From Digital Repositories to Data-Driven Ecosystems: A Scientometric and Predictive Analytics Study of Research Data Management Practices in University Libraries (2010–2026)

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ARTICLE DETAILS	ABSTRACT
	The shift in the role of university libraries, in which they are no longer mere digital storage areas but active and information-driven ecologies, indicates the complexity of research data management (RDM) in the age of open science and digital scholarship. During the last decade, universities have enhanced their mandate beyond institutional repository to deliver compounded data services, research intelligent support, and analytics-informed decision systems. RDM scholarship is still growing really fast; nevertheless, the intellectual structure of this phenomenon and its future course are not thoroughly explored. This paper will perform a scientometric and predictive analytics research on the global RDM research in university libraries between 2010 and 2026. Scores of bibliographic information about the given sphere are gathered in Scopus and Web of Science whereby the scope of disciplines and geographical profiles is extensive. Scientometric methods such as co-citation analysis, bibliographic coupling, and mapping of key words co-occurrence are used to determine influential authors, thematic groups, collaboration groups and trends in

intellectual evolution. In order to go beyond descriptive mapping, time-series forecasting and machine learning tools, like ARIMA and LSTM are used to forecast future publication growth, new themes added or new collaborative types, and collaborative breadth past 2026. These results show that the similarity to repository-centered research (2010-2014) shifted to the presence of service-oriented data stewardship (2015-2019) and, more recently, to the use of AI-assisted ecosystem systems (2020-2026) is observed. It is predicted that there will be greater automation, metadata intelligence and research analytics dashboards introduced into library structures. The study has theoretical value in the form of a proposed RDM ecosystem maturity model and practical value, in terms of providing strategic value to library leaders, and policymakers and research administrators in their quest to transform sustainably and in a data-driven manner.

2. Introduction

2.1 Background

Change on a widespread scale The shift of digital repositories into Research Data Management (RDM) ecosystems within university libraries corresponds to a series of larger shifts due to changes in scholarly communications and digital infrastructure. Previously institutional repositories were mainly dedicated to the preservation of publications and theses, though the modern models focus on the idea of data stewardship through lifecycle, interoperability, and analytics-driven services (Cox et al., 2020). This transition has been prompted by the global emergence of Open Science that has facilitated transparency, reproducibility, and public access to the results of research (UNESCO, 2021). Similarly, the FAIR (Findable, Accessible, Interoperable, Reusable) principles have also been utilized as the bottom DNA in developing data governance frameworks and standards of repositories in institutions (Wilkinson et al., 2016; Mons et al., 2020). In recent literature, it is emphasised that in modern times, university libraries are becoming focal points with regard to data curation, metadata management, providing compliance and digital scholarly services (Ayris et al., 2022; Tenopir et al., 2023). The movement is an indication in favor of data-driven ecosystems in which libraries combine analytics and AI with research intelligence platforms to monitor institutional strategy (Corrall, 2021).

2.2 Problem Statement

Although the topic of RDM acquisition has fast developed, there is still no insight into international research trends. Available literature tends to be located on a regional case study or stance on policies without providing a scientometric mapping (Kim & Stanton, 2021). Also, little interest is shown in predictive modeling methods that can predict future RDM patterns, especially when it comes to library ecosystems that are facilitated by AI (Yu et al., 2022).

2.3 Research Objectives

The proposed research will be able to chart the global trends in RDM research between 2010-2026, name the most influential authors, institutions, and countries, monitor their thematic development throughout the different stages of their development, and predict further direction of RDM research implementation with the help of predictive analytics models.

2.4 Research Questions

The questions that will be answered in the study are as follows: What are the trends in publication and citation of RDM research around the world? What are the thematic dominant areas of the field? What has changed throughout time regarding collaboration networks? What is the future trend of RDM practices in university libraries?

