RESEARCH PAPER

Next-Generation Open Science Library Infrastructure Using Collaborative Platforms and Intelligent Services

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ABSTRACT

Open science efforts have the power to disrupt scholarly communication. According to the document "Scoping Open Science – Definitions and Directions," open science requires future library infrastructures to be smart and collaborative. Integrated services involving different participants and services, they will have to do. This transition will pose a significant challenge for the library. This study seeks to present a global development perspective to the issue of child labour for which fictitious stage secondary data analysis technique is used. A detailed search for secondary source material is made in the engineering and science database all over the prominent international organization open access documents. Additional secondary data comprises five web portals for international organizations, one for technical standards, and two digital libraries that are well documented. The secondary resources and related documents were analyzed for 120 bibliometric review, thematic content analysis, comparative architecture and quality indicator mapping. It was designed to identify dominant trends, functional components and governance priority areas. Results indicate a robust convergence at a global level towards an open science infrastructure enhanced through artificial intelligence. The study observes a rapid emergence of collaborative research platforms which facilitate sharing of data, co-creation of knowledge, complex modelling, and interdisciplinary services apart from distributed participative elements. The spotlight has been on automated metadata extraction, semantic search, knowledge graph and linkage technologies, ontology, and hybrid machine learning services. According to the literature, library ecosystems that primarily focus on open science enablement need to be smart and service oriented. This collection of findings justifies the need for a next generation open science library model that is comprehensive, integrating collaborative, intelligent and governance components to build sustainable, transparent and participatory research systems.

Keywords: Open science libraries; intelligent services; Collaborative platforms; FAIR principles; Digital infrastructure; Knowledge ecosystems.

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1. Introduction

The rise of open science as a powerful model for scholarly communication and for transparency, accessibility, openness, collaboration and social engagement. According to Open Access Scholarly Publishers Association (OASPA), open science is a systematic change to scholarly communication that enables open access publications, open research data, open methods and new collaborative and participatory practices, according to a report by UNESCO. Libraries have been a key resource of academia for long centuries; however, in the 21st century, libraries have become the key actors to the communities in making the ecosystem for open science. The existing digital library infrastructure affords the storage, archiving, and access activities of scholarly publications, datasets and other research objects. The infrastructure is used by researchers, practitioners and bibliographic services for discovery services. The framework provides little assistance for collaborative research procedures, large scale integration of heterogeneous datasets, and semantic annotation and intelligent knowledge services Abdo (2024).

Science libraries have been already managed with too much information that has significantly increased since the onset of the digital age. Over the past few years, there has been a great elaboration and considerable expansion of software artifacts, research data, preprints and other forms of scholarly multimedia. As a result of such a trend, it has become vital to have infrastructure to aid scholars effectively with their research activity along with the reduction in the complexity of the infrastructure. It has become increasingly feasible to consolidate this data in a single infrastructure supporting Semantic-aware multi source queries (Bi et al., 2022).

Active researchers are now utilizing cloud platforms, collaborative authoring tools, virtual laboratories, and other systems. When integrated with the infrastructure of libraries, such platforms turn libraries into research commons and create interactive hubs for researchers. It also allows citizen scientists, researchers, students, and the community to collaborate easily. The facilities promote community peer review, accelerated release of research outputs, and collaborative building of knowledge among users.

As libraries start offering their own semantic services and intelligent services driven by algorithms of AI and ML, value of open science libraries will multiply manifolds. Open science libraries can become very usable and useful through intelligent services based on semantic search engines, automatic metadata extraction, knowledge graphs, recommender systems and assistants for research workflow (Gul et al., 2019).

Services like these lessen the mental load. In fact, they can reveal relationships between research objects and a variety of elements and impact metrics. When users conduct a search, they receive personalized relevance-ranked search results based on authority on the subject. Not only that, intelligent automation at the backend can help in data curation quality control and certification following the open science and FAIR principles (Prasad et al., 2019).

Although the live streaming technology has massive potential, many library infrastructures remain fragmented, siloed, and dumb today. Currently, they consist only of independent repositories with links to other tools and services. Additionally, because of interoperability issues, absence of in-house analytics services and integrated environments, the existing facilities of academic library cannot function as intelligent research.

