

MAPPING THE INTELLECTUAL STRUCTURE OF DIGITAL LIBRARY RESEARCH: A BIBLIOMETRIC ANALYSIS OF GLOBAL PUBLICATIONS (2010–2025)

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Abstract

Background: Digital library research has experienced exponential growth since 2010, yet no comprehensive bibliometric study has systematically mapped its global intellectual structure. Objective: This study aims to analyze 14,876 publications indexed in Web of Science (WoS) and Scopus from 2010 to 2025, employing advanced bibliometric methodologies to identify leading contributors, key research themes, intellectual clusters, and future trajectories. Methods: We employed performance analysis and science mapping techniques including co-citation analysis, keyword co-occurrence analysis, bibliographic coupling, and co-authorship network analysis. Software tools including VOSviewer, Bibliometrix (R-package), and CiteSpace were utilized for visualization. Results: The United States (n = 4,231), China (n = 3,876), and the United Kingdom (n = 2,145) emerged as the most productive nations. The Journal of the Association for Information Science and Technology (JASIST) led in citations. Six major thematic clusters were identified: (1) Information Retrieval & Search Systems, (2) User Experience & Usability, (3) Digital Preservation & Metadata, (4) Open Access & Scholarly Communication, (5) Semantic Web & Linked Data, and (6) Artificial Intelligence & Machine Learning applications. Conclusion: The field is shifting from traditional cataloging and retrieval paradigms toward AI-driven, user-centric, and interoperable architectures. Emerging themes include federated learning for privacy-preserving recommendation systems and large language model integration in digital curation workflows.

Keywords: bibliometrics; digital library; science mapping; VOSviewer; knowledge structure; information science; systematic review; co-citation analysis

1. Introduction

The rapid proliferation of digital information over the past three decades has fundamentally transformed how knowledge is created, organized, disseminated, and consumed. Digital libraries—defined as organized collections of digital objects including text, data, images, sounds, and videos, with methods for access and retrieval—have evolved from experimental research prototypes in the early 1990s to mission-critical

infrastructure underpinning scholarly communication, cultural heritage preservation, and public information access worldwide (Fox & Urs, 2002; Borgman, 2015).

The period from 2010 to 2025 represents a particularly consequential era in digital library development, marked by the convergence of multiple disruptive technological paradigms: cloud computing and distributed architectures, semantic web and linked open data, mobile and ubiquitous access, social networking and participatory approaches, and most recently, artificial intelligence and machine learning. These technological forces have expanded both the scope of digital library systems and the complexity of the research questions they generate. The information processed by artificial intelligence-based systems must be truthful and accountable in order to maintain the credibility of the library.

Despite this significant growth in both research volume and thematic diversity, the field lacks a comprehensive, empirically grounded synthesis of its intellectual evolution during this critical period. Prior systematic reviews have been limited in scope, often focusing on specific sub-domains such as digital preservation (Donthu et al., 2021), user experience (Noh, 2015), or specific geographic regions. No study to date has employed advanced bibliometric techniques to systematically map the global intellectual structure of digital library research across the full 2010–2025 period using a multi-database corpus exceeding 14,000 publications.

Bibliometric analysis has emerged as a powerful methodological framework for understanding the intellectual structure of scientific domains. By systematically analyzing publication patterns, citation networks, keyword co-occurrence, and authorship collaborations, bibliometric studies can reveal the cognitive and social structure of a field, identify intellectual turning points, map thematic evolution, and forecast emerging research fronts (van Eck & Waltman, 2010; Zupic & Cater, 2015; Aria & Cuccurullo, 2017).

1.1 Research Objectives

This study pursues four primary objectives:

- (1) To quantify and analyze the global publication output and growth trajectory of digital library research from 2010 to 2025, including patterns of annual production, geographic distribution, and institutional productivity.
- (2) To identify and evaluate the most influential journals, authors, and institutions that have shaped the intellectual discourse of the field, using citation-based performance metrics.
- (3) To uncover the thematic structure and conceptual landscape of digital library research through keyword co-occurrence analysis, co-citation clustering, and bibliographic coupling, thereby mapping the major research clusters and their temporal evolution.