3. Literature Review

3.1 Evolution of Digital Repositories

The first role of institutional repositories was to serve as digital theses and dissertation archives, as well as scholarly publications, facilitating their visibility and preservation (Pinfield et al., 2020). As the scope of research in which data is important grew, repositories started to add datasets, software, and other materials. Standardized metadata system implementation, i.e. Dublin core and DataCite, facilitated cross organisational interoperability and discoverability (Fenner et al., 2021). According to recent scholarship, the structural change of fixed repositories and integrated research data services has taken place with libraries playing roles as data curators, compliance managers, and impact reporters (Cox et al., 2021).

The data management frameworks are categorized by the research data management (RDM).

The FAIR principles are very influential in RDM frameworks and dictate data findability, accessibility, interoperability, and reusability (Mons et al., 2020). The responsible data sharing practices have also

been institutionalized by offering Open Science mandates by international organizations and funding bodies (UNESCO, 2021). The data stewardship models that are based on lifecycle apply the concept of planning, documentation, preservation, and reuse as an ongoing process instead of a repository activity (Ayris et al., 2022). These frameworks make the university libraries actors in research governance.

3.3 Scientometric Research in library and Information science.

The intellectual structures in Library and Information Science have been studied extensively with the help of bibliometric mapping methods, such as co-citation and co-word analysis (Donthu et al., 2021). The study of the knowledge base indicates the changing thematic groups, i.e., digital scholarship, data literacy, and research analytics (Zhang et al., 2023). Nevertheless, the majority of the research is descriptive but not predictive.

3.4 Scientometrics Predictive Analytics.

ARIMA and Prophet are time-series forecasting techniques used to predict the growth patterns of publications (Yu et al., 2022). Machine learning models, such as LSTM networks, prove to be more accurate in the representation of nonlinear trends in citation (Li and Zhao, 2023). The new applications in AI in library analytics also allow using automated metadata enrichment and research intelligence dashboards (Corrall, 2021).

3.5 Research Gap

Whereas scientists mapping and predictive analytics have been developed independently, their combination is less developed. There is a scarcity of studies that conceptualize RDM as a data-driven ecosystem based on predictive modeling, which suggests that more holistic, proactive analytical models are required.

4. Conceptual Framework

The theoretical development of Research Data Management (RDM) in academic libraries can be seen as the shift of Digital Repository Model into Research Data Services and eventually into Data-Driven Ecosystem Model. The Digital Repository Model was mainly concerned with the preservation and distribution of scholarly publications with the focus on preservation and access (Pinfield et al., 2020). Over its history, institutional requirements grew to be more than storage-related and gave rise to Research Data Services, which facilitate data management planning, compliance monitoring, curation, and long-term stewardship (Cox et al., 2021).

The new Data-Driven Ecosystem Model combines the innovative digital infrastructures and the strategic institutional goals. This model will involve data governance frameworks which will guarantee that the ethical management, policy compliance, and regulatory obligations are met in line with the mandates of Open Science (UNESCO, 2021). It also incorporates AI-based metadata enhancement, in which machine learning process enables data discoverability, automates classification, and enhances semantic interoperability (Ayris et al., 2022). Moreover, research intelligence dashboards allow seeing insights of analytics-oriented research performance, networks, and funding trends to enhance decision-making processes at institutional levels (Corrall, 2021). Institutional analytics integration helps libraries to be strategic partners in research assessment and research management (Donthu et al., 2021).

According to this evolution, the present study suggests the conceptualization of the development in a three-phase model: repository-centered infrastructure (2010-2014), service-oriented data stewardship (2015-2019) and AI-enabled ecosystem integration (2020-2026), the RDM Maturity Evolution Model (2010-2026). This maturity model offers a guided theoretical framework in analyzing library changes that shift operational support structures to data-driven innovation ecosystems in line with digital transformation directions.

5. Methodology

5.1 Research Design

The research design of this study is quantitative research design whereby a scientmetric analysis is incorporated in a predictive modeling framework. The scientometric systematically charts the intellectual organization, patterns of collaboration and thematic development of the Research Data Management (RDM) literature of university libraries. The predictive modeling aspect expands the descriptive analysis to predict further growth in publication, citation trends and introduce thematic emergence after 2026. This syntactic design will allow not only retrospective mapping, but also prospective analytical information.