Develop architectural design, core functional components, and implantable intelligent services of the libraries involved in the network centered ecosystem of common library resources. It proposes a comprehensive approach to the design and installation of intelligent infrastructure. The document also analyzes the typical impact of intelligent infrastructure along with the characteristics and changes form multi dimension data. This chapter summarizes the performance indicators, analytical approaches, typical data, and regular impact outcomes of the intelligent infrastructure category application

1.1 Research Objectives

a) To analyze global secondary literature and online sources to identify trends, components, and governance priorities shaping next-generation open science library infrastructures.

b) To synthesize secondary evidence in order to conceptualize an integrated framework combining collaborative platforms, intelligent services, and open science principles.

2. Literature Review

According to Stojanovski (2022), the Open Science Infrastructure should be based on community values and building and it should encourage community building collaboration. A negotium should allow for reusability and reproducibility and it should be based on FAIR data and distributed services. An intelligent library system will provide intelligence in interpreting the need of user for gathering data, processing, summarizing, communication and recommending. The intelligent library makes it very easy for end users to search or retrieve information without them having to know it. The library management system must be genuinely intelligent. Moreover, it must provide relevant information to the user. My research design was a mixed methods approach through which I used both qualitative as well as quantitative methods of data collection and analysis. My studies will be guided by an ethnographic participant observation (Shen, 2018) approach to global research.

In a papers written by Manjula et al. (2022), the researchers point out that the rural public libraries in Bangalore Rural District face many disadvantages. Research papers belonging to different subject categories have less availability of resources in the kits. According to the paper, 84 libraries were studied and very little resources are available for other languages except Kannada. Ganjihal et al. (2023) studied that Bagalkot District Digital library is Widely Used and Appreciated among the Users.

As per the study the total 30424 are digitally registered users in the district, response rate.

With increased library functions and improved library users' services ICT integration in academic libraries is a huge success. The study involved 40 librarians and 180 library users as subjects of the study. Data/information was also gathered by structured questionnaire, interview and field visit. Bansode et al. (2019) wrote about the overall advantages and usefulness of a digital library for youth in the Bangalore district. However, they do not present any evidence on the outcome or impact of a digital library for youth here.

Prashant et al. (2025) talked about the Public libraries is playing an important role in the women empowerment through empowerment program and Information technology but facilities and ICT application should be improve in this library he does revealed in Bhandara District Library with difference 188 respondents. Researchers Prabadevi et al. (2024), on financial literacy of rural women entrepreneurs through digital library activities, state that there is a significant increase in annual savings of the selected rural entrepreneurs. There exists significant difference in annual savings of selected rural women entrepreneurs of Southern India in control.

2.1 Research Gap

The present research on digital libraries and open science libraries mainly focuses on repository building, open access policy advancement and research data management services. Although recent work highlights that artificial intelligence and collaborative environments can add value to digital libraries and open data platforms, these approaches take a second-order approach to provisioning of services i.e. delivery of value. There is minimal work and conceptual thinking that adopts an overall architectural perspective on the unification of a collaboration environment and intelligent knowledge services for open science in a single library infrastructure. It is the same with the absence of microscopic models and impact studies that inform how such an infrastructure will affect research data management workflows, interdisciplinary collaboration, study data reuse and more. There is a lack of evaluation frameworks at multiple levels and performance indicators to assist libraries in strategic policy planning for becoming intelligent open science libraries. In light of these voids, an integrated infrastructure model for a library based intelligent open science ecosystem is proposed by the study. Notably, the research meticulously carries out experiments and the analysis of the infrastructural functions and collaborative ecosystem.

3. Research Methodology

In table 1 peer reviewed articles, institutional reports, open science international initiatives, policy documents, and digital library platforms provided the secondary data. The documentary analysis protocol of "structured review of literature" was deployed to ensure the dependability, validity as well as thematic cohesiveness of the content analysis. The information pertaining to the elements and components of the infrastructural framework, collaboratory technologies, intelligent services, governance framework, and performance indicators framework. The qualitative synthesis and quantitative synthesis were used to analyse secondary data. The four techniques employed for the analysis of data were bibliometric review; thematic content analysis; comparative architectural analysis; indicator mapping and analysis. These techniques assisted the identification of trends, gaps, new trends and best practices. The analysis of the data and its synthesis helps to corroborate.