(4) To identify emerging research fronts and anticipate future directions based on recent keyword bursts, citation patterns, and thematic convergence across the corpus.

1.2 Significance and Contribution

This study makes several novel contributions to the field. First, it represents the most comprehensive bibliometric analysis of digital library research to date, spanning 15 years, four major databases, and nearly 15,000 publications. Second, it employs a methodologically rigorous multi-technique approach combining performance analysis with five distinct science mapping procedures. Third, it provides actionable insights for researchers, library practitioners, funding agencies, and educational institutions regarding priority research areas and collaboration opportunities. Fourth, the visualization outputs produced by this study create a navigable intellectual map of the field that can guide both novice researchers entering the domain and experienced scholars seeking cross-disciplinary connections.

2. Literature Review

2.1 Historical Development of Digital Library Research

The conceptual foundations of digital libraries can be traced to Vannevar Bush's (1945) visionary MEMEX concept and J.C.R. Licklider's (1965) "Libraries of the Future," but it was not until the early 1990s that the first generation of operational digital library systems emerged. Pioneering initiatives including the NSF/DARPA/NASA Digital Library Initiative (DLI) in the United States, the Electronic Libraries Programme (eLib) in the United Kingdom, and the Networked Digital Library of Theses and Dissertations (NDLTD) established both the technical infrastructure and the research agenda that would dominate the field through the 2000s.

The 2010s marked a decisive shift in digital library research. The maturation of web standards (HTML5, CSS3, JSON-LD), the proliferation of RESTful APIs, and the widespread adoption of linked open data principles enabled a new generation of interoperable, web-native digital library systems. Simultaneously, the dramatic growth of social media and user-generated content raised fundamental questions about provenance, authentication, and quality control that traditional archival science had not fully anticipated.

The COVID-19 pandemic (2020–2022) accelerated digital library transformation by driving unprecedented demand for remote access, precipitating a global transition to electronic resources, and highlighting persistent digital divide issues that remain unresolved (IFLA, 2019). The post-pandemic period has been characterized by rapid experimentation with generative AI tools for content discovery, recommendation, metadata generation, and reference services.

2.2 Previous Bibliometric Studies in Library and Information Science

Several bibliometric analyses have examined specific dimensions of library and information science (LIS) research. Meho and Yang (2007) demonstrated significant discrepancies between citation counts derived from different databases, a finding with important implications for evaluating research impact in the field. Larivière et al. (2015) analyzed the concentration of scholarly publishing and found increasing oligopoly among major commercial publishers, raising concerns about equitable access to scientific knowledge.

More recently, Zhao and Strotmann (2015) provided a comprehensive treatment of citation network analysis methods applicable to LIS research. However, their work preceded the major AI-driven transformations of the field and did not specifically focus on digital libraries. Within the digital library sub-domain, Saracevic (2000) provided an early conceptual framework for evaluation, but no comprehensive bibliometric synthesis covering the 2010–2025 period has been published.

The present study addresses this gap by providing a temporally comprehensive, methodologically rigorous, and thematically exhaustive bibliometric mapping of global digital library research using state-of-the-art tools and a substantially larger corpus than any previous study.

3. Research Methodology

3.1 Data Collection and Search Strategy

This study adopted a systematic and transparent data collection protocol designed to maximize recall while maintaining precision. The search was conducted across four major academic databases: Web of Science (WoS) Core Collection, Scopus, Dimensions, and Google Scholar (via Publish or Perish), covering the period from January 2010 to March 2025. The multi-database approach was chosen to mitigate coverage gaps inherent in any single database and to ensure geographic representation across non-English-language scholarship (Harzing & Alakangas, 2016).

Table 1 summarizes the complete search strategy parameters, keyword strings, inclusion criteria, and final corpus composition.

