peoples from whom the data originate. In particular, they have the responsibility to provide information on how indigenous data is used in ways that effectively support indigenous peoples' self-determination and collective benefit. Respectful relationships are understood as relationships that contribute to strengthening capacity-building and which make sure that data is rooted in indigenous worldviews.

R1 For positive relationships: Working with indigenous data entails being responsible for ensuring that the collection, processing and use of data respect the dignity of indigenous peoples and communities. As such, the use of indigenous data must be embedded in a relationship based on the values of respect, reciprocity, trust and mutual understanding.

R2 For expanding capability and capacity: Using indigenous data entails a reciprocal responsibility to improve data literacy and capacity in indigenous communities. To do so, users of indigenous data should help strengthen the development of an indigenous data workforce and digital infrastructure that supports data practices from creation to collection, management, security, governance and application of data.

R3 For indigenous languages and worldviews: Provide resources to guide data generation that is grounded in indigenous peoples' languages, worldviews, lived experiences, values and principles.

Ethics

At all stages of the data lifecycle, and across the data ecosystem, the primary concern should always be indigenous peoples' rights and wellbeing. Representation and participation of indigenous peoples is therefore fundamental for the ethical conduct of data practices, as they should be the only ones assessing the potential benefits, harms and future uses, and ensuring that data governance and management practices are based on and reflect community values.

E1 For minimising harm and maximising benefits: Ethical data should not stigmatise indigenous peoples in terms of deficit, and must align with their ethical frameworks and rights. The assessment of potential harms and benefits is to be carried out from their perspective.

E2 For justice: Ethical processes should address power and resources asymmetries, taking into account how these impact indigenous peoples' rights, and ensuring that relevant Indigenous communities are adequately represented.

E3 For future reuse: Data governance should consider possibilities of future use and harm following ethical frameworks that are based on the values and principles of the relevant indigenous community. Metadata should provide information of the provenance and purpose, as well as any limitations in secondary use or consent issues.

At the heart of the CARE principles' vision is the importance of local and group control for *quality* and reproducibility of research and data. Context is thus put at the core of the process, and inclusion, trust and accountability are a starting point, in accordance with Leonelli's model of 'openness as judicious connection', which moves from inclusion to transparency, through quality (Leonelli 2023, 43) [13].

CARE provides a normative foundation in relation to data acquired about *populations as collectives* and, by complementing the data-centric approach of the FAIR principles, this framework brings the focus on people and purpose and highlights the increasingly important role of data in advancing innovation, governance and self determination. CARE can be combined with FAIR, as long as FAIR is guided by CARE, meaning that CARE ensures that FAIR data is not an abstraction without concrete conditions of production and use, i.e. not just a commodity for Western research.[7]

The two examples reported below provide a better understanding of how the principles fit into different contexts.

2.1. CARE in biodiversity and ecology

The first example of CARE principles in context stems from the paper "Applying CARE principles for indigenous Data Governance' to ecology and biodiversity in research" (Jennings et al. 2023) [11]. Starting from the observation that the majority of indigenous data neglect both FAIR and CARE principles,[8] the following question is addressed: how can scientists embed the rights, interests, expectations and responsibilities of indigenous peoples into the creation of information infrastructures to enhance indigenous governance of indigenous data? Recalling that there is no "one size fits all" approach, the authors emphasise the importance of ethics and responsibility in data relationships and provide recommendations to foster "intentional and collaborative" partnerships so as to establish fairer and more equitable frameworks for research and data practices.

The application of the CARE principles to biodiversity research is presented in three ways. Firstly, guidance is provided for each aspect of CARE, with recommendations on specific aspects to take into account to ensure that all the principles are addressed. Secondly, a table summarises the actions researchers and institutions can take to address the issues raised by communities with regard to the CARE principles, and is reported in Table 1. below. Thirdly, a collection of examples of CARE in practice showcases how non-indigenous partners and researchers, with support and advice from indigenous partners, have been innovative in addressing five key actions for researchers: acknowledging contributions, giving proper credit, determining authorship, ensuring access, and establishing authority.

CARE principles	**Issues raised by communities**	**Actions for institutions and researchers**
Collective benefit	Research that benefits communities	Prior to research, explain and demonstrate how your research and potential results are relevant and are of value to the interests of the community and individual members; research should support community-led initiatives and secure funding

---

[7] However, beyond concrete measures to manage the data with the oversight of indigenous people and recording their contributions in data production, the concrete aspects of CARE are not always crystal clear.

[8] Namely, the authors report general concerns about data being largely unsearchable due to missing or inappropriate metadata. Common issues are: data is mislabelled; data lacks the necessary metadata indicating indigenous provenance, protocols for use, reuse and sharing, and permissions; and data lacks appropriate identification of indigenous rights holders.

		for long-term investments in the community.
	Research that benefits communities	Prior to research, explain and demonstrate how your research and potential results are relevant and are of value to the interests of the community and individual members; research should support community-led initiatives and secure funding for long-term investments in the community.
	Data grounded in community values, aspirations and well-being	Develop and/or use indigenous data classification and analysis frameworks that reflect community values, needs and aspirations; include and value local community experts in the research team.
	Data for self-determined development	Collect and code using categories that identify indigenous communities and individuals in ways that they define; disaggregate data, especially in global or large geospatial datasets, to increase relevance for indigenous communities.
	Compensate local experts	Compensate community experts throughout the research process, including research proposal development, data collection, manuscript writing and community review of prepublication manuscripts.
	Recognize indigenous peoples' rights to and interests in their knowledges and data	Establish institutional principles or protocols for research development, data management and publication (for example, scholarly works, presentations and datasets) that support indigenous Data Sovereignty; include