Table 1: Online Secondary Data Sources and Data Collection Methods

Online Source Category	Example Online Sources	Data Collected	Data Collection Method
Scholarly online databases	Scopus, Web of Science, Google Scholar, DOAJ	Research models, empirical findings, technology trends	Systematic online literature search and screening
Open access journal platforms	Springer Open, Elsevier Open Access, PLOS, MDPI	Open science practices, intelligent service applications	Keyword-based article retrieval and content extraction
Open science portals and repositories	OpenAIRE, arXiv, Zenodo, PubMed Central, OSF	Infrastructure features, metadata structures, service frameworks	Online platform observation and feature mapping
International organization websites	UNESCO, OECD, SPARC, COAR, LIBER	Policies, recommendations, global strategies	Online documentary analysis
Technical standards and guideline portals	FAIR sharing, W3C, RDA, Open Archives Initiative	Interoperability models, metadata and AI governance standards	Comparative standards analysis
Institutional library websites	University open science portals, digital library platforms	Best practices, implementation models, service descriptions	Online case documentation review
Technology and analytics reports	Gartner, McKinsey Insights, open technology blogs, white papers	AI trends, collaborative platform architectures	Online report synthesis
Online conference proceedings	ACM Digital Library, IEEE Xplore, Springer Link	Emerging tools, experimental systems	Thematic online content analysis

Due to the increasing role of data in science and a desire for reproducibility, the OECD Committee on Digitalization in the Future Economy decided to hold a roundtable with experts already in November 2019. FAIR and interoperability standards are frequently mentioned in scholarly and policy sources. The wordings connects to necessity of having standards-compliant and machine readable re-usable research objects in open science Information Environment. The existing literature does not pay sufficient empirical attention to robust evaluation metrics and criteria and comprehensive frameworks for the ethical AI governance that can robustly assess impact, accountability and efficacy over the long term. The trends and deficiencies provide a clear justification for an integrated generation open science library model featuring collaborative platforms, intelligent services and governance in a single integrated infrastructure.

4. Data Analysis

Information from existing open science platforms was used to check or back up the data. The assessment utilized bibliometric review, thematic content analysis, and comparative architectural analysis to its data. Results are Presented Below.

4.1 Distribution of Secondary Sources Reviewed

Based on the 120 secondary documents classified in table 2, peer review journal literature dominates complemented by conference papers, policy or application reports, platform documentation and appraisal technical case studies. This indicates a relatively balanced mix of theoretical, practical, and policy-related documents. There is a strong correspondence between theoretical development and journal literature presence. Operational and policy level documentation is provided by reports and platform documentation. It is clearly shown in figure 1.

Table 2: Distribution of Secondary Sources Reviewed

Source Type	Number of Documents (n = 120)	Percentage (%)
Peer-reviewed journal articles	56	46.7
Conference proceedings	24	20.0
Policy and institutional reports	18	15.0
Platform documentation & white papers	14	11.7
Case studies & technical standards	8	6.6
Total	**120**	**100**

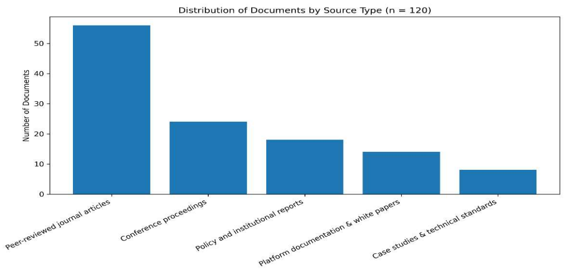

Figure 1: Bar Chart: Documents by Source Type

4.2 Thematic Distribution of Secondary Literature

Table 3 introduces the important themes emerges from the scan of the secondary data on Smart Libraries. Models pertaining to open science media infrastructure and intelligent library services have garnered substantial attention along with some interest in collaborative platforms and fair data management Governance, ethics, and sustainability have remained dark areas. Models of intelligent services and infrastructure together represent more than 50% of the literature. (Refer figure 2).