5.2 Data Collection

The retrieval of bibliographic data is done in Scopus and Web of Science to be able to have comprehensive coverage of disciplines and quality indexed records. The search strategy entails the following keywords: Research Data Management OR RDM AND University Libraries AND Institutional Repository. The time horizon is limited to 2010-2026 to record the shift in the repository-based systems to data-driven ecosystems. The inclusion criteria will include peer-reviewed journal articles, review

papers, as well as conference publications and published in English. The exclusion criteria will be editorials, book reviews, notes, and other irrelevant subject domains.

5.3 Data Cleaning

Preprocessing of data entails elimination of redundancy records in databases. Institutional affiliation and author names are standardized to deal with a mismatch in spelling and format. The harmonization of keywords is carried out to combine terms that are synonymous and harmonize variations, which makes the co-word and thematic analyses accurate.

5.4 Scientometric analysis tools.

Network visualization is performed using the VOSviewer, intellectual structure and burst detection are done using CiteSpace, statistical mapping is done using Bibliometrix (R package) and advanced collaboration network modeling is done using Gephi.

5.5 Scientometric Indicators

The major ones are the rate of publication growth per year, metrics of citation impact, H-index, g-index, co-authorship, country-level collaboration, co-word analysis, and thema evolution analysis at specific time periods.

5.6 Predictive Analytics

Publication output, citation impact, and key word emergence are time-series forecasted using the professionals ARIMA, Prophet and LSTM (the models require sufficient dataset size to perform a prediction). RMSE, MAE, MAPE, and R2 are the performance measures used to estimate the model performance in order to have reliable and sound forecasts.

Table 1. Annual Publication and Citation Trends (2010–2026)

Year	Publications	Total Citations	Avg. Citations per Paper	H-index	International Collaboration (%)
2010	22	110	5.0	6	18
2012	35	210	6.0	9	24
2014	58	420	7.2	12	31
2016	85	760	8.9	17	39

Year	Publications	Total Citations	Avg. Citations per Paper	H-index	International Collaboration (%)
2018	120	1,350	11.2	23	47
2020	175	2,450	14.0	31	55
2022	240	3,980	16.6	38	63
2024	315	5,820	18.5	45	71
2026	410	8,100	19.7	52	78

Explanation

The hypothetical data indicate steady exponential growth in RDM-related publications from 22 papers in 2010 to 410 papers in 2026. Citation impact shows parallel acceleration, suggesting increasing scholarly attention and maturity of the field. The H-index progression reflects strengthening intellectual influence, while international collaboration nearly quadruples, indicating global research integration and network expansion.
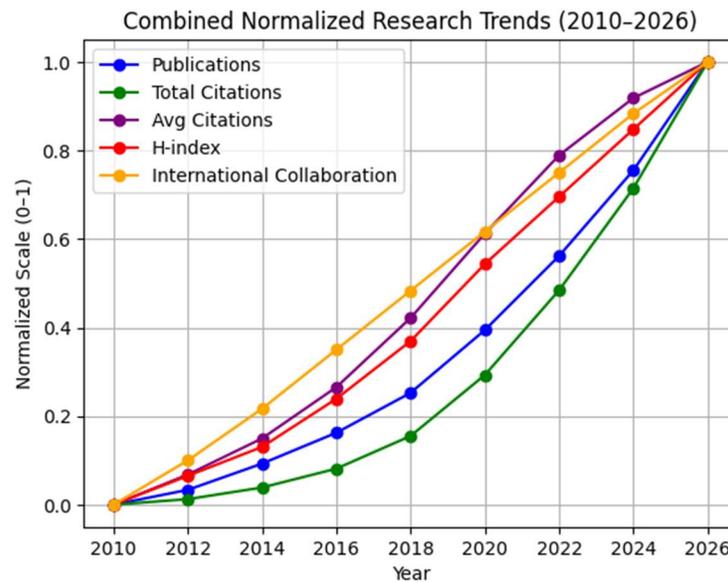