Authority to control		metadata fields available for disclosure of indigenous rights and interests.
	Recognize the rights of indigenous people to free, prior and informed consent	Ensure data use is consistent with individual and community consent provisions; ensure ongoing consent processes, including the ability to refuse, withdraw and reconsent.
	Data available for indigenous governance	Ensure indigenous communities have access to data, metadata about their people, communities and non-human relations in a usable format; return all outputs to the appropriate tribal authorities.
	Develop and enact Indigenous Data Governance protocols	Ensure community control and ownership of data and data protocols; use Indigenous frameworks and principles to inform data management protocols and processes; Indigenous community control of how, what, who and where research is conducted, and stewardship of data; publication standards require documentation of community support, participation and approval for publishing data and authorship.
	Enable capability and capacity sharing for research design and digital infrastructure	Create and expand opportunities for community capacity through (1) participatory methodologies including planning and design, knowledge management and data workforce capacity building, and (2) initiatives to enable the design, collection, management, storage, security, governance,

Responsibility		collective privacy and application of data.
	Respect reciprocity, trust and mutual understanding with those to whom data relate	Record the Traditional Knowledge and biocultural labels of the Local Contexts Hub in metadata; ensure review of draft publications before dissemination; identify and address sensitive data, including privacy issues for individuals and communities.
	Data-generating resources for languages, worldviews and lived experiences	Use the languages of indigenous peoples; affirm community worldviews; upload data with appropriate metadata labels (that is, Traditional Knowledge and biocultural labels, and provenance) in culturally accessible formats (digital storytelling, seasonal calendars, visual art forms and so on).
	Community-defined benefit sharing	Conduct research that is of mutual benefit, consent driven, inclusive and relevant to the needs of indigenous communities and individuals.
Ethics	Align with indigenous ethical frameworks	Assess research using indigenous ethical frameworks; community-defined review processes and appropriate reviewers (for example, community advisory boards) for activities delineated in data management plans.
	Maximize benefits from the perspectives of indigenous peoples	Researchers explain benefits to indigenous communities; identify and contribute to community-defined benefits; disclose potential financial gain and share benefits with communities from research outputs and/or economic value of data.

	Minimize harms from the perspectives of indigenous peoples	Use indigenous ethical frameworks; community-defined code of conduct is accessible; data-access protocols consider the potential for community harm and remedied through sharing data; ensure ongoing consent.
	Data governance accounts for potential future use	Apply community protocols for infrastructure, metadata and secondary use; include Traditional Knowledge and biocultural labels and metadata fields for community and/or tribal affiliation; use community guidelines for the use and reuse of data; allow data removal and/or disposal requests from aggregated datasets; record and recognize provenance.

Table 1. How institutions and researchers can apply the CARE principles, taken from Jennings et al., 2023.

For each aspect of CARE, the authors address four "issues raised by scientific communities", helping researchers and institutions to understand the motivations behind the recommended actions in the last column.

Here, the issues presented in the table highlight the purpose of each action, a concept central to CARE, which had already been identified as missing from the mainstream data frameworks in the International Data Week 2018 Conference workshop (Carroll et al. 2020) [4].

A second point is that the table, rather than distancing itself completely from mainstream frameworks, shows the coexistence of technical guidelines and more community-focused actions. Certain recommendations, such as using appropriate metadata labels and documentation, and accessible and usable data formats, directly recall the principles F2, F3, I1 and R1 of FAIR.[9] Others, more numerous, illustrate how the CARE principles bring the community at the centre with wording such as: considering community benefits and interests; compensation of community members; prioritising community-led initiatives; expanding community capacity; respecting community views; ensuring community control.

---

[9] As a reminder, the cited principles are as follows: F2. Data are described with rich metadata; F3. Metadata clearly and explicitly include the identifier of the data they describe; I1. (Meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation; R1. (Meta)data are richly described with a plurality of accurate and relevant attributes. See FAIR Principles overview.

As a general observation, we note that technical standards are essential but they must be guided by local governance and ethical values to ensure that data management practices respect indigenous sovereignty and well-being. While FAIR focuses on technically enabling data FAIRness, CARE introduces context-specific governance, and by calling for indigenous authority over data and decision-making processes, it embeds respect and reciprocity in data practices.

2.2. CARE in Archaeology

The second example of CARE principles in context is grounded in archaeology and also starts from the observation that researchers in the field have often failed to share data in an ethical manner, and following appropriate standards of practice. Instead, they have engaged in "gatekeeping" and "safeguarding" data from other scholars, and even from the communities to whom the data relate.

The CARE Principles and the Reuse, Sharing, and Curation of Indigenous Data in Canadian Archaeology (Gupta N. et al. 2023) [10] discusses how the CARE Principles can provide an ethical framework to support the development of digital methods and data practices which are appropriate for twenty first century archaeology.

Well known issues in archaeology and digital heritage include the lack of attention paid to ownership of digital archaeological data, and the unequal access to infrastructure for sharing, storing, analysing, and presenting digital archeological data, all of which have resulted in indigenous and descendant communities not having access to or ownership and possession of their material heritage.

Data management frameworks are a commonly used tool to define the rules, processes and responsibilities associated with the collection, organisation, storage and use of data. In fact, good data documentation practices and metadata tools can support an ethical care of digital resources. However, data-centric frameworks such as the FAIR principles fail to address power imbalances in scientific research and therefore need to be applied within a clear ethical framework to avoid perpetuating existing inequalities. Additionally, while data repositories and publishing data can provide opportunities for archaeologists in digital methods, information science, and data science practice, the authors note that such efforts have not directly tackled inequalities in capacity building for the vast majority of archaeologists, and especially for indigenous and racialised women.