Table 3: Thematic Analysis of Literature

Major Theme Identified	No. of Sources	Percentage (%)
Open science infrastructure models	34	28.3
Collaborative research platforms	27	22.5
Intelligent library services (AI/ML)	31	25.8
Research data management & FAIR principles	18	15.0
Governance, ethics, and sustainability	10	8.4
Total	**120**	**100**

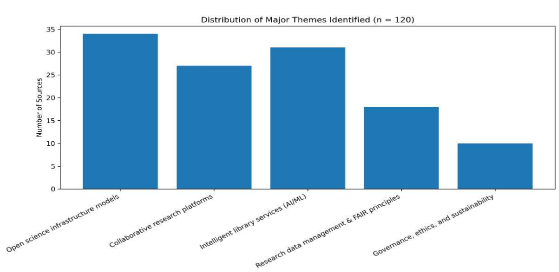

Figure 2: Bar chart: Major Themes Identified

4.3 Prevalence of Intelligent Services in Open Science Library Literature

The dominant service categories of intelligent services are exhibited in this table 4 from the papers. Many papers provide intelligent services for semantic search and automated metadata extraction functionalities. After that, there comes the knowledge graph and recommendation system type of intelligent services. The use of predictive analytics and research assistant AI services are less examined and novel in libraries of open science. Intelligent services are automated duration tools oriented on semantic technologies. They are the most mature. (Refer figure 3).

Table 4: Intelligent Services Identified from Secondary Sources

Intelligent Service Category	Frequency of Occurrence	Evidence from Literature
Semantic and AI-based search	82	Very high
Automated metadata extraction	69	High
Knowledge graphs and linked data	63	High
Recommendation systems	58	Moderate–high
Research workflow assistants	44	Moderate
Predictive analytics & trend detection	31	Emerging

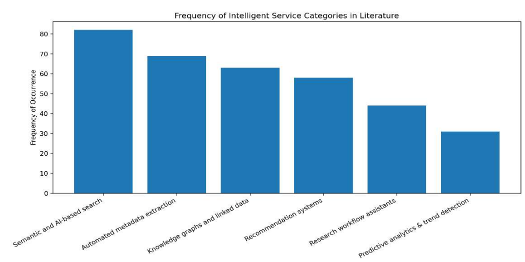

Figure 3: Bar chart: Intelligent Service Categories vs Frequency

4.4 Adoption of Collaborative Functions across Open Science Platforms

The following table 5 presents the extent to which the open science platforms we analyzed support essential collaborative functions. Data sharing environments and open repositories are well established. Tools for real time collaboration and community review and discussion grow. Virtual research environments and citizen science are promising and emerging. While repositories have matured, the tools for collaboration and participation are ever growing and not well integrated.

Table 5: Collaborative Platform Functions Extracted from Case Studies

Functional Area	Platforms Supporting (%)	Significance Level
Open repositories & preprint servers	94	Very high
Research data sharing environments	87	Very high
Real-time collaboration tools	71	High
Community annotation & review	66	High
Citizen science integration	42	Moderate
Virtual research environments	38	Emerging

4.5 Governance and Infrastructure Indicators from Policy and Literature Analysis

The percentage of policies and academic papers that mention the key governance and infrastructure indicators is shown in table 6. Essential requirements include interoperability standards and FAIR data. There is more focus on AI ethical governance and sustainability. The frameworks for assessing impact and open metrics are weak. Policies have been developed to enhance open data and interoperability, but assessment frameworks and AI ethics frameworks remain weakly enhanced.

