Open Access Research Journal of
Multidisciplinary Studies
Journals home page: https://oarjpublication/journals/oarjms/
ISSN: 2783-0268 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

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BUILDING SUSTAINABLE DIGITAL PRESERVATION ECOSYSTEMS IN INDIAN ACADEMIC LIBRARIES: A CONCEPTUAL FRAMEWORK

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Open Access Research Journal of Multidisciplinary Studies, 2026, 12(02), 020–027

Publication history: Received on 21 September 2026; revised on 28 October 2026; accepted on 30 October 2026

Article DOI: https://doi.org/10.53022/oarjms.2026.12.2.0042

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ABSTRACT

The rapid need of digital scholarship in India has made the role of academic libraries at the forefront of the perpetual management task of knowledge. Yet, the issue of digital preservation is not given due priority by most library authorities, thus rendering the vast amount of research work, theses, and data generated by academics at risk of being lost. Indian libraries are in dire need of a coordinated strategy and policy framework concerning digital preservation, as is evident from the disparate practices being followed by various organizations for their repository and digitization needs. The present paper studies this issue and attempts to provide a conceptual model that can act as a guide while developing digital preservation ecosystems in academic libraries while also maintaining a sustainable business model. The paper uses conceptual research while comparing its findings to various international standards like OAIS, PREMIS, and FAIR, along with digital preservation systems such as LOCKSS, CLOCKSS, and others. In addition, the paper also reviews the initiatives undertaken in India, including INFLIBNET, Shodhganga, NDLI, and e-ShodhSindhu, to highlight the disparity between the current practices and the issues faced. The paper concludes with a proposed framework for digital preservation in Indian academic libraries. The seven components of the framework are suggested based on the issues identified, including the need for developing digital governance and policy, infrastructure, metadata and standards, preservation strategies, capacity development, collaboration, and finally, sustainability. This paper's main contributions include the models & conceptual framework, which can be used for further empirical studies.

Keywords: Digital Preservation, Academic Libraries, Sustainability, Conceptual Framework, Knowledge Ecosystems

1 INTRODUCTION

Academic libraries have always struggled with the impermanence of knowledge. Decades ago, the threat was tangible – books and other media were constantly at risk of decaying away or being destroyed by some disaster, whether human-made or natural, but either way, gone for good. Now, the danger is increasingly intangible – the library's digital collections. Objects in a digital form are much less susceptible to the ravages of time and other physical forces, but storage drives can fail, programs can become outdated, and servers can simply cease to exist if their upkeep is too expensive to justify.

Indian academic libraries have witnessed phenomenal growth with the growth in higher education and research in the country. The resources like Shodhganga, NDLI, e-ShodhSindhu, etc., have enhanced findability, but just getting the content online is not enough for ensuring sustainability.

This gap between access infrastructure and preservation infrastructure is the central concern of this paper. The literature on digital preservation in Indian academic libraries reveals a consistent pattern: institutions digitize and deposit content, but rarely develop the governance structures, technical practices, or financial models needed to sustain that content beyond the immediate term [1]. Where preservation policies exist, they tend to be borrowed from Western models built on assumptions about funding stability, technical staff capacity, and legal frameworks for copyright that do not transfer cleanly to Indian conditions. What is absent is a framework that takes the Indian context as its starting point.

The purpose of this paper is to propose such a framework. By looking at international standards such as OAIS, PREMIS, FAIR, LOCKSS, CLOCKSS, and Indian initiatives, while also identifying gaps, a seven-component conceptual framework is proposed. It acts as a conceptual model that will help academic libraries in India make preservation investment decisions and enable policy makers to understand the components of a sustainable national strategy.

2 BACKGROUND OF THE STUDY

Digital preservation was first introduced in the field of library science in the mid-1990s when the Internet was invented and has been developing since then. It refers to the set of actions that need to be taken to ensure the long-term viability of digital information [2]. The concept itself is simple, but ensuring digital preservation involves solving numerous distinct problems such as technological changes, obsolescence of storage media, software modifications, migration issues, metadata losses, bit rot, and institutional discontinuity. And it is impossible to solve each of these problems separately.

