



A Narrative Analytical Review of Recovering Dark Data in Digital Document Preservation: An OAIS-Informed Perspective

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ABSTRACT

The rapid expansion of digital information has produced substantial dark data, unstructured, poorly described records lacking clear evidentiary purpose, which threatens institutional memory and evidentiary integrity. This narrative analytical review, using a PRISMA-adapted protocol across 45 sources, examines the Open Archival Information System (OAIS) as a framework for dark data recovery. A four-dimensional typology is proposed: structural stabilization, contextual reconstruction, evidentiary restoration, and ethical governance. OAIS Information Packages and Preservation Description Information enable reconstructive archival processes, restoring traceability and authenticity where provenance is incomplete. When augmented with AI-assisted metadata enrichment and ethical oversight, OAIS workflows transform dark data from latent liability into research-ready, trustworthy assets. This review highlights the integration of archival theory, metadata standards, and AI-driven curation to enhance discoverability, preserve authenticity, and mitigate epistemic and ethical risks, positioning OAIS as a dynamic infrastructure for responsible digital preservation and evidence-informed research.

Keywords: Dark data, OAIS, digital preservation, metadata, ethical governance

1.0 INTRODUCTION

Digital information has grown exponentially, creating a paradox for contemporary organizations: while storage capacities increase, a substantial portion of accumulated records remains unused, unanalysed, or poorly contextualized, forming the phenomenon widely termed dark data (Angelo, 2021; Corallo *et al.*, 2021; Gimpel, 2020; Marumolwa & Marnewick, 2025). Within archival and records management contexts, dark data manifests as unprocessed emails, incomplete metadata, legacy file formats, system logs, and digital traces lacking provenance and contextual anchoring (Jaillant, 2019; Jaillant & Caputo, 2022; Bowers *et al.*, 2024; O'Sullivan, 2025). This persistence undermines institutional memory, elevates regulatory risk, and complicates cybersecurity management (Gimpel & Alter, 2021; Ghosh & Singh, 2023; Bernard & Balog, 2025). Furthermore, incomplete or biased datasets compromise research validity, trustworthiness, and accountability (Morley *et al.*, 2020; Tiribelli *et al.*, 2024; Sanbein, 2025). Against this backdrop, the Open Archival Information System (OAIS) offers a conceptual and operational framework for rendering dark data intelligible, ethically managed, and preservation-ready (Jaber & Abbad, 2023; Maiorana, 2025; Pacheco *et al.*, 2023). When coupled with AI-assisted metadata enhancement and ethical reflection mechanisms, OAIS has the potential to transform dark data from latent liability into strategic archival and research assets

(Hernandez & Rockembach, 2025; Mannheimer *et al.*, 2024; Teel, 2024; Baird & Schuller, 2020).

1.1 Statement of the Problem

Despite growing investments in digital preservation infrastructures, vast volumes of organizational and archival records remain inaccessible, poorly contextualized, or analytically unusable. Causes include insufficient metadata, fragmented provenance, legacy formats, and limited alignment between OAIS-like standards and contemporary analytical practices (Consultative Committee for Space Data Systems, 2024; Angelo, 2021; Atah & Akeke, 2024; Al-Khateeb & Al-Juboori, 2023).

These deficits compromise evidentiary integrity, weaken institutional memory, and limit the reliability of evidence-informed research (Cook, 2011; Harris, 2002; Ezeani & Nwafor, 2024). Moreover, while OAIS provides a robust digital preservation architecture, its application to recovering dark data remains insufficiently theorized, with most literature treating dark data as a technical or organizational risk and OAIS as a normative standard rather than an epistemic framework (CCSDS, 2024; Kamau & Njoroge, 2023; Chen *et al.*, 2023).

1.2 Aim of the Study

The aim of this review was to analytically investigate how OAIS can facilitate recovery, contextualization, and ethical governance of dark data in digital document

preservation, with implications for evidence-informed research.