Efforts to align archaeological processes, practices and data repositories with the CARE Principles should be considered from the outset of a project. For instance, the CARE framework can guide the data management plan required by research funders, an example of implementing CARE for archaeological data management is provided. The authors of this study also strongly encourage archaeologists to consider the future of the data they gather, the communities connected to it, how these communities will be involved in project design, and how the data will be shared and archived. Indeed, having clear and transparent responsibilities from the beginning will lead to better-informed decisions, fostering stronger community relationships.

We first observed that the CARE principles were published in 2020 to bring an ethical dimension to the FAIR principles, which were limited to a methodological approach. While their application currently focuses on the contexts of indigenous people, the CARE principles could be extended beyond indigenous data, as a set of ethical and practical principles.

The following section examines the UNESCO definition of Open Science, and in particular the Open Science values and principles defined in the 2021 UNESCO Recommendation on Open Science [16], published one year after the CARE principles, and which has been endorsed by 193

Nations. In particular, we are interested in looking at how the values and principles of Open Science are defined, so as to try to understand, in the concluding section, whether or not they are compatible with the CARE principles and whether to some extent the former encompass the latter.[10]

3. Open Science values and principles

The UNESCO Recommendation on Open Science is structured into five main sections, which are preceded by a preamble reconstructing the genesis of the document.[11] Open science is there defined as "an inclusive construct that combines various movements and practices aiming to make multilingual scientific knowledge openly available, accessible and reusable for everyone, to increase scientific collaborations and sharing of information for the benefits of science and society, and to open the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community. It comprises all scientific disciplines and aspects of scholarly practices, including basic and applied sciences, natural and social sciences and the humanities, and it builds on the following key pillars: open scientific knowledge, open science infrastructures, science communication, open engagement of societal actors and open dialogue with other knowledge systems." (UNESCO 2021, 7) [16].

In the third chapter, the Open Science core values and guiding principles are outlined. The values "stem from the rights-based, ethical, epistemological, economic, legal, political, social, multi-stakeholder and technological implications of opening science to society and broadening the principles of openness to the whole cycle of scientific research". The principles provide "a framework for enabling conditions and practices within which the above values are upheld, and the ideals of open science are made a reality".

Compared to the definitions contained in the CARE principles, a new level is introduced here: the difference between values and principles. Values are high-level ethical principles, within the general framework of which principles act as methodological guidelines to guide research and its processes.[12]

The following figure presents the values and principles of Open Science, as identified in the Recommendation. Their analysis serves as a means to understand their general function in the

---

[10] It should be noted that the UNESCO Recommendation on Open Science does not explicitly mention FAIR data, but refers to open data. Nonetheless, data management practices following the FAIR principles do belong to Open Science practices, as illustrated in the EC mandates in this regard, and in particular in the EC Model Grant Agreement (European Commission 2024) [7].

[11] The premise defines in detail the context and the essential preconditions for the development of the Recommendation, and focuses on the social and economic relevance of Open Science, with particular reference to human rights and sustainable development. The first section of the text – Aim and objectives of the Recommendation is dedicated to the objectives of the Recommendation, while the second section – Definition of Open Science contains the common and internationally agreed upon definition of Open Science.

[12] The distinction between values and principles in the UNESCO definition cannot be explored in the context of this article, but is certainly worthy of in-depth study and reflection.

Open Science ecosystem, and, in particular, in relation to its individual pillars, including open and FAIR data.[13]

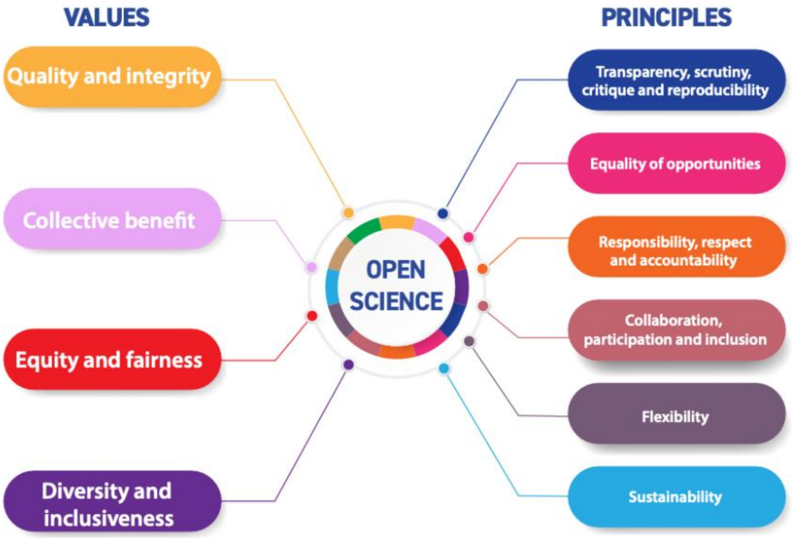

Figure 1 - Open Science core values and guiding principles (UNESCO 2021, 19)

Values of Open Science

1. Quality and integrity

To ensure the quality and integrity of research, Open Science must support academic freedom and respect for human rights, with research being subject to rigorous scrutiny. High quality research is achieved through collaboration between different sources of knowledge, and when scientific methods and results are widely accessible, allowing for thorough and transparent assessment processes.

2. Collective benefit

Recognising that science is a global public good which belongs to all of humanity implies that its benefits must be universally shared, and that scientific knowledge is made available to everyone. Equal opportunities to contribute to and benefit from scientific advancements are fostered only when the practice of science is inclusive, sustainable and equitable.