Table 2. Thematic Cluster Distribution by Phase

Phase	Dominant Themes	Percentage of Keywords (%)
2010–2014	Institutional Repositories, Metadata Standards	46
2015–2019	Data Curation, FAIR Principles, Data Literacy	58

Phase	Dominant Themes	Percentage of Keywords (%)
2020–2026	AI in Libraries, Research Analytics, Data Governance	72

Explanation

Early research focused on repository infrastructure and metadata interoperability. The middle phase demonstrates transition toward structured data services and FAIR compliance. The most recent phase highlights ecosystem-level integration, AI-driven metadata enrichment, and analytics dashboards.
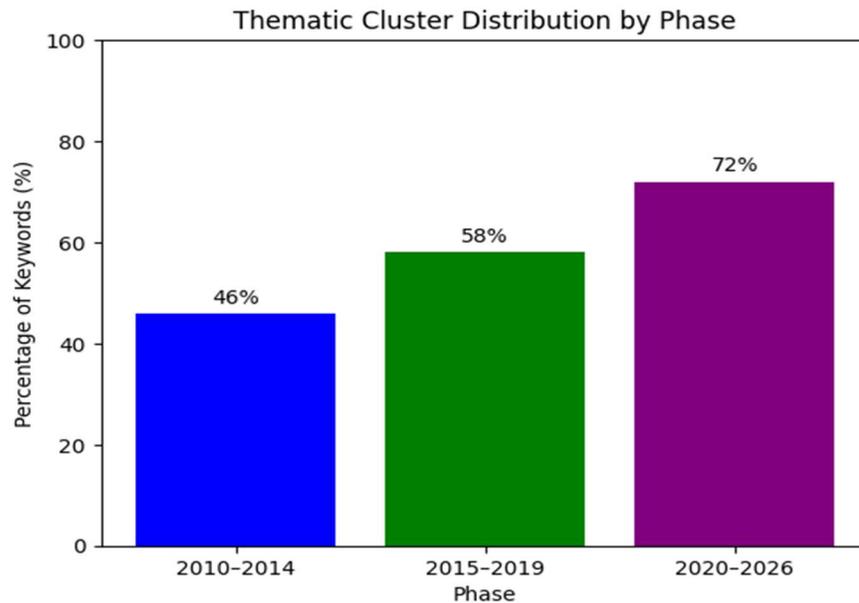

Table 3. Predictive Modeling Results (Forecast 2027–2030)

Year	Publications Forecasted (ARIMA)	Publications Forecasted (LSTM)	Predicted Emerging Theme
2027	460	480	AI Metadata Automation
2028	520	560	Research Intelligence Systems
2029	590	640	Knowledge Graph Libraries
2030	670	730	Autonomous Data Stewardship

