

*Original Research*

## **Mapping Knowledge Domains of Global Digital Library Research Output: A Scientometric Assessment**

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### **Abstract**

Digital Libraries have emerged as an essential component of worldwide information infrastructure, adopting the latest Information and Communication Technology (ICT) to promote an organizational structure that encourages communication and resource sharing between academicians and researchers across the countries. The study explored global digital library literature that has been carried out in the years 2007-2021 based on various scientometric indicators such as publication output, prolific author, collaboration network by author, productive institution, and country. The key term "digital library" was used in our search strategy from the Web of Science. The data was saved and imported into R Studio and VOS viewer for analysis and illustration of our data. We accessed 5855 records retrieved from the Web of Science. The United States had the most documents published, followed by China and England. The journals of Electronic Library were ranked first. The University of California System was the top organization with many scientific publications with 5549 citations. This research gives scholars and practitioners a thorough overview of the key research issues and trends in digital library research worldwide. Digital libraries worldwide have impacted the research society. It is an extension of a physical library into an electronic library. This study is very significant in the current scenario to know the global growth rate of scientific literature.

**Keywords:** Mapping Knowledge, Digital Library, Scientometric, Citation, H-Index, G-Index.

### Introduction

Over the past few decades, the computerization of libraries has focused on creating surrogate data of printed documents available in a library or providing computerized services through locally stored secondary databases on CD-ROM and magnetic tape (Taala, Franco Jr & Cordero 2019). However, recent versions of digital library packages provide additional features and functionality that interest digital libraries. Digital data sources include not only the rapidly growing collection of electronic full-text resources but also electronic forms such as electronic books, electronic -journals and e-magazines, e-newspapers, videos, sound records, images, graphics, photographs, and other digital formats (Sun & Yuan, 2012). A digital library is not just a collection of electronic information; it's a well-organized data system that can be a valuable resource for its users. Today's digital libraries are built around the Internet and web technology (Rahman, 2020). While the Internet acts as a carrier and delivery mechanism for content, it also provides tools and strategies for publishing, hosting, and accessing web content (Sinha, Kumar & Bhattacharjee, 2006).

The most significant change in building digital collections is the broader interoperability of information systems across networks (Fox & Marchionini, 1998). Libraries are starting small digitization projects as individual libraries or as a group of libraries now that technology is affordable. Electronic journals are the building blocks of today's digital libraries, which are based on Internet and web technologies (Dhawan, Gupta, Gupta, Kumar & Bansal, 2017). Figure 1 depicts the infrastructure of digital libraries and the services they can generate.