3. Equity and fairness

---

[13] The first of the four pillars is in fact Open scientific knowledge, which "refers to open access to scientific publications, research data, metadata, open educational resources, software, and source code and hardware" (UNESCO, 2021, p. 9)

Access and contribution to scientific knowledge should be available to all interested parties, whatever their background or situation. Emphasis is placed on the idea that no one should be prevented from accessing or contributing to science, or suffer any form of differential treatment. Rather, both producers and consumers of scientific knowledge deserve equal opportunities to participate in the research process, regardless of personal interest, prejudice or favouritism.

4. Diversity and inclusiveness

In order for science to be inclusive and attend to the needs of the scientific community as a whole, but also of diverse research communities, including stakeholders outside academia such as indigenous peoples and local communities, the wide variety of knowledge practices, workflows, languages, research topics and outputs must be encouraged and supported.

Guiding principles to make Open Science a reality

1. Transparency, scrutiny, critique, and reproducibility

To strengthen the quality and rigour of science, maximise its impact on society, and improve our collective ability to tackle complex correlated global challenges, openness should be encouraged across all the stages of the research lifecycle. This principle highlights that transparency and trust in scientific information can be achieved through greater openness in each step of the scientific process.

2. Equality of opportunities

Everyone, regardless of their background or circumstances, should be equally able to access, contribute to, and benefit from scientific knowledge. This principle ensures that opportunities in science are not limited by factors such as nationality, gender, economic status, or geographic location, so that a diverse range of voices and perspectives can contribute to scientific progress.

3. Responsibility, respect, and accountability

Researchers and actors involved in the scientific process bear the responsibility to conduct research with the highest standards of integrity, and to be aware of the wider impacts their work may have on society and the environment. This principle raises awareness on the importance of public accountability, avoiding conflicts of interest, respecting the intellectual integrity of research, and upholding the associated ethical principles.

4. Collaboration, participation, and inclusion

For scientists to be able to tackle large, complex, societal problems, collaboration must be supported across all levels of the scientific process, thereby overcoming barriers related to geography, language, age, and resources. To that extent, cross-disciplinary collaboration should be encouraged and the effective participation of a diverse range of contributors from different knowledge systems should be enabled, in particular societal actors and marginalised communities.

5. Flexibility

Recognising the diversity of contexts, people and capabilities related to or involved in research across the globe, this principle acknowledges that there is no one-size-fits-all way of practising science. A flexible approach will facilitate the development of different strategies to reach the objectives of Open Science, while maintaining a set of shared core values.

6. Sustainability

To maximise the efficiency and impact of science in the long term, it should rely on a system of sustainable practices, services, infrastructures and financial models which guarantees the equal participation of researchers and scientific actors from less privileged organisations and countries in the production of knowledge. Through the concept of sustainability, this principle makes it clear that Open Science infrastructures should be established and funded with a not-for-profit, long-term vision which promotes Open Science practices, and ensures broad, permanent, and unrestricted access to knowledge for everyone.

Looking at the values and principles of the Recommendation, one can identify several areas of intersection with the CARE principles framework. Comparing the two frameworks brings these connections to light.

Respect appears in both frameworks with similar connotations, underscoring the need to recognise the dignity and rights of all stakeholders involved in scientific research. *Ethics* and *responsibility* are also shared values, highlighting the need for ethical conduct and accountability in research processes and outcomes. *Equity* is another common theme, reflecting the commitment to fairness in the distribution of resources, opportunities, and benefits derived from science.

Both frameworks also contain a series of overlapping themes, which may not convey the exact same meaning, but which nonetheless tend to point towards the same direction. In that sense, it can be argued that *accessibility*, *inclusivity*, and *diversity of actors and knowledge systems* parallels the CARE Principles' focus on *inclusive development & innovation* and *community values*, with both frameworks advocating for the inclusion of diverse voices and knowledge systems in the scientific process (even though the CARE Principles place a stronger emphasis on the sovereignty and self-determination of indigenous communities). And vice versa, UNESCO's concept of *science as a global public good* also echoes the CARE principle of *collective benefit*, as both highlight the importance of making scientific knowledge accessible and beneficial to all of humanity, rather than restricting it to a privileged few.

Some values and/or principles are unique to each framework, and could be interpreted as a reflection of distinct priorities. For instance, the CARE Principles are based on and uphold the concepts of *sovereignty*, *authority*, and *self-determination*—concepts that specifically address the rights of indigenous peoples to control their data and research narratives. Though it emphasises inclusivity, the UNESCO framework does not explicitly address the governance and authority issues concerning data and knowledge. Conversely, UNESCO places the emphasis on *transparency*, and *accessibility*, which are not directly addressed in the CARE Principles, but are an essential component of the FAIR framework.

4. Conclusions

While criticisms have been made to the Open Science movement for potentially conflicting with the protection of indigenous peoples' rights and interests (Jennings et al. 2023) [11], the UNESCO Recommendation actually addresses these concerns, making thirteen explicit references to indigenous peoples and their rights. A thorough reading of the Recommendation even suggests a high degree of compatibility between the values and principles it promotes, and those contained in the CARE framework. Specifically:

a) The preamble of the Recommendation indicates from the outset UNESCO's intention to recognise the rights and interests of indigenous peoples and to align with the UNDRIP

(UNESCO 2021, 3) [16]. In this preliminary section of the Recommendation, it is stated that Open Science should encourage the inclusion and exchange of scholarly knowledge from underrepresented communities, such as indigenous researchers, thereby promoting open dialogue with indigenous peoples, and respect for the diversity of knowledge holders in addressing contemporary challenges (UNESCO 2021, 5) [16].

b) The definition section then sheds light on the expected outcomes of Open Science (UNESCO 2021, 7) [16], which are summed up in the following page (UNESCO 2021, 8) [16]. Here, parallels can be drawn between the goals of the Open Science movement and the overarching principles of CARE.

