International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Special Edition: Volume: 04 PKDAL – 2025 DOI: 10.55041/ISJEM.PKDAL034
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

A Study of Digital Resources Preservation: Techniques and Tools

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Abstract

Digital preservation is a critical process for ensuring long-term access to digital resources in an era of rapid technological change. This study paper explores the primary techniques and tools used in digital preservation, including migration, emulation, encapsulation, and bit-level preservation. It examines open-source and commercial tools such as DSpace, Eprints, Greenstone, alongside case studies of Dspace application. The paper also addresses challenges like technological obsolescence, resource constraints, and metadata management. The findings underscore the importance of proactive strategies, robust policies, and interdisciplinary collaboration to safeguard digital heritage.

Keyword: E-resources, digital preservation, digital library, DSpace, Eprint, Geenstone

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1. Introduction

In the digital era, libraries and archives face the critical challenge of preserving vast amounts of born-digital and digitized content to ensure long-term access and usability. Digital preservation, a cornerstone of modern library science, encompasses strategies, methodologies, and technologies designed to safeguard digital assets against obsolescence, degradation, and technological change. As cultural heritage institutions increasingly rely on digital formats to store information—ranging from manuscripts and photographs to websites and multimedia—effective preservation techniques and tools have become essential to maintaining the integrity, authenticity, and accessibility of these resources for future generations.

The rapid evolution of technology poses unique challenges to digital preservation. File formats become obsolete, storage media degrade, and software dependencies shift, threatening the longevity of digital content. Simultaneously, the exponential growth of data demands scalable and sustainable solutions. Digital preservation techniques, such as migration, emulation, and metadata standardization, address these issues by ensuring that digital objects remain usable and interpretable over time. Tools like Eprint, DSpace, and Greenstone have emerged to support these efforts, offering robust frameworks for managing, storing, and securing digital collections. These solutions not only protect against data loss but also align with principles of interoperability and compliance with international standards, such as the OAIS reference model.

This paper explores the landscape of digital preservation techniques and tools, examining their theoretical foundations, practical applications, and limitations. By analyzing current methodologies and technologies, it aims to provide insights into best practices for library professionals tasked with preserving digital heritage. As libraries navigate the complexities of digital stewardship, understanding these tools and techniques is crucial

to ensuring that digital resources remain accessible, fostering knowledge continuity in an ever-evolving technological landscape.

2. Objective

The primary objective of this research paper is to critically examine the techniques, tools, and institutional practices involved in the digital preservation of e-resources, with a particular focus on library systems in India. Specifically, the study aims to:

- Identify and analyse the core digital preservation techniques—such as migration, emulation, encapsulation, metadata standardization, redundancy, and web archiving—and assess their applicability and effectiveness in library environments.
- To evaluate widely used digital preservation tools including DSpace, EPrints, Greenstone, LOCKSS, and Web Recorder, highlighting their functionalities, strengths, limitations, and alignment with international standards such as OAIS and Dublin Core.
- Assess the challenges faced by Indian libraries and institutions in implementing digital preservation—such as technological obsolescence, metadata inconsistencies, lack of skilled personnel, and policy gaps.
- To Promote awareness and best practices by offering recommendations for improving digital preservation strategies through robust policy formulation, capacity building, and adoption of interoperable standards.

3. Methodology

This study adopts a qualitative approach, synthesizing findings from a literature review and case studies. The literature review draws on peer-reviewed articles from Research Gate, google scholar, various websites and Case studies are selected to illustrate the application of preservation techniques and tools in diverse contexts, including research data management, archival records, and cultural heritage. The analysis evaluates the effectiveness, scalability, and challenges of these techniques and tools, with a focus on their alignment with international standards like the Dublin core metadata standerds, Open Archival Information System (OAIS).

4. Literature Review

Digital preservation has attracted growing attention among Indian researchers and institutions, who are actively engaging with international frameworks such as OAIS and metadata standards while adapting practices to local contexts.

Katre (2011) provides a critical Indian lens on digital convergence in libraries, archives, and museums, emphasizing that digital preservation is yet to be fully integrated in curricula and practice across heritage institutions in India Policy frameworks for digital preservation in Indian libraries remain nascent, with gaps in coordinated approaches and standardization across institutions. Research on Shodhganga's metadata practices highlights pressing quality concerns in ETD repositories.