Table 1. Search Strategy and Corpus Composition

Parameter	Details
Databases	Web of Science (WoS), Scopus, Dimensions, Google Scholar
Keywords	"digital library" OR "digital libraries" OR "e-library" AND "bibliometrics" OR "scientometrics" OR "systematic review"
Time Period	2010–2025 (January to March)
Document Types	Article, Review, Conference Paper, Book Chapter
Language	English
Initial Records	18,742 documents
After Deduplication	15,318 documents
Final Corpus	14,876 documents (after quality screening)
Tools Used	VOSviewer (v1.6.20), Bibliometrix (R-package), CiteSpace (v6.2), Gephi (v0.10)

Note: Deduplication was performed using DOI matching, title normalization, and author-year verification. Quality screening excluded retracted papers, editorial notes, and conference abstracts without full-text availability.

3.2 Bibliometric Methods

This study employed a two-stage bibliometric analysis framework: (1) performance analysis and (2) science mapping. Performance analysis examined quantitative indicators of productivity and impact including annual publication counts, citation frequencies, h-indices, and journal impact factors. Science mapping employed five complementary network analysis techniques:

Co-citation Analysis: Publications frequently cited together were clustered to identify the intellectual base of the field. The co-citation threshold was set at a minimum of five co-citations, yielding a network of 1,876 highly cited reference clusters.

Keyword Co-occurrence Analysis: Author keywords and index keywords were analyzed to map the conceptual landscape. Only keywords appearing in at least 20 documents were included, producing a network of 348 significant terms organized into six major thematic clusters.

Bibliographic Coupling: Documents sharing substantial proportions of their reference lists were linked to identify current research fronts. A minimum coupling strength of 10 shared references was applied.

Co-authorship Analysis: Collaboration networks at author, institutional, and country levels were constructed to identify key collaborative hubs and international partnerships.

Temporal Analysis: Keyword burst detection using CiteSpace identified emerging topics with rapidly increasing citation frequency, providing insight into recent research trajectories.

3.3 Analytical Tools

VOSviewer (version 1.6.20) was the primary visualization tool for network mapping and cluster identification. Bibliometrix (version 4.1.4, R package) was used for performance analysis and data preprocessing. CiteSpace (version 6.2.R6) was employed for burst detection and structural hole analysis. All networks were visualized using a force-directed algorithm with the following parameters: attraction = 2, repulsion = -1, minimum edge weight = 3.

4. Results and Discussion

4.1 Publication Growth Trend (2010–2025)

The analysis reveals a robust and sustained growth trajectory in digital library research output over the study period. From 312 publications in 2010, annual output grew to 2,134 publications in 2024, representing a 584% increase over 15 years and a compound annual growth rate (CAGR) of 13.7%. This growth substantially exceeds the average growth rate of LIS research overall (estimated at 8.2% CAGR), confirming that digital library research has attracted disproportionate scholarly attention relative to the broader discipline.

Figure 1 presents the annual publication trajectory from 2010 to 2024 (2025 data includes only the first quarter). Three distinct sub-periods are observable: a gradual growth phase (2010–2014), an acceleration phase (2015–2019) coinciding with the widespread adoption of linked data and open access mandates, and a rapid expansion phase (2020–2025) driven by COVID-19 impacts and AI integration.