First, Open Science is expected to lead to greater collaboration and sharing of scientific information for the benefit of all. This brings to mind the first and last principles of CARE, Collective benefit and Ethics, which emphasise that data should be used in ways that allow indigenous peoples and their communities to derive collective benefit from it.

Second, the Open Science movement aspires to open all the steps of the scientific process so as to allow for the participation of actors beyond the traditional academic community. This objective recalls the principles of Authority to control and Responsibility of CARE, the former stressing the right of indigenous peoples to control how data and research that impacts them is used and shared, the latter highlighting the need for positive and respectful relationships in which capacity-building is fostered, and data reflects indigenous worldviews.

Finally, the Open Science movement aims to make scientific knowledge multilingual, open, available, and reusable for all. The mention of multilingual knowledge is a first step towards multiculturalism, and the respect for indigenous languages and worldviews emphasised in the Responsibility principle of CARE. But this Open Science objective is maybe the one which raises the most concerns with regard to safeguarding indigenous peoples' needs and interests. As it has rightly been argued that making indigenous data openly accessible without proper governance frameworks risks harming indigenous peoples (Carroll et al. 2020; Carroll et al. 2021) [2] [3], it should be kept in mind that if scientific knowledge is to be open and available to all, it should effectively support indigenous peoples' control and use of data for development and policy purposes, and not the contrary.

c) In section 2 detailing the four pillars of Open Science, indigenous rights and knowledge are recognised on several occasions. Although the term "indigenous" is not always explicitly mentioned, the vocabulary used often directly reflects UNDRIP and indigenous frameworks.

d) The Recommendation acknowledges that open access to scientific knowledge may be limited only if necessary and justified, as it can be the case with the respect of intellectual property rights, or the protection of "sacred and secret indigenous knowledge" (UNESCO 2021, 11) [16]. It is also stated that if access to knowledge is restricted, "pertinent governing instances" should be the ones to define access criteria. The use of "pertinent governing instances" recalls the UNDRIP vision which recognises indigenous peoples' rights and interests in data governance, and calls for empowering them to have authority to control and govern such data. This can be reached by enabling them to develop their own cultural governance protocols for indigenous data, and lead the stewardship and control of access to such data.

e) Open Science infrastructures (UNESCO 2021, 12) [16] are shared research infrastructures that support Open Science and serve the needs of different communities. While there is no direct reference to indigenous peoples in this section, UNESCO's vision for infrastructures is that they should be community-led, sustainable and available to all, regardless of location, language or ability. Such values recall the ideas of equity, and participation in governance at the core of the CARE principles.

It is worth mentioning that the ambitions for Open Science infrastructures to serve the needs of different communities across the globe have yet to be fully realised. The *UNESCO Open Science Outlook* (2023) [17] highlighted significant disparities in the distribution of open access and open data repositories worldwide, with Western Europe and North America accounting for 85%, and Africa and the Arab region together accounting for less than 5%. Leonelli (2023) [13] also pointed out that many researchers, particularly those in less well-funded or internationally visible institutions, struggle to engage with Open Science infrastructures, a difficulty which often stems from the design of infrastructures which reflect the priorities and assumptions of their developers, typically English-speaking scientists from wealthy institutions. Therefore, the fact that overly technical implementations of Open Science principles, practices and infrastructures risk overlooking the cultural and organisational dimensions essential to equitable access and participation should be kept in mind.

f) The concept of open engagement of societal actors supports a more inclusive and accessible scientific process which actively involves stakeholders outside academia. By fostering dialogue and ensuring that all actors can have a voice in shaping research that aligns with their concerns, needs, and aspirations, this approach also reflects that contained in the CARE principles and in the UNDRIP. It underscores the importance of Collective Benefit by promoting "collective intelligence for problem solving" (UNESCO 2021, 13) [16], where citizens and communities play a central role in knowledge creation. This engagement ensures that research processes and outcomes are not only inclusive but also guided by the values and knowledge of diverse communities, including indigenous peoples. To maximise the reuse of the outputs of participatory science, these outputs need to be carefully curated, standardised, and preserved. This aligns with the CARE principles by ensuring that data practices respect indigenous governance, ethics, and community values.

g) Open dialogue with other knowledge systems is the Open Science pillar which most evidently supports alignment with the CARE principles and the UNDRIP. Recognising the rich variety of knowledge systems, producers and holders, it specifically calls for building connections with indigenous knowledge systems in accordance with the UNDRIP and CARE frameworks to ensure that "the rights of indigenous peoples and local communities to govern and make decisions on the custodianship, ownership and administration of data on traditional knowledge and on their lands and resources" is acknowledged and respected (UNESCO 2021, 15) [16].

h) Finally, the section Areas of Action adopts a clear stance on the protection of indigenous peoples rights and interests, especially in paragraph (i) 16. where it is stated that the practice of Open Science should "not involve unfair and/or inequitable extraction of data and knowledge", nor "infringe on indigenous peoples' rights and needs over their knowledge" (UNESCO 2021, 20) [16].