Tapaswi (2023) identifies issues such as duplicate records, missing abstracts, non standard cataloging, misclassification by subject and department, and inconsistent file linking—and recommends robust metadata controls and training to address these flaws. Complementary analysis by Ranjan et al. (2023) compares metadata standards (Dublin Core, METS, MODS, ETD MS) across global ETD platforms, including Shodhganga, to advocate for greater interoperability and standard compliance in Indian repositories Shodhganga, hosted by the INFLIBNET Centre.

Velmurugan (2013) and Arora (2006) describe how technical heterogeneity, format obsolescence, and limited professional skills challenge preservation, while calling for systematic digitization, policy formulation, and cooperative frameworks across institutions. These findings align with global scholarship on migration, metadata standardization, and distributed storage, reinforcing the relevance of techniques such as LOCKSS, emulation, encapsulation, and web archiving. Migration , the most widely used method, involves transferring digital content from obsolete formats to newer, more sustainable ones. It is supported by studies from Hedstrom (1998) and Rosenthal et al. (2005), who highlight both its practicality and its risks—particularly potential data loss or changes in rendering fidelity.

Emulation, discussed by Rothenberg (1999), offers an alternative by recreating the original environment needed to access content. While offering high fidelity and authenticity, emulation is technically demanding, requiring long-term support for obsolete systems. Metadata standardization is emphasized by Gilliland-Swetland (2000), who argues that structured metadata is essential for ensuring the discoverability and contextual understanding of preserved digital assets. Complementary to OAIS are metadata standards such as Dublin Core, PREMIS (Preservation Metadata), and METS (Metadata Encoding and Transmission Standard), which support the documentation of digital object provenance, structure, and preservation history (Caplan, 2009).

5. Digital Preservation Techniques

Digital preservation techniques for library resources are critical for ensuring long-term access to digital content in the face of technological obsolescence, media degradation, and evolving user needs. Below is a concise overview of key techniques tailored for library resources, informed by established practices in libraries:

5.1. Migration

Migration involves converting Print to Digital (document scanning) and digital objects from outdated file formats or systems to current, widely supported formats to maintain accessibility. In libraries, this process is applied to resources such as digitized manuscripts, e-books, or databases—such as converting PDF 1.4 files to PDF/A—to ensure they remain compatible with modern software and systems. The primary advantage of migration is that it maintains the usability of digital materials and is relatively straightforward to implement. However, challenges include the potential risk of data loss or alteration during the conversion process and the need for continuous monitoring of evolving format standards.

5.2. Emulation

Emulation replicates the original software or hardware environment to access digital objects in their native formats, preserving both functionality and authenticity. In libraries, emulation is particularly valuable for maintaining access to legacy digital collections, such as old CD-ROM databases or early digital archives that depend on specific, often obsolete, software environments. A key advantage of emulation is its ability to preserve the original user experience and ensure historical accuracy. However, it presents challenges due to its technical complexity and the need for specialized expertise and ongoing support to maintain emulators.

5.3. Metadata Standardization

Creating and maintaining detailed metadata—such as OAI-PMH , PREMIS or Dublin Core—documents the context, structure, and preservation actions of digital objects, playing a critical role in digital preservation. In libraries, metadata is used to track important information like file formats, provenance, and access rights for digital resources such as journals or institutional repositories. The use of metadata enhances discoverability

and ensures the long-term interpretability of digital content. However, it can be time-intensive to implement and requires consistent application across collections to be effective.

5.4. Redundancy and Distributed Storage

Storing multiple copies of digital objects across geographically dispersed locations is a preservation strategy designed to mitigate data loss. In libraries, this approach is commonly implemented using systems like LOCKSS (Lots of Copies Keep Stuff Safe), which enable the creation of redundant, secure backups for e-journals or digitized collections. The main advantage of this method is its ability to increase resilience against hardware failures, natural disasters, or other threats to digital content. However, it also presents challenges, such as high storage costs and the need for coordination among multiple institutions.

5.5. Encapsulation

Packaging digital objects with their metadata and dependencies—such as software and documentation—is a method known as encapsulation, aimed at ensuring future usability. In libraries, this approach is used to preserve complex resources like audio-visual collections by including essential playback instructions and contextual information. The advantage of encapsulation lies in its comprehensive preservation of both the digital object and its operating environment. However, it also introduces challenges, including increased storage demands and the complexity of managing bundled components. An example is encapsulating a digital video archive along with its codec and player documentation to support future access and interpretation.