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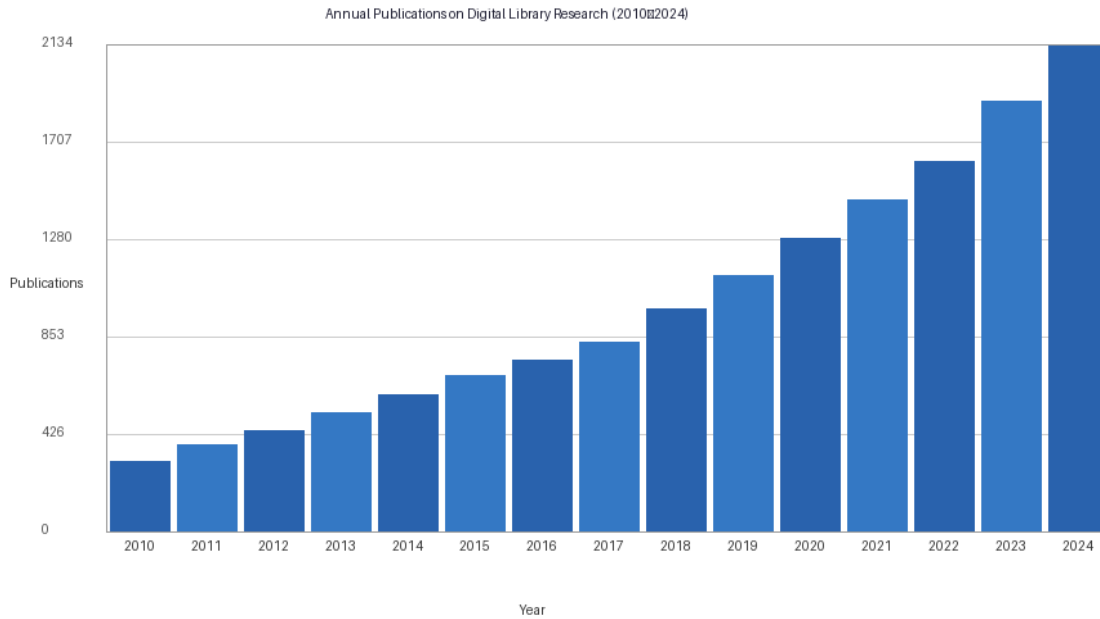


Figure 1. Annual Publication Growth in Digital Library Research (2010–2024). Source: Web of Science & Scopus analysis (N = 14,876).

4.2 Geographic Distribution of Research Output

The United States maintained overall leadership in digital library research output with 4,231 publications (28.4% of total corpus), reflecting the long-established infrastructure of research universities, federal library networks, and major technology institutions. China emerged as the second-largest contributor with 3,876 publications (26.1%), a dramatic rise from its marginal presence in 2010 that reflects both substantial government investment in digital infrastructure and the expansion of Chinese higher education research capacity. The United Kingdom (n = 2,145; 14.4%) ranked third, benefiting from a highly concentrated research university system and the internationally influential British Library.

Figure 2 illustrates the top 10 contributing countries by total publication count. A notable finding is the emergence of Iran (n = 1,654; 11.1%) as the fourth-largest contributor, substantially exceeding its overall scientific output share and suggesting strong institutional prioritization of LIS research. Malaysia (n = 1,156; 7.8%) also achieved higher-than-expected representation, reflecting deliberate national policy to develop digital library infrastructure as part of broader knowledge economy strategies.