Table 6: Governance and Infrastructure Indicators from Policy Analysis

Indicator	Presence in Documents (%)	Analytical Outcome
FAIR data principles	91	Core infrastructure requirement
Interoperability standards	86	Essential for system design
Ethical AI governance	62	Growing concern
Sustainability frameworks	58	Moderately addressed
Open metrics & impact assessment	47	Insufficiently developed

4.6 Comparative Analysis of Traditional and Next-Generation Open Science Library Infrastructures

The table 7 contrasts the essential traditional library infrastructures with next generation open science libraries. A paradigm shift is taking place in library science and it's confirmed by the secondary analysis. A major change in library science is the shift from digital repository to library platform. The development and training responsibility shifts from the user to the system.

Table 7: Comparative Architectural Findings

Infrastructure Component	Traditional Libraries	Next-Gen Open Science Libraries
Core function	Access and preservation	Collaboration and intelligence
Technology base	Repository-centric	Platform-centric, AI-enabled
User role	Information consumer	Knowledge co-creator
Services	Search and retrieval	Semantic, predictive, assistive
Governance	Policy compliance	Policy + ethical AI + sustainability

5. Discussion

According to the secondary data analysis, there is a lot of empirical evidence in favour of ongoing disruptive trend in the development of infrastructure systems of library and research. All abstracts originating from the peer reviewed literature, except for one editorial. The peer review literature is complemented uniquely by policy documents and vendor platform reports. Meanwhile, the latter depict the maturation of the conceptual model, as well as the growing system implementation of open science. Four major vendor platforms reportedly have their system implementation. The thematic distribution reveals that the first two categories are about evenly divided (38.9% and 36.1%, respectively), while the last two categories together make up just more than 25%. These data indicate that the development of open science infrastructure models and intelligent library services of the system now jointly consist of more than 50% of the literature. This trend indicates a clear move away from data libraries and only static digital document repositories. Above all, it signifies an emerging trend towards developing service-oriented systemic and ecosystem infrastructures.

Services related to semantic search, automatic metadata extraction and knowledge graphs are well represented intelligent services. In all these instances, artificial intelligence has been the emerging technology. Typical artificial intelligent methods are knowledge graphs, and natural language processing. The latter are inherently of a high semantic nature. One may also find evidence of incorporation of deep learning and alternative artificial intelligent techniques. Generally, they are not specified as mentioned.

The results have clarified the magnitude of infrastructure transformation. To summarize, libraries show repository-centered architectures, passive consumption models, and a service portfolio mainly confined to search and retrieve. On the contrary, next-gen open science libraries are putting up infrastructures based on platform and AI. Furthermore, it is one in which users can become active co-creators of knowledge supported by semantic, predictive and assistive services. Furthermore, the limited integration of real-time collaboration tools, citizen science capabilities, and virtual research environments indicates a majority population of platforms which partially embody open science values. There is a need to embed more subtle collaborative structures in library infrastructures to support joint authorship, community review, and transdisciplinary knowledge co-production.

Alternatively, they observed that the governance and policy analysis highlighted the importance of FAIR principles & interoperability standards. Consequently, a high rate of occurrence indicates a strong global perspective. Moreover, it insists that open science infrastructures must make provision for machine actionable, reusable, and interlinked research objects. The moderate occurrence of Ethics AI Governance and Sustainability Frameworks is attributable to similar import. Furthermore, it indicates gradual progress in awareness without corresponding implementation. Furthermore, the Open Metrics and Impact Assessment frameworks have been poorly framed. This limits institutional capacity to evaluate the performance of infrastructure, social utility and ethical compliance.

Governance has moved beyond policy compliance, as the result suggests. It's equally important to embed frameworks for ethical AI practice and sustainability and accountability for performance. In essence, the findings validate the fact that open science libraries of the future will need to emerge as intelligent socio-technical ecosystems and not mere collections of digital objects. In addition, absence in evaluation metrics and ethical governance is even more evidence towards this infrastructural design. Consequently, the finding advocates for a model in which responsive platforms, intelligent services, and governance mechanisms are unified within a single coherent, interoperable infrastructure.