1.3 Objectives of the Study

To operationalize the stated aim and address the epistemic vulnerabilities inherent in dark data, this study is guided by four interconnected objectives that proceed logically from conceptual grounding to practical application. This sequential framework ensures a comprehensive examination that moves beyond technical description toward theoretical contribution. By progressing from the ontological characterization of dark data to the application of the OAIS model, followed by a critical evaluation of ethical implications, the study culminates in a synthetic proposal for transforming latent liabilities into archival assets. Collectively, these objectives structure the inquiry to bridge archival theory, preservation practice, and ethical governance, as detailed below:

- i. Conceptually examine the nature and persistence of dark data in digital archival and records management environments, with emphasis on issues of provenance, metadata insufficiency, and technological obsolescence.
- ii. Analyse the Open Archival Information System (OAIS) reference model as a framework for recovering, contextualising, and preserving dark data, focusing on its core functional entities, information packages, and preservation metadata components.
- iii. Evaluate the epistemic and ethical implications of unrecovered dark data for evidence-informed

research, particularly in relation to authenticity, trustworthiness, accountability, and responsible reuse of digital records.

- iv. Synthesize insights from archival science, digital preservation, and ethical data governance literature to demonstrate how OAIS-aligned practices can transform dark data from a latent organisational liability into a credible archival and research asset.

1.4 OAIS-Informed Conceptual Framework

OAIS provides a conceptual lens for understanding dark data recovery, emphasizing structured pathways from Submission Information Packages (SIPs) to Archival (AIPs) and Dissemination (DIPs), augmented by Preservation Description Information (PDI) documenting provenance, context, fixity, and access rights (Cook, 2011; Harris, 2002; Pacheco *et al.*, 2023). OAIS functional entities, Ingest, Data Management, Archival Storage, Preservation Planning, Access, and Administration, enable systematic governance, ethical oversight, and scholarly rehabilitation of unstructured or latent digital materials (CCSDS, 2024; Cameron *et al.*, 2023; Li & Xu, 2024). AI-assisted enrichment further improves discoverability, metadata quality, and semantic linkage, mitigating the risks of fragmentation while requiring embedded ethical reflection (Hernandez & Rockembach, 2025; Mannheimer *et al.*, 2024; Biagini, 2025).

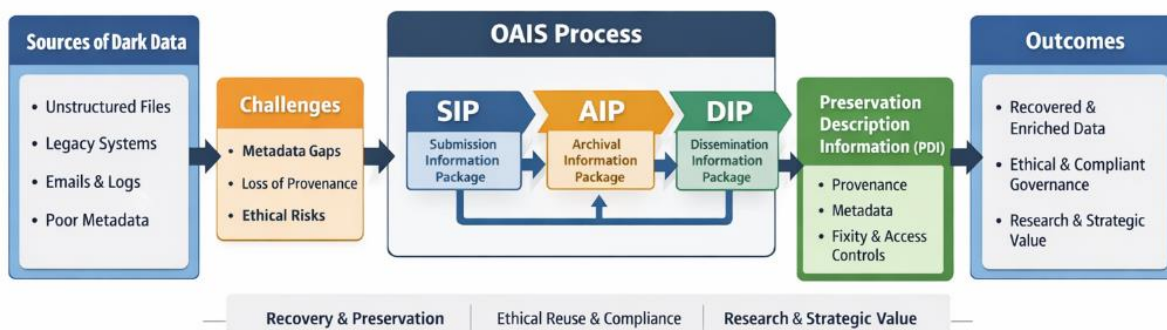


Figure 1. Conceptual Framework addressing Dark Data with OAIS

The diagram presents a conceptual OAIS-based framework for recovering dark data in digital document preservation. Dark data is processed through OAIS functional entities, Ingest, Archival Storage, Data Management, Preservation Planning, Access, and Administration, using Submission, Archival, and Dissemination Information Packages enriched with preservation metadata. AI-assisted curation and ethical

governance enhance discoverability, provenance, and responsible reuse. The framework transforms unstructured or latent records into structured, reliable, and evidence-ready digital resources.