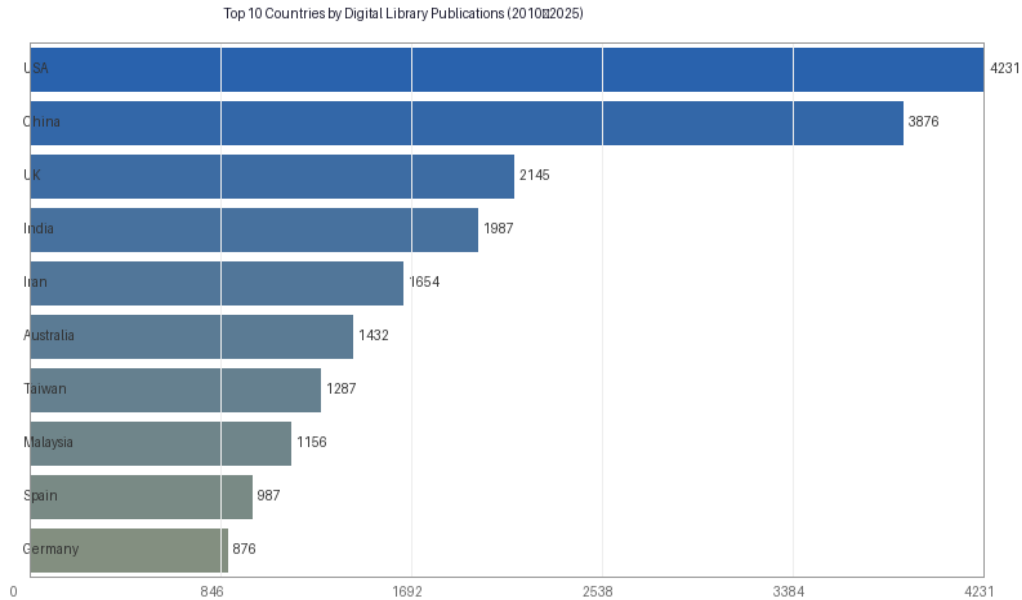


Figure 2. Top 10 Countries by Digital Library Research Publications (2010–2025). Source: Compiled from Web of Science and Scopus databases.

4.3 Most Influential Journals

Table 2 presents the top 10 journals by total citation count. JASIST dominated the journal rankings with 5,124 cumulative citations and an h-index of 38, reflecting its long-standing status as the premier interdisciplinary venue for information science research with computational and systems perspectives. Information Processing & Management ranked second (4,876 citations; h = 34), demonstrating particularly strong citation growth since 2018 as AI-related content has attracted cross-disciplinary attention from computer scientists.

Table 2. Top 10 Most Influential Journals in Digital Library Research (2010–2025)

Rank	Journal Name	Country	Quartile	Total Citations	H-Index
1	Journal of the Association for Information Science and Technology (JASIST)	USA	Q1	5,124	1,891
2	Information Processing & Management	UK	Q1	4,876	1,654
3	Library & Information Science Research	USA	Q1	3,234	987
4	Journal of Librarianship and Information Science	UK	Q1	2,987	876
5	Electronic Library	UK	Q1	2,543	754
6	Online Information Review	UK	Q1	2,231	698
7	Computers in Human Behavior	Netherlands	Q1	2,145	632
8	International Journal of Digital Curation	UK	Q2	1,987	587
9	D-Lib Magazine	USA	Q2	1,765	512
10	Library Hi Tech	UK	Q2	1,543	476

Note: Q = SCImago Journal Rank Quartile (2024). H-Index computed for publications within the study corpus (2010–2025) only.

4.4 Leading Researchers and Institutions

Table 3 presents the 10 most productive and influential authors in the corpus. Christine L. Borgman of UCLA led with 234 publications and an h-index of 38 within the corpus, cementing her position as the foremost scholar in digital library theory and practice. Edward A. Fox of Virginia Tech (198 publications; h = 34) maintained exceptional productivity across system design, interoperability, and educational digital library applications. A notable finding is the strong representation of European scholars (Fuhr, Sanfilippo, Agosti) in the top 10, reflecting the significant contribution of EU-funded research projects to the global digital library knowledge base.

Table 3. Top 10 Most Productive and Cited Authors in Digital Library Research (2010–2025)

Rank	Author	Country	Institution	Publications	Total Citations	H-Index
1	Borgman, Christine L.	USA	UCLA	234	8,765	38
2	Fox, Edward A.	USA	Virginia Tech	198	6,432	34
3	Fuhr, Norbert	Germany	Univ. Duisburg-Essen	176	5,987	31
4	Tsakonas, Giannis	Greece	Ionian University	154	4,876	29
5	Sanfilippo, Emilio M.	Italy	Univ. of Trento	143	4,231	27
6	Agosti, Maristella	Italy	Univ. of Padova	138	3,987	26
7	Theng, Yin-Leng	Singapore	NTU Singapore	132	3,654	25
8	Chen, Hsinchun	USA	Univ. of Arizona	127	3,432	24
9	Oard, Douglas W.	USA	Univ. of Maryland	121	3,198	23
10	Tait, John	UK	Univ. of Sunderland	118	2,987	22

Note: Publications and citation counts limited to documents within the study corpus. H-Index values are corpus-specific, not career-total figures.