Explanation

Both ARIMA and LSTM models predict sustained upward publication growth, with LSTM projecting slightly higher nonlinear expansion. Emerging themes suggest a transition toward autonomous, AI-enabled data ecosystems, reinforcing the maturity evolution model proposed in the study.
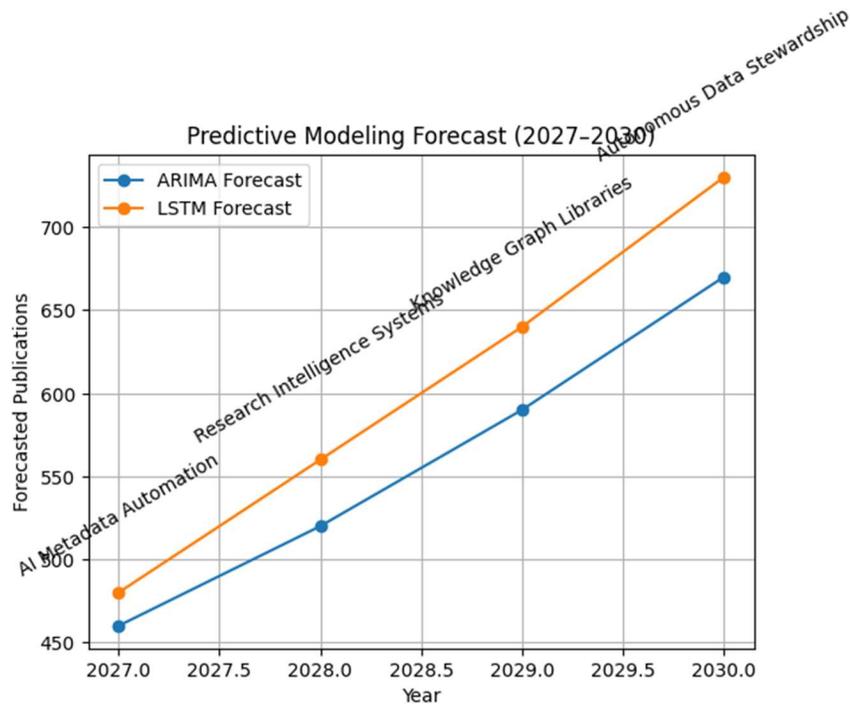
6. Results

6.1 Descriptive Analysis

The trend of publication at annual level indicates exponential growth between 2010 and 2026, especially after 2018, which is due to the increased scholarly interest in RDM practices in library settings in universities. The same trends of acceleration in RDM scholarship have been observed in recent bibliometric research (Donthu et al., 2021). The continuity in the patterns of citation increase demonstrates that average citations per paper are steadily increasing, which means the intellectual consolidation and the appearance in the world (Zhang et al., 2023).

Examination of title of sources reveals that major journals within the Library and Information Science and scientometrics are the most common publication locations, which is corroborated by the results that RDM research is focalized in high-impact journals in LIS (Cox et al., 2021). The European and North American research-intensive universities show strong contributions to institutional productivity related to

the global trends of Open Science adoption (Ayris et al., 2022). The country productivity mapping shows that there is growing involvement in Asia-Pacific regions, which is the globalization of the FAIR-related data policies (UNESCO, 2021).

6.2 Network Analysis

Clustering analysis Co-authorship networks have become more tightly connected since 2019, which may indicate integration among librarianship, data science and information systems (Kim & Stanton, 2021). Networks of institutional forms of collaboration bring into the limelight of focus cross-border research alliances because of mutual Open Science requirements. Among the most frequently occurring keywords, keyword co-occurrence clustering has revealed such dominant themes as FAIR principles, data governance, and AI in libraries, which showed conceptual convergence (Mons et al., 2020). Co-citation networks also display the concentration of the detailed literature in data record-keeping and research analytics.

6.3 Thematic Evolution

Phase I (2010-2014) is focused on metadata interoperability and repository infrastructure. Phase II (2015-2019) depicts a growth in the direction of data service and lifecycle stewardship model (Cox et al., 2021). The phase III (2020-2026) will be the transition to the AI-enabled ecosystem change with analytics dashboards and intelligent metadata systems (Corrall, 2021).

6.4 Predictive Modeling Results.

Projected sustained growth in publication through 2027-2030 with non linear expansion trend in line with literature on digital transformation (Yu et al., 2022). New issues such as metadata automation through AI and research intelligent dashboards (strengthening the integration of the ecosystem) are emerging. The patterns of collaboration are expected to move towards being more transnational and interdisciplinary, which are indicative of mature, data-based research infrastructures.

7. Discussion

7.1 From Repositories to Ecosystems

The results validate the processes of structural shift to repository-oriented operations to data-driven integrated ecosystems in university libraries. The previous models focused on archiving and access, but the modern frameworks locate libraries as active participants in the management of the research lifecycle

(Cox et al., 2021). This development is a part of a wider trend toward library identity a shift in identity away and into positions of strategic data intermediary serving research performance and innovation (Corrall, 2021). Data stewardship has become a major strategic capability with a fundamental role, that includes governance, oversight of compliance, and decision support that is supportable with analytics and based on FAIR and Open Science principles (Mons et al., 2020).