2.0 LITERATURE REVIEW

Although OAIS provides a structured preservation architecture, the recovery of dark data exposes epistemic

tensions. These tensions are not merely technical but involve the ontological and evidentiary nature of pre-archival digital material (Angelo, 2021; Corallo et al., 2021; Marumolwa & Marnewick, 2025; Jaillant, 2019). OAIS presumes coherent Submission Information Packages (SIPs) with associated Preservation Description Information (PDI) at ingest (CCSDS, 2024; O'Sullivan, 2025). Dark data, however, is often unstructured, fragmented, and lacking provenance (Gimpel, 2020; Corallo et al., 2021; Jaber & Abbad, 2023; Gimpel & Alter, 2021). Legacy emails, logs, and databases exist in a pre-archival liminality that requires reconstructive archival labour (Jaillant & Caputo, 2022; Cameron et al., 2023; Maiorana, 2025). This necessitates retroactive metadata generation, contextual reconstruction, and inferential provenance, bridging gaps between what exists and what OAIS expects (Cook, 2011; Bhatia & Kumar, 2024; Pacheco et al., 2023).

OAIS relies on the "Designated Community" to define adequate Representation Information (CCSDS, 2024). Dark data, whose value is latent or context-dependent, lacks a clear audience, rendering metadata decisions speculative (Gimpel, 2020; Trajanov, 2018; George et al., 2023; Kim, 2024). This raises epistemic questions: whose frameworks guide recovery, and how much contextualization is sufficient? Preservation Description Information safeguards authenticity, but for dark data, it must reconstruct missing provenance and context (Cook, 2011; Harris, 2002; Pacheco et al., 2023). Reconstructive efforts introduce uncertainty, interpretive bias, and meta-documentation requirements to maintain evidentiary transparency (Sanbein, 2025; Bernard & Balog, 2025; Shehu et al., 2025).

AI can scale metadata recovery, pattern detection, and semantic annotation (Hernandez & Rockembach, 2025;

Mannheimer et al., 2024; Teel, 2024; Li & Xu, 2024). However, algorithmic opacity and bias pose ethical and epistemic risks, potentially substituting one form of uncertainty with another (Morley et al., 2020; Tiribelli et al., 2024; Jaillant & Rees, 2023; Biagini, 2025; Baird & Schuller, 2020). OAIS can function as an epistemic infrastructure when applied flexibly:

- i. Documenting reconstructive decisions and interpretive frameworks (Shehu et al., 2025; Mannheimer et al., 2024);
- ii. Iterative SIP development as context emerges (CCSDS, 2024; O'Sullivan, 2025);
- iii. Embedding ethical reflection to mitigate bias and ensure accountability (Mannheimer et al., 2024; Willem et al., 2025);
- iv. Accepting that recovered dark data may retain degrees of uncertainty (Gimpel, 2020; Zhou, 2020; Dlamini & Moyo, 2025).

3.0 METHODOLOGY

A narrative analytical review approach was adopted (Cook, 2011; Jaillant, 2022). Using a PRISMA-adapted selection process, 45 sources were retained from 135 initially identified publications, emphasizing relevance to dark data, OAIS, AI-assisted archival practice, and ethical governance. A detailed breakdown of the screening stages is provided in Figure 2. Analysis used a hybrid coding strategy combining deductive OAIS-derived categories with inductive thematic emergence (Zhang & Li, 2024; Shehu et al., 2025; Wang & Chen, 2025). Triangulation ensured conceptual rigour across archival theory, digital preservation scholarship, and AI governance literature.