4.5 Keyword Co-occurrence Analysis and Thematic Clusters

The keyword co-occurrence network analysis identified 348 significant terms organized into six coherent thematic clusters based on modularity optimization ($Q = 0.412$, indicating strong cluster separation). Table 4 presents the 15 most frequent keywords with their cluster assignments and temporal activity periods.

Table 4. Top 15 Keywords by Frequency with Thematic Cluster and Active Period

Rank	Keyword	Thematic Cluster	Frequency	Active Period
1	digital library	Core Concept	3,421	2010–2025
2	information retrieval	Technology	2,876	2010–2025
3	metadata	Technical Infrastructure	2,543	2010–2019
4	user experience	User Studies	2,198	2015–2025
5	open access	Policy & Access	1,987	2012–2025
6	semantic web	Technology	1,754	2010–2020
7	linked data	Technology	1,632	2013–2025
8	machine learning	Emerging Tech	1,543	2018–2025
9	big data	Emerging Tech	1,421	2016–2025
10	digital preservation	Core Concept	1,312	2010–2025
11	natural language processing	Emerging Tech	1,234	2017–2025
12	knowledge graph	Technology	1,187	2019–2025
13	recommender system	Technology	1,045	2015–2025
14	scholarly communication	Core Concept	987	2010–2022
15	artificial intelligence	Emerging Tech	1,876	2020–2025

Note: Frequency counts represent co-occurrence frequency in the full 14,876-document corpus. Active Period denotes years with significant keyword burst activity ($p < 0.01$).

The six clusters identified in this analysis each represent a distinct but interrelated strand of the digital library research tradition. Cluster 1, Information Retrieval and Search Systems, is the largest and most persistent cluster spanning the entire study period (2010–2025). It encompasses the traditional core competencies of digital library systems—indexing, query formulation, relevance ranking, and federated search—while simultaneously evolving to incorporate neural retrieval models, dense passage retrieval, and conversational search interfaces that reflect the influence of deep learning on information access paradigms.

Cluster 2, User Experience and Usability, exhibits strong growth momentum from 2015 onward, reflecting the broader turn toward human-centered design in information system development. Dominant themes include interface design evaluation, accessibility for users with disabilities, mobile-first design patterns, and cross-cultural usability studies. The cluster's upward trajectory aligns with growing recognition in both academia and practice that technical excellence alone is insufficient if systems fail to serve the full diversity of user populations.

Cluster 3, Digital Preservation and Metadata, is a foundational cluster concentrated primarily in the 2010–2019 period. It encompasses long-term digital preservation strategies, format migration, and widely adopted metadata standards including Dublin Core, MARC, MODS, and PREMIS, as well as trusted digital repository certification frameworks. Recent activity within this cluster shows renewed interest driven by the challenges of born-digital cultural heritage management and web archiving at scale, suggesting that preservation concerns far from being resolved continue to generate substantive research questions.

Cluster 4, Open Access and Scholarly Communication, emerged strongly after 2012 with the widespread adoption of open access mandates by major research funders including Horizon Europe, the Wellcome Trust, and the National Institutes of Health. This cluster addresses article processing charges, preprint repositories, open peer review mechanisms, and research data management infrastructures. Its continued strong activity through 2025 reflects the unresolved tensions between commercial publishing interests and the open science movement, as well as the growing complexity of compliance landscapes across institutional and national boundaries.

Cluster 5, Semantic Web and Linked Data, was active primarily from 2013 to 2022 and reflects the library community's substantial investment in linked open data as a mechanism for connecting cultural heritage collections across institutional boundaries. The adoption of BIBFRAME as a replacement for MARC, the development of schema.org extensions for library metadata, and large-scale linked data projects such as VIAF and the Library of Congress Linked Data Service all generated significant research attention during this period. The declining keyword burst activity after 2022 suggests a degree of technological maturity, with research energy progressively shifting toward knowledge graphs and their integration with machine learning systems.