The sustainability aspect is complicated by the fact that preservation that cannot be maintained over time is not preservation at all, but rather short-term storage with an expiration date. [3] in his discussion of digital library sustainability notes that sustainability should be considered from three perspectives – technical (is the system designed in such a way that it can adapt to changing technological needs?), economic (is the organization able and willing to fund such a system?), and social (is the staff going to be available to operate and maintain the system?). All three aspects need to be present for sustainability.

Sustainability in context of Indian academic libraries appears to be challenging in all three areas. While open source options such as DSpace reduce the technical challenges of infrastructure building, they do not solve the more immediate issues of staffing and funding [4]. Indian academic libraries face funding issues on a national level, with digitization being considered a nice-to-have, but not a priority, and existing mostly as a result of specific grants programs that do not extend to long-term maintenance [5].

The public good aspect fits in by providing additional context for discussion of preservation as a public good. With the adoption of the UNESCO Recommendation on Open Science [6], open access to scientific information is now considered a public good, and access to such information therefore requires appropriate infrastructure. It follows that fragmented institutional solutions are no longer sufficient, and a national-level infrastructure is required to meet this emerging requirement.

2.1 Statement of the Problem

India's higher education system is among the largest by enrollment, and its research output has grown significantly in the last decade. However, the preservation infrastructure for these research outputs, including theses, datasets, institutional repositories, and digitized heritage resources, remains fragmented and vulnerable.

The issues raised in the context of India concern the lack of policy regarding standard preservation practices at the national level, the fragmentation of library networks, the absence of proper infrastructure in terms of technologies and procedures, and the insufficient governance in terms of organizational structures and policies for digital preservation.

Academic libraries do not have a national preservation policy, resulting in varying practices for storage, digitization, access, and technology. In addition, libraries do not have a standard preservation infrastructure; some repositories lack the necessary tools for quality control, disaster recovery, and other processes [7].

Most importantly, there is an issue of governance since in most cases, digital preservation does not fall under the official remit of any organization, let alone in-depth policies on the matter being developed.

The outcomes of these challenges are unfortunately all too realistic. First, the obsolescence of formats is a real possibility if the software where files are stored ceases to be used, rendering them inaccessible without specialized, and potentially unavailable, tools for reading old data [8]. Second, there is a possibility that an organization discontinuing its activity or a particular employee leaving the institution in charge of the repository will cause it to be forgotten about or neglected. Finally, if the repository is not described with interoperability in mind, its resources may prove inaccessible to other organizations seeking to use them.

These issues are discussed in the global literature on digital preservation. Meanwhile, in India, in contrast to the availability of problems, their solutions are presented with a lag, which focuses on the need for independent, local approaches that would take into account the specifics of the regional environment.

2.2 Objectives and Research Questions

This paper is organized around five objectives:

- to examine why sustainable digital preservation matters for Indian academic libraries and what is at stake if it is not addressed;
- to identify the specific challenges that Indian libraries face;
- to review international standards and models that have shaped global preservation practice;
- to develop a conceptual framework suited to Indian conditions;
- to suggest implementation strategies realistic within existing constraints.

3 LITERATURE REVIEW

3.1 International Standards and Models

The OAIS (Open Archival Information System) reference model, formalized as ISO 14721, is the foundational international standard for digital archiving [9]. It defines a functional architecture that involves ingest, archival storage, data management, preservation planning, and access, supporting information for its community of users in ways understandable to those users in the long term. PREMIS, as maintained by the Library of Congress, facilitates digital preservation by defining metadata standards for digital objects, events, agents, and rights management information.