5.6. Web Archiving

Capturing and preserving dynamic web content, such as library websites or online exhibits, involves using tools like WebRecorder to ensure long-term access to ephemeral digital materials. Libraries apply this approach to archive their websites, digital exhibits, or open-access repositories, maintaining records of online content. The main advantage is its ability to preserve interactive and short-lived content that might otherwise be lost. However, challenges include the difficulty of capturing dynamic or database-driven content accurately and the need for regular updates to keep archives current.

Libraries must align preservation strategies with the OAIS reference model to ensure standardized workflows. Budget constraints, staff expertise, and the diversity of digital formats (e.g., text, multimedia, databases) influence technique selection. Regular audits and policy updates are essential to adapt to technological changes.These techniques, when combined with robust tools and policies, enable libraries to safeguard digital resources, ensuring their accessibility and integrity for future generations.

6. Digital Resources Preservation Tools

E-resources preservation tools are vital for libraries to protect and maintain long-term access to digital content such as e-books, electronic journals, databases, and multimedia collections. As the volume of digital materials grows, libraries face challenges including file format obsolescence, hardware failures, and evolving software environments that threaten the usability and integrity of these resources. Preservation tools help address these challenges by enabling activities like format migration, emulation, metadata management, and distributed storage, ensuring that digital collections remain accessible and authentic over time. There is many tools are available in the market but here is discussed some commonly used e-resources preservation tools in libraries like LOCKSS (Lots of Copies Keep Stuff Safe) for decentralized digital preservation, Web Recorder for capturing dynamic web content, DSpace, eprints and Greenstone for managing institutional repositories with built-in preservation features, and Greenstone for building digital libraries with multimedia support. Together,

these tools empower libraries to safeguard their digital heritage and support on-going access for researchers and the public.

6.1 DSpace

Image Source: https://dspace.org/

DSpace is an open-source digital repository software platform used for building open access repositories for scholarly and research content. Developed jointly by MIT Libraries and HP Labs in 2002, DSpace has become one of the most widely adopted digital library solutions globally, particularly among academic, research, and institutional libraries.

Key Features:

• Open Source: Freely available under the BSD open-source license, allowing customization and community-driven development.

• Metadata Support: Uses Dublin Core as the default metadata standard, with support for qualified Dublin Core, METS, MODS, PREMIS, and OAI-PMH for metadata harvesting.

• Content Types: Supports a wide range of digital content including PDFs, images, videos, datasets, and audio files.

• Submission Workflow: Offers configurable submission and approval workflows, including user roles, review processes, and embargo options.

• Access Control: Allows restriction of access to content at the item, collection, or community level.

• Preservation Tools: Includes basic preservation features like checksum verification and format registries, and supports integration with preservation tools.

• Web Interface: Provides a user-friendly web interface for submission, search, browsing, and administration.

• Search & Browse: Full-text search, faceted browsing, and filtering by author, title, subject, and more.

• Multilingual Support: Supports multiple languages for interface and metadata.

• Integration: Can be integrated with institutional systems (like LDAP/AD for authentication) and discovery platforms.

6.2 eprints

Image source: https://files.eprints.org/

eprints is an open-source digital repository software developed at the University of Southampton, UK, and first released in 2000. It is designed to manage, preserve, and disseminate digital content, particularly scholarly and scientific publications. EPrints is widely used by academic institutions for building institutional repositories, open access archives, and research data repositories.

Key Features:

- Open Source: Released under the GNU General Public License (GPL), EPrints is free to use and highly customizable.
- Metadata Flexibility: Supports Dublin Core by default but allows institutions to define custom metadata schemas suited to their collections.
- Content Types: Handles various digital object types including text documents (e.g., PDFs), images, videos, datasets, and audio files.
- User Roles and Workflow: Offers configurable workflows for deposit, review, and publication, with roles such as authors, editors, and administrators.
- Access Control: Fine-grained control over who can view, edit, or manage content, including embargo options.
- Search & Browse: Powerful search functionality, with options to browse by author, year, subject, or type. Also supports full-text indexing.
- OAI-PMH Compliance: Supports Open Archives Initiative Protocol for Metadata Harvesting, allowing easy sharing and exposure of metadata to aggregators like OpenAIRE and BASE.
- Multilingual Support: Offers interface and metadata support in multiple languages.
- Statistics and Reporting: Built-in tools for tracking repository usage, downloads, and citation metrics.