Therefore, a comparative analysis of the UNESCO Open Science values and principles against the CARE principles indicates a significant degree of compatibility between both frameworks, revealing that not only does the former include and support the latter, but that the contrary is also true.[14] A significant report of the Royal Society published in 2012 , which can be seen as a precursor of the research data management principles definition, recognised in the latter a strong cultural component, combining cultural dimensions with methodological elements (Royal

---

[14] A mapping of both frameworks is provided in the Appendix and makes this correspondence explicit.

Society 2012) [15]. While this value-driven component was somehow forgotten in the formulation of the FAIR principles themselves, it re-emerges as a central focus in the UNESCO Recommendation, reaffirming the broader cultural and ethical foundations of Open Science.

Focusing on values (ethical elements) and principles (methodological elements) as equally essential aspects of scientific activity is a fundamental step in bringing about the cultural change needed for Open Science practices to take root, including good research data management. This entails considering contexts and communities as the starting point, and the application of the FAIR principles a small piece, and a single practice, of a much larger ecosystem. The CARE principles hold particular importance for indigenous communities, but they also play a wider role by bringing value-oriented considerations back to the forefront of discussions and policies for science. In that regard, it should however be noted that the UNESCO Recommendation stands out, especially by embedding good research data management practices in the broader, more complex, yet richer field of Open Science practices. Focusing on the critical nature of this aspect is a prerequisite to foster a new research culture, whose foundation lies in data management in accordance with the FAIR principles.

Appendix - Mapping Open Science values and principles against the CARE principles

The compatibility between the values and principles of Open Science outlined in the UNESCO Recommendation and the CARE Principles is illustrated in Table a. below, in which the four UNESCO values (Quality and Integrity; Collective Benefit; Equity and Fairness; Diversity and Inclusiveness) and the six principles (Transparency, scrutiny, critique, reproducibility; Equality of opportunities; Responsibility, Respect, accountability; Collaboration, participation, inclusion; Flexibility; Sustainability) are mapped against the four CARE principles. It appears that all of the UNESCO values and principles can, in some way, support and uphold the specific sub principles of CARE.

UNESCO Values and Principles	**Reflected in the CARE Principles**			
	Collective Benefit	**Authority to Control**	**Responsibility**	**Ethics**
Quality and Integrity	C2 For improved governance and citizen engagement	A1 Recognizing rights and interests		
Collective Benefit	C1 For inclusive development and innovation		R2 For expanding capability and capacity	E1 For minimising harm and

	C3 For equitable outcomes			maximising benefits
Equity and Fairness	C3 For equitable outcomes	A1 Recognizing rights and interests	R1 For positive relationships	
Diversity and Inclusiveness	C1 For inclusive development and innovation		R3 For indigenous languages and worldviews	
Transparency, scrutiny, critique, reproducibility	C2 For improved governance and citizen engagement		R2 For expanding capability and capacity	
Equality of opportunities			R1 For positive relationships	E2 For justice
Responsibility, Respect, accountability	C2 For improved governance and citizen engagement		R1 For positive relationships	E1 For minimising harm and maximising benefits
				E3 For future reuse
Collaboration, participation, inclusion	C2 For improved governance and citizen engagement			E2 For justice
Flexibility		A2 Data for governance	R1 For positive relationships	
			R3 For indigenous languages and worldviews	
Sustainability		A3 Governance of data	R3 For indigenous languages and worldviews	

Table a. Correspondence between UNESCO values and principles and CARE principles

A second table, in which the correspondence is reversed, shows how the CARE principles include elements of, and intersect with, the UNESCO framework.

CARE principles		Explanation of CARE principle	**UNESCO addresses this in**	*citation from text*
Collective Benefit	C1 For inclusive development and innovation	Facilitate indigenous innovation, value generation, and local self-determined development processes by supporting indigenous peoples' use and reuse of data.	Collective benefit (V2)	*The practice of science should be inclusive,*
			Diversity and Inclusiveness (V4)	*Open Science should embrace a diversity of knowledge ... that support the needs and epistemic pluralism of the scientific community. ... as well as the wider public and knowledge holders beyond the traditional scientific community, including indigenous peoples.*
	C2 For improved governance and citizen engagement	Data should improve planning policy-making, and service delivery for indigenous communities, and foster better engagement between citizens, institutions, and governments. Open data is used in an ethical manner, with the aim to improve transparency and decision-	Quality and integrity (V1)	*making research methods and outputs widely available for rigorous review and scrutiny, and transparent evaluation processes*
			Transparency, scrutiny, critique, reproducibility (P1)	*Increased openness in all stages of the scientific endeavour with the view to reinforcing the strength and rigour of scientific results, enhancing the societal impact of science and increasing the capacity of society as a whole.* *Increased openness leads to increased transparency and trust in scientific information*
			Collaboration, participation, inclusion (P4)	*collaborations ... should become the norm, and collaborations between disciplines should be promoted together with the full and effective participation of societal actors and inclusion of knowledge from marginalised*

		making processes.		*communities in solving problems of social importance*
			Responsibility, Respect, accountability (P3)	*with greater openness comes greater responsibility for all Open Science actors and stakeholders... which forms the basis for good governance of science*
	C3 For equitable outcomes	Taking into account that indigenous data are grounded in community values, any value created from such data should equitably provide benefits to indigenous communities and support their aspirations to wellbeing.	Collective benefit (V2)	*scientific knowledge should be openly available and its benefits universally shared. The practice of science should be inclusive, sustainable and equitable*
			Equity and Fairness (V3)	*Open Science should play a significant role in ensuring equity among researchers*
Authority to Control	A1 Recognizing rights and interests	recognise the collective and individual rights of indigenous peoples to free, prior and informed consent in the collection and use of indigenous knowledge and data, and in developing policies and protocols for data collection.	Quality and integrity (V1)	*respect academic freedom and human rights*
			Equity and Fairness (V3)	*Open Science should play a significant role in ensuring equity among researchers from developed and developing countries, enabling fair and reciprocal sharing of scientific inputs and puts*