The FAIR Principles Findability, Accessibility, Interoperability, Reusability articulated by [10] and focused on research data are complementary to the issue of data preservation. The connection between these two areas is evident from the fact that without findability, and especially interoperability, any data stored somewhere become inaccessible in practice, rendering such data as effectively lost.

The levels of digital preservation proposed by the NDSA refine the OAIS's general principles into a particular set of four-digit maturity levels: beginning, developing, progressing, and sustaining [11,12]. This maturity model allows institutions to assess their level, moving realistically towards higher-level maturity. The model helps to avoid unreachable requirements, so that an organization can achieve the standard of CoreTrustSeal certification by meeting the auditing requirements and then move on to the next level [13].

3.2 Indian Initiatives and Their Limitations

India has several national-level digital library initiatives that deserve special attention. First, the UGC-affiliated organization called INFLIBNET has provided shared academic library infrastructure, including the Shodhganga portal containing scholarly works and e-ShodhSindhu, the consortia-based resource discovery system for research databases [1]. The second is NDLI, which was developed at IIT Kharagpur, and it offers resources aggregated from multiple sources with a discovery tool, and its main purpose is the access rather than preservation [14]. Finally, as one of the INFLIBNET projects, IRINS develops current research information systems in India (India, IRINS n.d.).

Although these digital library initiatives have improved access to works, they have failed to address digital preservation issues adequately. Shodhganga lacks comprehensive PREMIS metadata and an official preservation policy for file migration [16]. Repository initiatives in India were rarely managed with a view to long-term preservation and were largely driven by accreditation rather than by preservation needs [17]. As argued by [18], institutional repositories require long-term institutional commitment, which has not been the case in India.

3.3 Research Data Management and Emerging Challenges

Internationally, research data management (RDM) connects digital preservation to research infrastructure. [19] report on the varying levels of RDM service development and the importance of organizational investment into data

preservation. At the same time, [20] reveal the discrepancy between perceived and actual levels of RDM services, which are probably also characteristic of academic libraries in India.

AI-assisted tools are being explored for metadata generation, format identification, and integrity monitoring. The research indicates promising applications for repositories and cultural heritage communities, while also raising governance, authenticity, and accountability concerns [21,22]. Additionally, several works focus on AI and generative AI for library practices and metadata management, with limited exploration of their implications for digital preservation activities [23–25].

4 METHODOLOGY

The study will employ a conceptual research methodology that will focus on interpreting international standards for preservation, Indian initiatives for developing digital libraries, research on digital library sustainability and data stewardship. The comparative case analysis methodology will be adopted from [3] to review the existing standards, practice, and problems encountered to develop a set of recommendations for future research. The intention is to formulate recommendations and not test a particular hypothesis.

5 CURRENT STATUS OF DIGITAL PRESERVATION IN INDIAN ACADEMIC LIBRARIES

Indian academic libraries have made significant strides in terms of digitization. However, it appears that the transition process towards long-term digital preservation is not happening at the same speed. Most Universities tend to use DSpace or EPrints repositories for their research outputs which are good in terms of showcasing but do little to actually preserve. The literature review suggests that libraries seem to focus more on ingestion and discoverability of resources while paying lip service to migration and maintenance. A similar observation was made by [26] who found out that the process of implementing digital services often precedes organizational capacity building to support long-term digital preservation.

While Shodhganga and NDLI have been successful in terms of the number of digital resources and the number of users, neither of the platforms has demonstrated a detailed preservation policy that would ensure that digital resources can be maintained beyond the transition to a new technological platform. [27] emphasizes that successful preservation initiatives require a strategic approach that is informed by technical, organizational, and financial considerations. From this perspective, it is evident that the majority of the institutional repositories in India lack a strategic approach to long-term sustainability.

6 CHALLENGES FACED BY INDIAN ACADEMIC LIBRARIES

The challenges facing Indian academic libraries in digital preservation include technical, financial, organizational, human resource, legal, copyright, and metadata issues.