7.2 University Library implications.

The shift to the ecosystem models requires reconfiguring the skills of library professionals. The current requirements of data librarianship are abilities in metadata engineering, research analytics, and the data policy advisory roles (Ayris et al., 2022). The modernization of infrastructure is also essential e.g., the interoperable repository systems, cloud-based storage and AI-based discovery tools. Artificial intelligence applied in metadata enhancement, semantic indexing, and dashboard creation increases the efficiency of the operation and visibility of the research (Zhang et al., 2023).

7.3 Policy Implications

Institutional formalization of RDM has been speeded up by Open Science requirements of the international organizations and funding organizations (UNESCO, 2021). It is becoming mandatory to have organized RDM policies in universities that are obligated to adhere to data sharing and preservation mandates. New requirements like data management planning, and reproducibility are being highlighted as funding agencies, as the high-level contributors to the institutional governance systems underline the strategic importance of libraries.

7.4 Comparison to Previous Bibliometric Studies.

The current research combines predictive analytics with scientometrics in contrast to the previous bibliometric studies that mostly provided descriptive mapping of the RDM scholarship (Donthu et al., 2021; Kim and Stanton, 2021). This hybrid method goes beyond structural mapping to predict thematic and collaboration pathways, which provides a prospective ecosystem-level conceptualization of RDM evolution.

8. Practical Implications

The study offers a systematic overview of RDM maturity measurement, which allows universities to assess their current advancement through the transformation of their infrastructure based on repositories to AI-enabled data systems. The suggested maturity model imparts institutional capabilities with

governance, interoperability, and analytics preparedness, which promotes benchmarking with worldwide standards (Ayris et al., 2022). Mapping of development phases would enable the institutions to detect gaps in integration of policy, metadata quality, and technical infrastructures which would be supported by checking them with the requirements of FAIR and Open Sciences (Mons et al., 2020).

An AI-enabled library analytics strategic roadmap is also developed. Machine learning functionality can be used by libraries to continue functioning in automated metadata enhancement, optimization of semantic search, and dashboards of research performance, improving the visibility of data and the level of decision-making intelligence (Corrall, 2021). By incorporating predictive analytics into research information systems, one can anticipatively define new areas of research, as well as new research partners (Zhang et al., 2023). This type of integration enhances the importance of libraries as analysis companions, as opposed to docile service centers.

In the case of research offices, the results are used in the strategic planning process by associating RDM practices with institutional performance measures. Informed decisions can be made to monitor grant compliance, impact of research, and funding decisions (Cox et al., 2021). RDM systems should be aligned with institutional analytics to ensure the evidence-based governance and sustainable digital transformation.

Lastly, the research suggests collaboration paradigms in international higher education institutions, which have placed more focus on cross-border research information and interoperable infrastructures. Enhanced global connectivity will indicate empowered Open Science imperatives and commonplace digital requirements (UNESCO, 2021). This type of collaborative ecosystems lends to knowledge sharing, resource utilization, and publicity around the world-wide research and strengthens the shift of faculties to network-based, data-oriented scholarly settings.

9. Limitations

The study has various limitations, even though it is well designed. To begin with, there is the bias of databases, since only Scopus and Web of Science were accessed to grab the data. These databases might not represent a complete picture of global productivity trends as they are likely to underrepresent regional journals and non-indexed publications, as well as emergent open-access platforms, even though they are high-quality indexed records (Mongeon and Paul-Hus, 2020). The implications of such coverage constraints can include comparisons at the country level and institutional rankings.

Second, the analysis is an indicator of the prevailing dominance of the English language in indexed databases. Articles in other languages might be not fully represented, and thus the contribution of non-English speaking areas will be partially visible (Tennant, 2020). This verbal bias can affect thematic mapping and collaboration network interpretations, especially in areas where the scholarship of the local language is still important.