	A2 Data for governance:	ensure that indigenous peoples and communities' right to access indigenous data is relevant to their worldviews and supports self-determination and self-governance is respected	Flexibility (P5)	*due to the diversity of science systems, actors and capacities … there is no one size fits all of practising open science. Different pathways of transition must be encouraged while upholding the core values of UNESCO recommendation*
	A3 Governance of data	ensure that indigenous peoples' right to develop cultural governance protocols for indigenous data is respected and that they are the ones to lead the stewardship and access to such data.	Sustainability (P6)	*Open Science should build on long term practices, services, infrastructures and funding models that ensure the equal participation of scientific producers from less privileged institutions and countries*
Responsibility	R1 For positive relationships	working with indigenous data entails being responsible for ensuring that the collection, processing and use of data respect	Equity and Fairness (V3)	*Open Science should play a significant role in ensuring equity among researchers from developed and developing countries, enabling fair and reciprocal sharing of scientific inputs and outputs*
			Equality of opportunities (P2)	*all.. have an equal opportunity to access, and contribute to and benefit from Open Science*

		the dignity of indigenous peoples and communities. As such, indigenous data use should be in line with relationships based on the values of respect, reciprocity, trust and mutual understanding.	Responsibility, Respect, accountability (P3)	*with greater openness comes greater responsibility for all Open Science actors and stakeholders... which forms the basis for good governance of science*
			Flexibility (P5)	*due to the diversity of science systems, actors and capacities … there is no one size fits all of practising open science. Different pathways of transition must be encouraged while upholding the core values of UNESCO recommendation*
	R2 For expanding capability and capacity	using indigenous data entails a reciprocal responsibility to improve data literacy and capacity in indigenous communities. To do so, users of indigenous data should help strengthen the development of an indigenous data workforce and digital infrastructure that supports data practices from creation to collection, management, security, governance	Collective benefit (V2)	*the practice of science should be inclusive, sustainable and equitable also in opportunities for scientific education and capacity development*
			Transparency, scrutiny, critique, reproducibility (P1)	*Increased openness in all stages of the scientific endeavour with the view to reinforcing the strength and rigour of scientific results … increasing the capacity of society as a whole*

		and application of data.		
	R3 For indigenous languages and worldviews	provide resources to guide data generation that is grounded in indigenous peoples languages, worldviews, lived experiences, values and principles.	Diversity and Inclusiveness (V4)	*Open Science should embrace a diversity of knowledge, practices,workflows, languages, research outputs and topics that support the needs and epistemic pluralism of the scientific community. … as well as the wider public and knowledge holders beyond the traditional scientific community, including indigenous peoples.*
			Flexibility (P5)	*due to the diversity of science systems, actors and capacities … there is no one size fits all of practising open science. Different pathways of transition must be encouraged while upholding the core values of UNESCO recommendation*
			Sustainability (P6)	*Open Science should build on long term practices, services, infrastructures and funding models that ensure the equal participation of scientific producers from less privileged institutions and countries*
Ethics	E1 For minimising harm and maximising benefits	Ethical data should not stigmatise indigenous peoples in terms of deficit, and must align with their ethical frameworks and rights. The assessment of potential harms and	Collective benefit (V2)	*Open Science should … and benefit humanity as a whole*
			Responsibility, Respect, accountability (P3)	*with greater openness comes greater responsibility for all Open Science actors and stakeholders together with … vigilance as to possible social and ecological consequences of research activities*

		benefits is to be carried out from their perspective.		
	E2 For justice	Ethical processes should address power and resources asymmetries, taking into account how these impact indigenous peoples' rights, and ensuring that relevant indigenous communities are adequately represented.	Equality of opportunities (P2)	*all.. have an equal opportunity to access, and contribute to and benefit from Open Science*
			Collaboration, participation, inclusion (P4)	*collaborations ... should become the norm, and collaborations between disciplines should be promoted together with the full and effective participation of societal actors and inclusion of knowledge from marginalised communities in solving problems of social importance*
	E3 For future reuse	Data governance should consider possibilities of future use and harm following ethical frameworks that are based on the values and principles of the relevant indigenous community. Metadata should provide information of the provenance and purpose, as well as any	Responsibility, Respect, accountability (P3)	*with greater openness comes greater responsibility for all Open Science actors and stakeholders together with ... vigilance as to possible social and ecological consequences of research activities, intellectual integrity, and respect for ethical principles and implications pertaining to research.*

		limitations in secondary use or consent issues.		

Table b. UNESCO values and principles for Open Science found in the CARE framework.

In this reverse mapping exercise, we observe the following:

Firstly, Collective benefit mirrors UNESCO's emphasis on inclusiveness, transparency, and openness in science, supporting the availability of research results and methods while ensuring that benefits are widely shared and inclusive. Secondly, Authority to Control, which focuses on governance and recognising the rights and interests of indigenous subjects, is recalled in the respect for academic freedom and human rights stated in the UNESCO framework. There, the sub-principles Data for governance and Governance of data are reflected in the UNESCO principles for sustainability and flexibility which acknowledge the importance of equal participation in research practices and encourage diverse pathways. Thirdly, Responsibility, whose underlying principles promote positive relationships, increasing capabilities and respect for diverse worldviews, reflects the importance placed by UNESCO on ensuring equity and responsibility among research actors, providing equal opportunities, recognising diverse science systems and knowledge holders beyond the traditional scientific community, and fostering capacity building in marginalised communities. Finally, the Ethics principle which focuses on minimising harm, and supporting ethical processes and future reuse, echoes the UNESCO principles of equality of opportunities in accessing and contributing to science, of responsibility for all actors involved in the scientific process, respect and accountability, as well as collaboration with, and inclusion of, marginalised communities in addressing societal issues in research.