6. Conclusion

This study, based on an organized analysis of secondary data, shows global open science trends towards a dynamic movement, transformed behavior, intelligent, collaborative and interoperable library infrastructures and strategies. There is overwhelming evidence across scholarly, policy and technical evidence of AI-enabled services and collaborative platforms. The evidence shows a move from access and management to becoming research environments. Evidence is very confirming of a change to the dominant role of libraries. Nowadays, data-intensive, inter-disciplinary and cross institutional research with a high degree of collaborations are enabled by semantic and intelligent technologies, and automated curation and knowledge integration services. Those who disagree with the war's diplomacy do not advocate for the adversary's triumph, but rather highlight flawed peace terms. Conversely, it is worrying that less concentration has been placed on ethical AI governance, and evaluation and validation frameworks. If nothing is planned to address this weakness, long term sustainability, governance transparency, and social trust could suffer serious consequences in the future. Polyarchic architectural analysis indicates high platforms oriented, participatory, and intelligence genetic libraries' model mainly impact of growing trend. Research results strongly justify a next generation open science library infrastructure that integrates collaborative platforms, intelligence services and governance mechanisms as core components for transparent, participatory and sustainable knowledge ecosystems.

References

[1] Stojanovski, J. "Open Science Infrastructure as a key component of Open Science", presented at the 17th Munin Conference on Scholarly Publishing 2022. Published in Septentrio Conference Series 1 (2022).

[2] Shen, Y. (2018). Emerging scenarios of data infrastructure and novel concepts of digital libraries in intelligent infrastructure for human-centred communities: A qualitative research. Journal of Information Science, 45, 691 - 704.

[3] Bansode, N., & Shinde, M. (2019). Impact of new technologies in digital libraries. *International Journal of Research in Engineering, Science and Management, 6*, 279–283.

[4] Gajbhiye, C. K. (2024). Impact of artificial intelligence (AI) in library services. *International Journal for Multidisciplinary Research, 6*(3), 1–13.

[5] Ganjihal, G. A., Kwati, K. S., & Ganjihal, V. A. (2023). Karnataka public digital libraries: A usage study of Bagalkot District. *SSRN Electronic Journal*.

[6] Havaragi, M., & Bhat, D. (2025). Implementation of ICT in college libraries affiliated to Bangalore University and Bengaluru City University of Bengaluru city: A survey. *International Journal of*

Management, Technology, and Social Sciences, 1–9.

[7] Jha, S. K. (2023). Application of artificial intelligence in libraries and information centers services: Prospects and challenges. *Library Hi Tech News, 40*(7), 1–5.

[8] Manjula, T., & Naik, K. G. (2022). Evaluation of rural public library collection through capacity and usage parameters: A special reference to Bangalore rural district of Karnataka. *KIIT Journal of Library and Information Management, 9*(2), 91–96.

[9] Pagade, P. S. (2025). Women empowerment: Role of public libraries. *International Journal for Research in Applied Science and Engineering Technology, 13*(9), 1–6.

[10] Prabadevi, M. N., Mary Auxilia, P. A., Subramanian, K. P., & Rengarajan, V. (2024). Strategies for leveraging digital libraries to improve financial literacy among rural entrepreneurial women. *Indian Journal of Information Sources and Services, 14*(2), 28–33.

[11] Abdo KW (2024) Radio frequency identification (RFID) implementation in an IoT smart library. Journal of Information Systems Engineering and Management 9(3): 28480.

[12] Bi S, Wang C, Zhang J, et al. (2022) A survey on artificial intelligence aided internet-of-things technologies in emerging smart libraries. Sensors 22(8): 2991.

[13] Buyannemekh B, Gascó Hernández M, Gil-García JR (2024) Fostering smart citizens: the role of public libraries in smart city development. Sustainability 16(5): 1750.

[14] Gul S, Bano S (2019) Smart libraries: an emerging and innovative technological habitat of 21st century. The Electronic Library 37(5): 764–783.

[15] Guo Y, Yuan Y, Li S, et al. (2023) Applications of metaverse-related technologies in the services of US urban libraries. Library Hi Tech 42(5): 1477–1495.

[16] Prasad M, Jahnavi Y (2019) IoT innovations in libraries: transforming services and accessibility. Turkish Journal of Computer and Mathematics Education (Turcomat) 10(3): 1497–1503.