6.3 Greenstone

Image Source: https://gti.greenstone.org/cgi-bin/library.cgi?e=p-00000-00---off-0--00-----01-10-00---0---0prompt-10----4-------0-1l--10-en-50---1-20-home---0--1-00-00--4----0-0-01-10---0utfZz-8-00&a=p&p=gsdl

Greenstone is an open-source digital library software suite developed by the New Zealand Digital Library Project at the University of Waikato. It was first released in 1997 and is designed to build, distribute, and manage digital library collections in a flexible and scalable way. Greenstone is widely used by libraries, museums, universities, and other institutions to provide access to diverse types of digital content.

Key Features:

- Open Source: Greenstone is freely available under the GNU General Public License (GPL), allowing customization and extension by users worldwide.
- Multimedia Support: Capable of handling a wide range of digital formats including text, images, audio, video, and composite multimedia collections.
- Metadata Standards: Supports multiple metadata schemas such as Dublin Core, METS, NZGLS (New Zealand Government Locator Service), and AGLS (Australian Government Locator Service).
- Flexible Collection Building: Users can create collections with complex hierarchical structures, combining heterogeneous materials and metadata.
- Powerful Search & Browsing: Provides full-text search, fielded search, and browsing by metadata fields such as author, title, subject, and date.
- Customizable User Interface: Offers configurable themes and multilingual support, enabling tailored user experiences.
- Interoperability: Supports standards like OAI-PMH for metadata harvesting, enabling integration with other digital repositories and aggregators.
- Import & Export: Easily imports content in various formats and exports collections to CD/DVD or web servers for distribution.

6.4 LOCKSS:

Image Source: https://www.lockss.org/about/about-our-logo

LOCKSS (Lots of Copies Keep Stuff Safe) is an open-source digital preservation software system developed by Stanford University Libraries to ensure the long-term preservation and accessibility of digital content. Designed primarily for libraries and publishers, LOCKSS creates a decentralized network of participating institutions that preserve and provide access to replicated copies of digital materials, especially scholarly e-journals and other electronic publications.

Key Features:

- Decentralized Preservation: LOCKSS operates on a peer-to-peer network model where multiple copies of digital content are stored across geographically dispersed locations to protect against data loss.
- Automated Crawling and Harvesting: The system automatically collects and updates content from publisher websites or institutional repositories using web crawling technologies.
- Content Integrity Checking: LOCKSS regularly compares copies across its network to detect and repair corrupted or altered files, ensuring authenticity and integrity.

- Open Source: Freely available under an open-source license, allowing institutions to deploy and customize LOCKSS nodes according to their needs.

- Supports Various Content Types: Commonly used for e-journals, books, and other scholarly materials, but adaptable to diverse digital content.

- Access Control: Participating libraries control local access to preserved content, ensuring compliance with copyright and licensing agreements.

- Interoperability: Supports standards like OAI-PMH for metadata harvesting and can be integrated with institutional repositories and digital libraries.

6.5 Web Recorder

Image Source: https://netpreserve.org/about-us/members/webrecorder/

Web Recorder is a web archiving tool designed to capture and preserve dynamic, interactive web content exactly as users experience it in their browsers. Developed by Rhizome, Web Recorder allows users to create high-fidelity, browsable archives of websites, including complex multimedia, JavaScript-driven elements, and interactive features that traditional web crawlers often miss.

Key Features:

- High-Fidelity Web Capture: Records web pages along with all embedded resources—images, videos, scripts, and interactive elements—preserving the exact look and feel.

- User-Driven Archiving: Unlike automated crawlers, WebRecorder captures content through user browsing sessions, ensuring dynamic content like maps, forms, and media players are fully archived.

- WARC File Format: Saves captures in the standardized Web ARChive (WARC) format, facilitating long-term storage and interoperability with other web archiving tools.

- Replay and Browsing: Archives can be replayed in browsers exactly as originally viewed, allowing future users to interact with the preserved content.

- Open Source: Available under an open-source license, enabling customization and integration into digital preservation workflows.

- Cross-Platform: Runs as a desktop application or as a web service, supporting multiple operating systems.

7. Case Studies

7.1 DSpace:

Shodhganga is a digital repository of Indian electronic theses and dissertations (ETDs), maintained by the INFLIBNET Centre (Information and Library Network Centre), an autonomous Inter-University Centre of the University Grants Commission (UGC) of India. The repository provides open access to theses and dissertations submitted by research scholars from Indian universities. To manage, preserve, and provide

seamless access to this vast and growing collection, Shodhganga uses the DSpace digital repository software as its core platform.