PRISMA Flow Diagram – Dark Data & OAIS Narrative Review

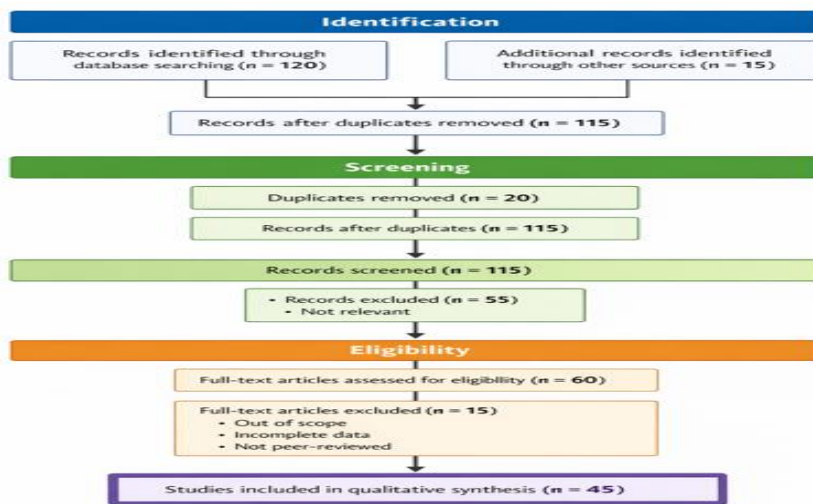


Figure 2. PRISMA Flow Diagram

Source: Researchers, 2025

After applying the inclusion and exclusion criteria, 45 studies were selected for the final synthesis. Figure 2

presents the PRISMA flow diagram detailing each stage of the screening process, from the initial identification of 135 records to the final 45 included sources

4.0 FINDINGS AND DISCUSSION

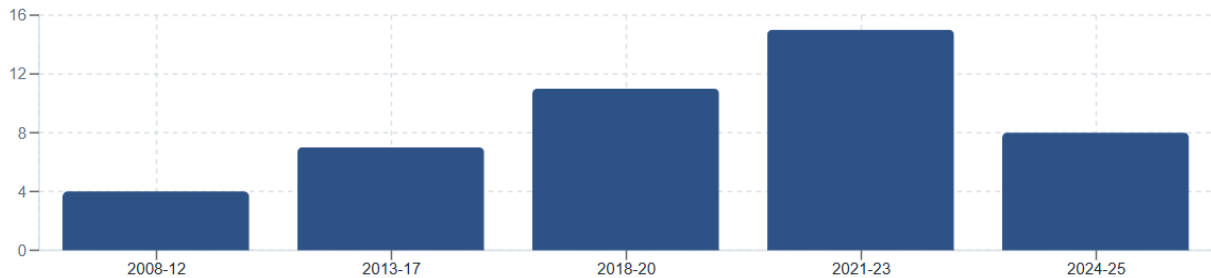


Figure 3. Publication Year Distribution

To understand the temporal trajectory of scholarship in this area, the 45 included sources were analyzed by publication year. As shown in Figure 3, scholarly activity peaked between 2021 and 2023, reflecting growing academic interest in AI-assisted preservation and ethical data governance.

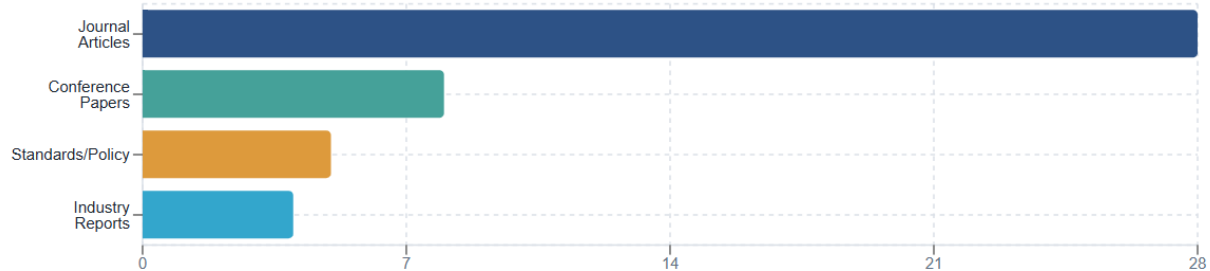


Figure 4. Source Type Classification

The 45 included sources were categorized by publication type to assess the nature of available evidence. As presented in Figure 4, peer-reviewed journal articles constituted the majority of the corpus (62%), supplemented by conference proceedings and authoritative standards documents.