Technical Barriers: Indian academic libraries face technical barriers such as obsolete file formats, weak backup systems, lack of integrity checking, and limited migration tools. These problems make it difficult to preserve digital resources for the long term, especially due to insufficient technical expertise and infrastructure.

Financial Constraints: Digital preservation involves high costs and requires continuous and constant investment. The issue of grant-based funding is not always adequate for sustaining such processes in Indian academic libraries. The phenomenon of rapid growth of digital content combined with the limited availability of funds is a significant problem, on which the current funding practices for content acquisition and digitization have little impact.

Organizational and Governance Issues: Many Indian academic libraries do not have clear digital preservation policies or proper organizational structures. The roles of stakeholders are not well defined, and there are limited systems to evaluate the effectiveness of preservation practices.

Human Resource Barriers: The human resource barrier is closely related to the organizational issues. Digital preservation is a specialized area that requires a certain level of technical competence, but Indian academic libraries do not have the resources to hire qualified personnel. [28] noted that institutional repositories require human resources to be effective, and the staff members need to have the appropriate skills.

Legal, Copyright, and Metadata Challenges: The legal and copyright challenges in India are significant, and they prevent libraries from developing the necessary policies and procedures for preserving digitized content. Metadata issues also affect digital preservation initiatives in Indian academic libraries. The Dublin Core Metadata Initiative (DCMI) has developed a comprehensive set of metadata standards, but they are only used inconsistently in India. Similarly, PREMIS

preservation metadata is not used widely to describe and preserve digital content [29,30]. There is no adequate metadata for most of the digital content stored in India's academic libraries.

7 INTERNATIONAL STANDARDS AND BEST PRACTICES

Drawing together the standards considered in Section 5, it emerges that several principles have been considered essential to any functional program. First, OAIS sets out the overarching activities: ingest, storage, management, preservation planning or "value creation," and access, while stressing the need to ensure the intelligibility of content to the appropriate community [9]. Second, PREMIS establishes the metadata infrastructure necessary for such a system of preservation [29]. Third, the FAIR Principles add to this list the requirement for findability, accessibility, and reusability as attributes that cannot be taken for granted even in storage [10]. Thus, these standards contribute to the LOCKSS concept of multiple copies stored in different organizations as a way of achieving institutional resilience when the single-library approach is too risky [31].

Meanwhile, the NDSA Levels of Digital Preservation offer a maturity model for designing digital preservation strategies at different levels of sophistication [32], while CoreTrustSeal gives a set of criteria that can be formally used to evaluate a preservation repository.

What emerges is that all standards listed above recognize the need for a comprehensive approach to digital preservation that involves governance (who does what?), infrastructure (what does it take to make it work?), metadata (what does it take to make data manageable?), and sustainability (how to pay for it all). This sets the framework for the program to be developed below.

8 PROPOSED CONCEPTUAL FRAMEWORK

The framework comprises of seven components. Governance and policy provide the overarching context within which the other six components develop. These include infrastructure, metadata, preservation strategies, capacity building, collaboration, and monitoring and sustainability all of which are critical to digital preservation and sustainability.

8.1 Component 1: Governance and Policy

Sustainable digital preservation needs to be underpinned by governance and formal policy that defines roles and responsibilities to ensure continuing capability and capacity for digital preservation. UGC and INFLIBNET have to take the lead in promoting adoptions of policy to provide sustainability despite organizational, personnel, and budgetary changes.

8.2 Component 2: Infrastructure

Infrastructure for digital preservation refers to technical systems, storage, and hardware that ensure the information stored there is maintained for the long term. The most critical requirements for infrastructure are storage backup, integrity checks, identification of formats, and disaster recovery. Software such as DSpace, Eprint, and Fedora, and scalable cloud storage can be utilized in digital preservation with possible risks.