Image Source: https://shodhganga.inflibnet.ac.in/

7.2 eprints

Vidyanidhi (meaning "Treasure of Knowledge") was one of the pioneering digital library initiatives in India aimed at archiving and disseminating Indian doctoral research. It was launched by the University of Mysore, with support from the Department of Information Technology (DIT), Government of India, and the Ford Foundation. To manage and provide open access to electronic theses and dissertations (ETDs), Vidyanidhi implemented the EPrints digital library software, leveraging its flexibility and metadata-rich structure.

Image source: https://www.vidyanidhi.org.in/#google_vignette

7 .3 Greenstone:

The Digital Library of India (DLI) is one of the most ambitious digital library initiatives in India, aimed at preserving and providing free access to the rich cultural and literary heritage of the nation. Spearheaded by the Indian Institute of Science (IISc), Bangalore, in collaboration with other major institutions like the Indian Institutes of Technology (IITs) and International Digital Library Projects, the DLI project uses the Greenstone Digital Library Software to build and manage its extensive multilingual digital collections.

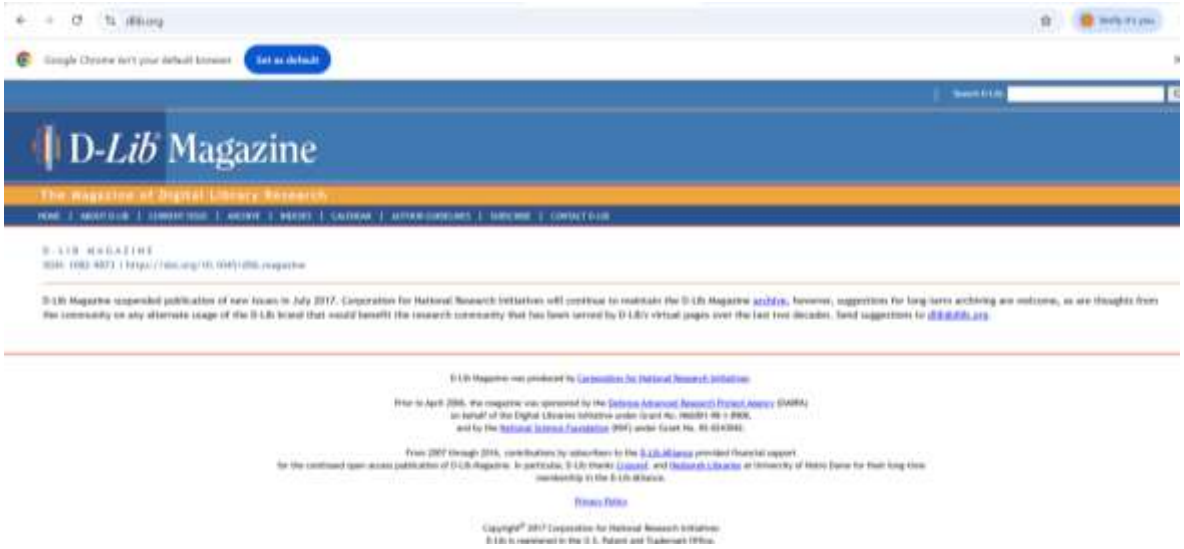

Image Source: www.dlib.org

7.4 LOCKSS (Lots of Copies Keep Stuff Safe)

Digital preservation has become a growing concern for Indian libraries, especially with the increasing reliance on e-resources and digital archives. To address this, the National Digital Preservation Program (NDPP), initiated by the Ministry of Electronics and Information Technology (MeitY), Government of India, identified and promoted the adoption of trusted digital preservation frameworks. As part of this initiative, some Indian academic and research institutions adopted the LOCKSS (Lots of Copies Keep Stuff Safe) software to ensure the long-term preservation and access of electronic journals and digital content. Some participating universities, such as the University of Hyderabad and Jawaharlal Nehru University (JNU), began pilot projects using LOCKSS.