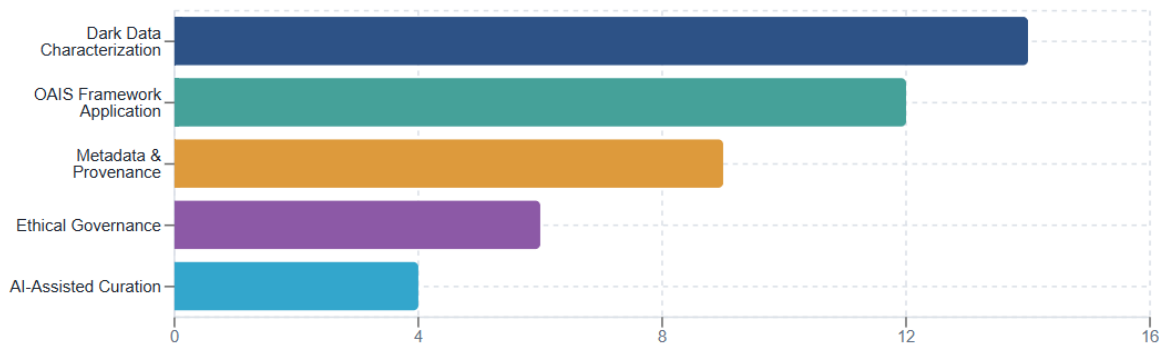


Figure 5. Thematic Distribution of Sources

To identify the predominant areas of inquiry within the literature, the 45 included sources were analyzed according to their primary thematic focus. As illustrated in Figure 5, dark data characterization and the OAIS (Open Archival Information System) framework application emerged as the dominant themes across the corpus.

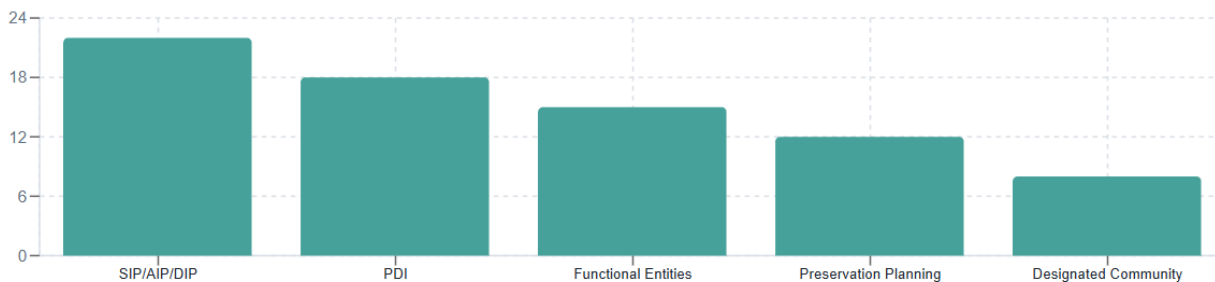


Figure 6. OAIS Components in Dark Data Recovery

To understand how OAIS conceptual frameworks are operationalized in the context of dark data recovery, the literature was examined for references to specific OAIS components. As shown in Figure 6, Information Packages (SIP/AIP/DIP) and Preservation Description Information (PDI) emerged as the most frequently discussed components for transforming dark data into preservation-ready assets.

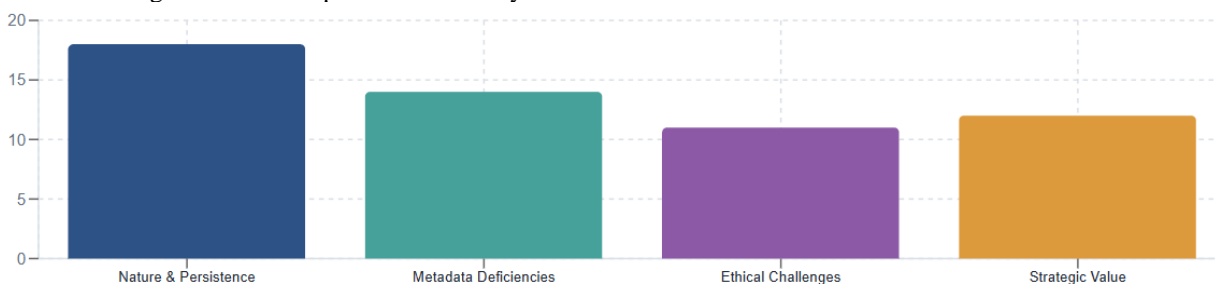


Figure 7. Key Findings by Category

To synthesize the evidence in relation to the study objectives, the 45 sources were analyzed according to four core findings. As presented in Figure 7, the nature and persistence of dark data received the most scholarly attention, indicating a foundational concern with understanding the problem before addressing preservation solutions.