8.3 Component 3: Metadata and Standards

The most successful practice is the extensive use of metadata and its compliance with established standards. Dublin Core provides a platform for representing basic descriptive metadata elements for resource discovery [30]. Preservation Metadata Initiative (PREMIS) supports the creation, management, and use of metadata for preserved objects, events, agents, and rights for the purpose of long-term digital preservation. The training of library staff on PREMIS and its adoption will promote preservation through interoperability, information sharing and discovery, and management of digital resources across repositories and systems.

8.4 Component 4: Preservation Strategies

Digital preservation through migration, emulation, and normalization. Migration deals with format obsolescence, while emulation helps in presenting complex data objects for future use, and normalization ensures that digital objects are organized according to standard formats upon receiving. Digital preservation needs appropriate policies that should be used in accordance with the strategies applied to particular content types, continuous tracking of obsolete formats, and regular migration as a periodic activity [8,13].

8.5 Component 5: Capacity Building

People are the most critical component of digital preservation since technology and policies are only useful with the appropriate personnel. Capacity development activities should be undertaken to enhance initial professional skills,

advanced and continuing professional development, managerial and leadership skills, and knowledge exchange strategies. The library professional needs to fully understand both the capabilities and constraints of artificial intelligence systems in digital preservation [21,23]. Therefore, capacity building must be planned and budgeted for as an ongoing process.

8.6 Component 6: Collaboration

A library in India cannot be able to preserve information digitally on its own. This is due to certain limitations like resources, expertise, and risks involved. The collaboration of institutions along with national programs would provide the most optimal way for achieving the preservation of information. The LOCKSS model demonstrates this concretely: distributed networks reduce risk and substitute collective infrastructure for what no individual institution could provide alone [31]. National coordination through INFLIBNET, the use of consortia to form managed infrastructure, and cooperation with CLOCKSS and other international standards bodies are all approaches that can contribute to a distributed preservation system beyond the capacity of any one organization to achieve alone.

8.7 Component 7: Monitoring and Sustainability

Sustainability is a continuous process that requires constant auditing at the technical, policy, and financial levels. I would ensure that the library has regular and recurring funding for storage, software, training, and migrations while encouraging public investment in the preservation of research infrastructure [6].

Recommendations

UGC and INFLIBNET must evolve and adopt a national strategy for digital preservation in academic libraries based on OAIS reference model for developing countries.

UGC should encourage academic libraries to adopt preservation standards for ensuring integrity, identification of formats, reliable storage and disaster recovery by strengthening existing consortia like INFLIBNET and moving towards cloud storage.

Digital preservation should be made mandatory in library schools and continuing education curriculum for academic librarians. Universities should create positions with appropriate staffing and time dedicated to digital preservation and not rely only upon volunteers or extra mural activities.

9 CONCLUSION

Digital preservation in Indian academic libraries is a multifaceted issue, involving not only technical but also governance and funding aspects, as well as capacity development and collaboration strategies, and thus requires a systemic approach. The study suggests a seven-component framework, including Governance and Policy, Infrastructure, Metadata and Standards, Preservation Strategies, Capacity Building, Collaboration, and Monitoring and Sustainability, aimed at understanding digital preservation as a complex system in which all components are highly interrelated and therefore have to be taken into consideration for long-term sustainability.

The framework proposed in this paper is only conceptual and there is a need to test it more thoroughly in varied institutional environments in India. Future studies could take up the framework and attempt a field testing of its relevance and efficacy through case studies, surveys and evaluations of digital preservation programmes in academic libraries.

It is important that this research is conducted, as the need is acute now more than ever. Indian higher educational institutions are crossing new milestones in terms of volume and quality of research produced, and almost all of this output is digital. The knowledge and research embodied in these outputs need to be preserved for the sake of Indian academic community, which produces and uses this research, for the sake of the country, which funds this research, and for the reputation of Indian academic libraries.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The author declares that there are no conflicts of interest, financial or otherwise, that could have influenced the research, analysis, or presentation of this manuscript.

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