References

[1] Bosman, Jeroen, Ian Bruno, Chris Chapman, Bastian Greshake Tzovaras, Nate Jacobs, Bianca Kramer, Maryann Elizabeth Martone, et al. 2017. 'The Scholarly Commons - Principles and Practices to Guide Research Communication'. OSF Preprints. https://doi.org/10.31219/osf.io/6c2xt.

[2] Carroll, Stephanie Russo, Ibrahim Garba, Oscar L. Figueroa-Rodríguez, Jarita Holbrook, Raymond Lovett, Simeon Materechera, Mark Parsons, et al. 2020. 'The CARE Principles for Indigenous Data Governance'. *Data Science Journal* 19 (1). https://doi.org/10.5334/dsj-2020-043.

[3] Carroll, Stephanie Russo, Edit Herczog, Maui Hudson, Keith Russell, and Shelley Stall. 2021. 'Operationalizing the CARE and FAIR Principles for Indigenous Data Futures'. *Scientific Data* 8 (1): 108. https://doi.org/10.1038/s41597-021-00892-0.

[4] Carroll, Stephanie Russo, Maui Hudson, Jarita Holbrook, Simeon Materechera, and Jane Anderson. 2020. 'Working with the CARE Principles: Operationalising Indigenous Data Governance'. Ada Lovelace Institute Blog. https://www.adalovelaceinstitute.org/blog/care-principles-operationalising-indigenous-data-governance/.

[5] European Commission: Directorate-General for Research and Innovation and PwC EU Services. 2018. *Cost-Benefit Analysis for FAIR Research Data - Cost of Not Having FAIR Research Data*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/02999.

[6] European Commission: Directorate-General for Research and Innovation. 2018. *Turning FAIR into Reality: Final Report and Action Plan from the European Commission Expert Group on FAIR Data*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/1524.

[7] European Commission. 2024. 'Horizon Europe (HORIZON) Euratom Research and Training Programme (EURATOM) General Model Grant Agreement'. https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/agr-contr/general-mga_horizon-euratom_en.pdf.

[8] European Parliament and European Council. 2023. *Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on Harmonised Rules on Fair Access to and Use of Data and Amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act) (Text with EEA Relevance)*. Official Journal of the European Union L 2023/2854. http://data.europa.eu/eli/reg/2023/2854/oj/eng.

[9] G7 Science Ministries. 2023. 'Annex 1: G7 Open Science Working Group (OSWG)'. https://www8.cao.go.jp/cstp/kokusaiteki/g7_2023/annex1_os.pdf.

[10] Gupta, Neha, Andrew Martindale, Kisha Supernant, and Michael Elvidge. 2023. 'The CARE Principles and the Reuse, Sharing, and Curation of Indigenous Data in Canadian Archaeology'. *Advances in Archaeological Practice* 11 (1): 76–89. https://doi.org/10.1017/aap.2022.33.

[11] Jennings, Lydia, Talia Anderson, Andrew Martinez, Rogena Sterling, Dominique David Chavez, Ibrahim Garba, Maui Hudson, Nanibaa' A. Garrison, and Stephanie Russo Carroll. 2023. 'Applying the "CARE Principles for Indigenous Data Governance" to Ecology and Biodiversity Research'. *Nature Ecology & Evolution* 7 (10): 1547–51. https://doi.org/10.1038/s41559-023-02161-2.

[12] Krūminas, Pijus, Joy Davidson, Ingrid Dillo, Carmela Asero, Jonas Antanavičius, Peter Doorn, Aurinta Garbašauskaitė, et al. 2022. *European Research Data Landscape Study Report (Deliverables 3.2, 4.2, 5.2)*. Zenodo. https://doi.org/10.5281/zenodo.7351121.

[13] Leonelli, Sabina. 2023. *Philosophy of Open Science*. Elements in the Philosophy of Science. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009416368

[14] van Reisen, Miriam, Mia Stokmans, Mariam Basajja, Antony Otieno Ong'ayo, Christine Kirkpatrick, Barend Mons. 2020. 'Towards the Tipping Point for FAIR Implementation'. *Data Intelligence* 2 (1-2): 264–275. https://doi.org/10.1162/dint_a_00049

[15] Royal Society. 2012. *Science as an Open Enterprise: Open Data for Open Science*. London: The Royal Society. https://royalsociety.org/-/media/policy/projects/sape/2012-06-20-saoe.pdf

[16] UNESCO. 2021. *UNESCO Recommendation on Open Science*. UNESCO Digital Library. https://doi.org/10.54677/MNMH8546.

[17] ———. 2023. *Open Science Outlook 1: Status and Trends around the World*. UNESCO Digital Library. https://doi.org/10.54677/GIIC6829.

[18] United Nations General Assembly. 2007. *United Nations Declaration on the Rights of Indigenous Peoples: resolution / adopted by the General Assembly*, A/RES/61/295'. https://www.refworld.org/legal/resolution/unga/2007/en/49353.

[19] Wilkinson, Mark D., Michel Dumontier, IJsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, et al. 2016. 'The FAIR Guiding Principles for Scientific Data Management and Stewardship'. *Scientific Data* 3 (March):160018. https://doi.org/10.1038/sdata.2016.18.