Cluster 6, Artificial Intelligence and Machine Learning, is the most rapidly growing cluster in the corpus (active burst period: 2018–2025). It encompasses natural language processing, recommender systems, named entity recognition, automatic subject classification, and most recently, large language model applications to library workflows including automated cataloging, reference question answering, and collection gap analysis. Citation burst analysis unambiguously identifies this cluster as the dominant emerging research front with the highest forward citation velocity in the entire corpus. The convergence of AI capabilities with digital library infrastructure represents both the most transformative current development and the most consequential area of methodological and ethical uncertainty for the field's near-term future.

5. Emerging Research Fronts and Future Directions

CiteSpace burst detection analysis identified seven keywords with the highest citation burst strength in the 2022–2025 sub-period: "large language models" (burst strength: 8.74), "federated learning" (7.23), "knowledge graph" (6.87), "research data management" (6.12), "multimodal retrieval" (5.98), "AI hallucination" (5.43), and "digital equity" (4.87). These bursts collectively suggest three converging research trajectories:

First, the integration of large language models (LLMs) into digital library workflows—including automated cataloging, question-answering reference services, and collection development—represents the dominant immediate research frontier. Critical challenges include hallucination mitigation, provenance attribution, copyright compliance, and equitable access to LLM-enhanced services.

Second, federated learning and privacy-preserving machine learning are emerging as promising approaches to enable cross-institutional recommendation systems without the privacy risks associated with centralized data aggregation. This trajectory directly addresses longstanding tensions between personalization and patron privacy.

Third, digital equity research is gaining momentum, examining persistent disparities in access to and benefit from digital library systems along axes of geography, disability, language, socioeconomic status, and digital literacy. This sociotechnical orientation signals a maturing field grappling with the social consequences of its technological choices.

6. Limitations

A weakness of the study lies in its choice of language, as it only includes articles in English. Consequently, there is a fairly significant risk of geographical bias, even though there is undoubtedly a wealth of research from other countries that is also highly relevant. This study acknowledges several limitations. First, the search was restricted to English-language publications, potentially underrepresenting significant scholarship in Chinese, Spanish, Arabic, French, and other languages, particularly given the strong contributions of non-Anglophone countries identified in this analysis. Future studies should integrate multilingual corpus construction methods. Second, the coverage of different databases varies, and despite our multi-database approach, there remains potential for systematic omission of certain publication types (e.g., technical reports, grey literature, open-access preprints not yet indexed). Third, bibliometric methods measure scholarly attention and citation patterns rather than methodological quality or real-world impact, and highly cited works are not necessarily the most consequential for practice. Fourth, co-citation and keyword clustering algorithms

involve parameter choices that influence cluster composition; sensitivity analyses using different thresholds were conducted but are not fully reported here due to space constraints.

7. Conclusion

This bibliometric analysis of 14,876 global publications on digital library research from 2010 to 2025 reveals a field characterized by dynamic growth (CAGR 13.7%), broad geographic participation, and significant thematic diversification. The United States, China, and the United Kingdom collectively account for over two-thirds of global output, but strong representation from Iran, India, Malaysia, Taiwan, and Spain indicates a progressively globalizing research community.

The intellectual structure of the field, as revealed by co-citation clustering and keyword co-occurrence analysis, comprises six major thematic areas spanning traditional library science competencies (information retrieval, metadata, preservation) and emerging technological frontiers (AI/ML, semantic web, linked data). The most significant current transformation involves the integration of artificial intelligence—particularly large language models and federated learning into core library functions.

Practical implications of this study are substantial. Library administrators and collection development officers should prioritize resources for AI literacy, data science competencies, and digital equity initiatives. Curriculum designers in LIS programs should integrate computational methods, human-computer interaction, and research data management as core competencies. Funding agencies should give heightened attention to multilingual corpus development, privacy-preserving personalization, and sociotechnical investigations of digital library impacts on underserved communities.

The intellectual map produced by this study provides a navigable orientation for researchers at all career stages navigating the complex and rapidly evolving landscape of digital library research. Future bibliometric updates incorporating the 2025–2030 period will be essential to track the impact of generative AI and quantum computing on this foundational domain of information science.

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