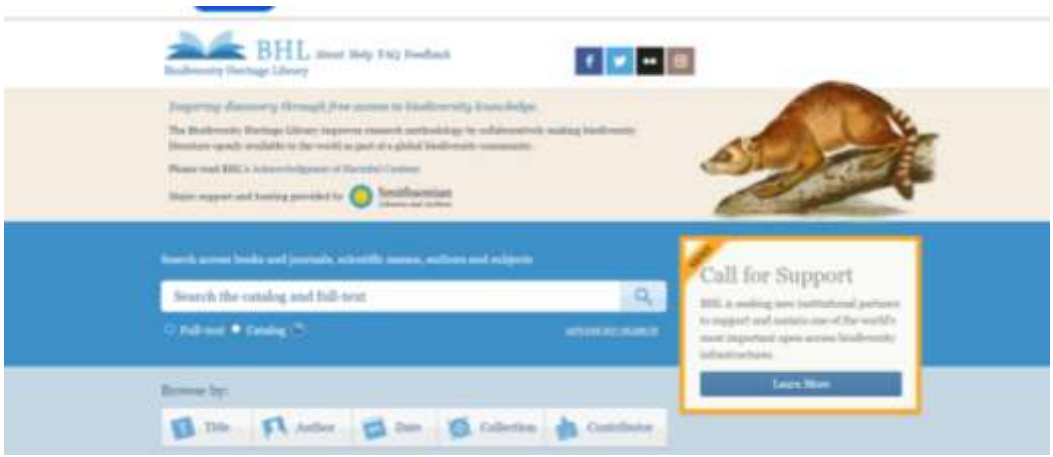

Image source : https://www.biodiversitylibrary.org

7.5 Web Recorder:

With the growing importance of digital content in cultural and academic institutions, preserving interactive and dynamic web materials has become essential. In India, the National Mission on Libraries (NML)—a Government of India initiative under the Ministry of Culture—recognized this need in its efforts to modernize and digitally link libraries across the country. To support long-term access to digital exhibits, online library interfaces, and ephemeral content, WebRecorder, a high-fidelity web archiving tool, was piloted by select

institutions like the National Library of India, Kolkata, and public libraries participating in the NML's digitization projects. Online exhibitions on Mahatma Gandhi's writings, rare manuscripts, and post-independence publications.

Image source: https://www.indiaculture.gov.in/knowledge-resources-heritage

8 . Challenges in Digital Preservation

- Technological Obsolescence: Rapid changes in hardware and software render digital objects inaccessible without proactive intervention.
- Resource Constraints: Limited budgets and technical expertise hinder preservation efforts, particularly in smaller institutions.
- Metadata Management: Inadequate metadata can compromise the discoverability and authenticity of digital objects.
- Policy Development: Comprehensive preservation policies are often lacking, complicating long-term planning.

9. Conclusion

In an increasingly digital world, the preservation of digital resources is not merely a technical challenge but a critical cultural imperative. This study has explored a range of preservation techniques—including migration, emulation, encapsulation, metadata standardization, distributed storage, and web archiving—each offering distinct advantages and trade-offs. Tools such as DSpace, EPrints, Greenstone, LOCKSS, and WebRecorder provide practical solutions for implementing these techniques, enabling libraries and institutions to safeguard their digital assets against obsolescence and data loss.

The Indian case studies examined—Shodhganga, Vidyanidhi, the Digital Library of India, and others demonstrate both the potential and the limitations of digital preservation in a developing context. While India has made significant strides through government initiatives and academic collaboration, the challenges remain substantial. Metadata inconsistencies, limited infrastructure, and gaps in policy and training continue to undermine the effectiveness of preservation efforts. Nonetheless, the success of platforms like Shodhganga illustrates how open-source tools, aligned with international standards such as OAIS and Dublin Core, can be leveraged for large-scale, long-term preservation.

A key takeaway from this research is that digital preservation is not a one-time solution but a dynamic, ongoing process that requires proactive planning, interdisciplinary collaboration, and sustained investment. To ensure future access to today's digital knowledge, libraries must not only adopt appropriate tools and

standards but also institutionalize preservation policies, conduct regular audits, and invest in staff capacity building.

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23. https://shodhganga.inflibnet.ac.in/
24. https://www.vidyanidhi.org.in/#google_vignette
25. https://www.dlib.org/
26. http://lib.jnu.ac.in/Rules_and_Regulation
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28. https://indianculture.gov.in/MoCorganization/national-library
29. https://ir.inflibnet.ac.in/items/576f2e59-2e85-4149-8c4c-ca1c92409f08
30. https://or.niscpr.res.in/index.php/ALIS/article/view/1834?utm_source=chatgpt.com

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