4.1 A Four-Dimensional Typology of Dark Data Recovery

A four-dimensional typology was synthesized: structural, contextual, evidentiary, and ethical recovery from the review.

- i. Encompasses format normalization, bit-level integrity, and storage stabilization (CCSDS, 2024; Corallo *et al.*, 2021; Jaillant, 2019).
- ii. Metadata and provenance enhancement re-establish the archival bond linking records to their administrative and functional origins (Angelo, 2021; Cameron *et al.*, 2023; Pacheco *et al.*, 2023).
- iii. Fixity, reference validation, and provenance reconstruction restore authenticity and trustworthiness (Cook, 2011; Harris, 2002; Jaillant, 2022).

iv. AI-assisted workflows operate under governance frameworks ensuring fairness, transparency, and responsible reuse (Bernard & Balog, 2025; Hernandez & Rockembach, 2025; Mannheimer *et al.*, 2024; Tiribelli *et al.*, 2024; Sanbein, 2025).

4.2 Discussion

The review indicates that dark data in digital archives consists of unstructured, incomplete, or poorly documented records, such as emails, logs, legacy files, and weak metadata, persisting due to fragmented provenance, insufficient governance, and technological obsolescence (Angelo, 2021; Jaillant, 2019; Corallo *et al.*, 2021; Gimpel, 2020; Gimpel & Alter, 2021). These gaps undermine institutional memory, evidentiary integrity, and evidence-informed research (Cook, 2011; Harris, 2002;). Metadata and provenance deficiencies hinder discoverability, interoperability, and analytical reuse (Zhou, 2020; Cameron *et al.*, 2023; Teel, 2024), while unmanaged dark data introduces ethical and epistemic risks, including bias, lack of transparency, and non-compliance (Bernard & Balog, 2025; Morley *et al.*, 2020; Tiribelli *et al.*, 2024; Sanbein, 2025). OAIS addresses these issues through structured information packages and Preservation Description Information,

restoring traceability and enabling responsible reuse (Jaillant, 2022; Pacheco *et al.*, 2023; Hernandez & Rockembach, 2025). Complemented by AI-assisted curation, OAIS transforms dark data into a reliable, strategic archival and research resource (Bowers *et al.*, 2024; Maiorana, 2025; Mannheimer *et al.*, 2024).

4.3 Implications

Persistent dark data arises from insufficient metadata, technological obsolescence, and governance gaps (Angelo, 2021; Corallo *et al.*, 2021; Gimpel & Alter, 2021). OAIS provides structured pathways for transforming these liabilities into evidence-ready assets, augmented by AI for scalable enrichment, while ethical oversight mitigates bias (Jaillant & Caputo, 2022; Hernandez & Rockembach, 2025; Teel, 2024; Bernard & Balog, 2025).

5.0 CONCLUSION

OAIS bridges technical, organizational, and epistemic dimensions, transforming dark data into strategic archival and research assets. Integration with AI and collaborative ethical workflows enhances usability, recoverability, and governance (Hernandez & Rockembach, 2025; Teel, 2024; Mannheimer *et al.*, 2024; Bowers *et al.*, 2024; Maiorana, 2025). This study advances digital preservation scholarship by positioning OAIS as a dynamic epistemic infrastructure capable of addressing dark data's ontological vulnerabilities, operationalizing a four-dimensional recovery typology, and reconciling technical protocols with ethical imperatives.

5.1 Contribution and Limitations

By synthesizing archival theory, international preservation standards, and emerging AI governance scholarship, this narrative review provides a roadmap for transforming latent digital liabilities into trustworthy, evidence-ready assets (Cook, 2011; CCSDS, 2024; Mannheimer *et al.*, 2024; Bernard & Balog, 2025; Shehu & Ogbonna, 2025). The review is interpretive, reliant on conceptual synthesis, and not empirically validated. Future work should combine institutional case studies, empirical testing, and broader disciplinary perspectives (Dlamini & Moyo, 2025; Wang & Chen, 2025; Li & Xu, 2024).

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