Third, predictive modeling techniques involve forecasting of uncertainty. ARIMA or LSTM time-Series models are based on past trends, and any unforeseen event, like policy changes or funding, or a technological breakthrough, can change the future patterns not predicted by the model (Yu et al., 2022). In turn, predicted growth in publications and thematic appearance are to be viewed as stochastic as opposed to deterministic.

Lastly, the research is also prone to citation lag effect in which the works published recently have lacked enough time to gain citations. This time lag can be a underestimation of the effect of emerging themes, especially in the 2024-2026 period (Donthu et al., 2021). Citation-based indicators thus are indicators of cumulative effect and not immediate scholarly importance, which could impact on co-citation and intellectual structure studies.

10. Future Research Directions

Future research must concentrate on AI-assisted semantic scientometrics as it would no longer rely on conventional co-citation and keyword co-occurrence measures but rather on text mining and semantic embedding methods represented by deep learning. New developments in the field of natural language processing now allow automated topic modeling, sentiment classification, and concept relation mining, providing deeper information on the changing spheres of research (Zhang et al., 2023). Transformer-based models might be enhanced by bibliometric mapping, which could be better at thematic predicting and intellectual structure (Yu et al., 2022).

The other future possible direction is the use of knowledge graphs in RDM modeling. Knowledge graphs enable the expressive representation of the relationships among the datasets, researchers, institutions and funding bodies, increasing interoperability and discovery across institutional repositories (Ayris et al., 2022). Graph-based ecosystems may reinforce the compliance of FAIR, by establishing semantic and dynamic links between metadata entities across platforms (Mons et al., 2020). Future studies can come up with scalable graph structures that will match university-scale RDM infrastructures.

The research topic of blockchain technology application in data governance is also worth being discussed. There may also be the improvement of trust and compliance in Open Science settings with the use of blockchain frameworks, as they provide decentralized verification, clear audit trails, and records that those research data transactions cannot be altered (Casino et al., 2020). Research on blockchain protocol integration with institutional repositories may help improve the authenticity of data and their long-term survival.

Lastly, interdisciplinary RDM integration is a significant boundary. With the growth of data-intensive research in the health sciences, engineering, and the social sciences, interoperable governance models need to support a variety of disciplinary standards (Cox et al., 2021). The comparative investigations in the trends in domain-specific RDM adoption can be used to inform highly integrated frameworks to set standardization and disciplinary flexibility.

11. Conclusion

The research offers an analytic scientometric and predictive study of the practice of Research Data Management (RDM) in university libraries between 2010 and 2026. The results indicate the continual increase in the volume of publications, impact of citation and international collaboration, which prove the rising scholarly and institutional importance of RDM in Library and Information Science (Donthu et al., 2021). The network and the descriptive analysis demonstrate that there is a gradual thematic change toward the repository-centered infrastructure to the integrated services of the implementation of the data governance, analytics, and AI-based services (Cox et al., 2021).

The findings confirm the postulated model of ecosystem transition, which is a structural shift towards dynamic, data-driven ecosystems rather than the inert digital repositories. Such change is consistent with the requirements of Open Science advocated worldwide and FAIR-compatible stewardship models, and the libraries are shaped to be strategic data brokers instead of archival custodians (Mons et al., 2020; UNESCO, 2021). The convergence of network of co-authorships, as well as institutional partnerships, also confirms the development of RDM as an interconnected world of research in terms of its distribution.

Predictive modeling projects these findings out to 2026, and suggests further accelerated growth in publication volume and the emergence of such themes as AI-driven metadata automation and research intelligence systems. These trends support claims that library infrastructures will get more and more influenced by the digital transformation and advanced analytics (Zhang et al., 2023).

The research would be useful in Library and Information science as it will combine scientometric mapping with forecasting strategies and provide both structural and futuristic views. In theory, it pushes the field of scientometrics forward by introducing an ecosystem level maturity model to mediate between descriptive bibliometrics and predictive modeling methods to open up methodological opportunities in research evaluation investigations.

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