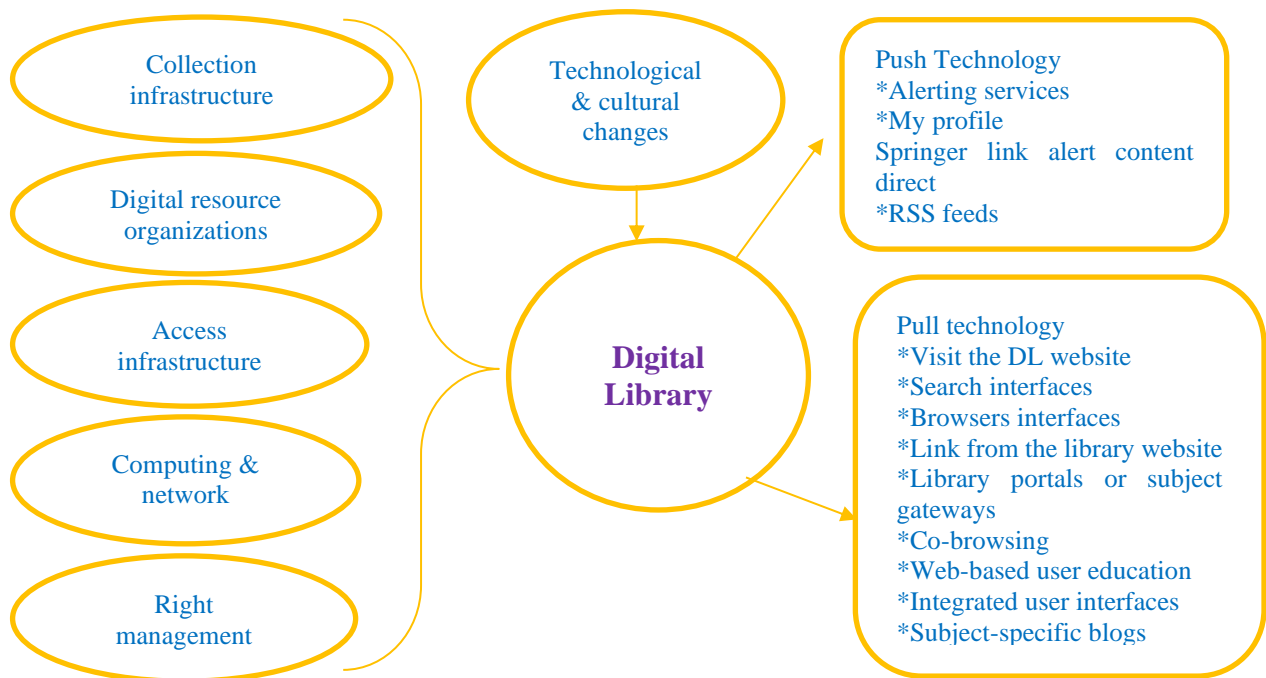


Figure 1: Digital Library Infrastructure and Services

The emergence of the Internet, particularly the World Wide Web (WWW), as a medium of information delivery and access and the availability of a highly evolved, extraordinarily simple, and intuitive user interface can all be attributed to the growth and development of digital libraries. Electronic publishing provides the products and services that go into the digital library (Rafiq, Ashiq, Ur Rehman & Yousaf, 2021). The scientometric analysis is a quantitative study of bibliographic materials (Gaffar, Kumar & Hossain, 2020) that provides an overall picture of a research field that articles, authors, and journals may classify. Scientometric methods use a quantitative method to describe, evaluate, and observe published research articles (Jeyasekar & Saravanan, 2014).

This paper presents a scientometric analysis of scientific literature on digital libraries by looking into five main research questions: I. How has digital library research evolved and been distributed? II. Who had the central role in digital library research? III. What was the major key used in the digital library? IV. What were the major countries/regions' and institutions'/organizations' scientific collaborations? and V. What were the relationships between authors, institutions, and countries? To answer these three questions, our scientometric analysis considered the following aspects of the literature on digital libraries. There are several studies in the field of digital libraries around the world. The current study evaluates the publication growth of global digital library research publications as indexed in the Web of Science during 2007-2021.

In this manuscript, the future research directions have been identified by most articles published in previous studies, and there is a need for a present study of digital libraries. Two stages are followed to accomplish this. First, a thorough disclosure of the sets of information from previous studies, including future directions mentioned by earlier studies, is required to get insights. The authors find a "space" to identify future directions when systematically searching based on articles published in digital libraries. These gaps need improvement or new research related to current scheduling needs, in particular, big data, the Internet of Things, blockchain technology, and artificial intelligence, which can help formulate a model and automate tasks. Second, the authors identified the gaps found in the previous stage to undertake a systematic search of papers on the Web of Science.

### **Purpose and Significance of the Study**

This research aims to provide insight into the contemporary involvement of scientists with different aspects of digital libraries through various research output assessment activities. The paper examines digital library research from around the world as reflected in the Web of Science. Scientometrics can assist numerous stakeholders in tracking the field's progress and spotting trends and changing patterns. It provides information about writers who are actively engaged with the issue and the publications in which researchers publish their findings to scholars. It also illustrates the types of digital libraries that have been thoroughly researched as well as those that have yet to be discovered.

### **Literature Review**

The following articles have been found suitable for the literature review for this study. Chowdhury and Rahman (2019) carried out a study on comparative analysis of India, China, and the USA related to the digital library from 2007 to 2017; 242 papers were obtained from the Web of Science database for the study. They showed that India was the most productive

country regarding digital library services among the nations. Khan (2016) conducted a scientometrics study in the *DESIDOC Journal of Library and Information Technology* from 2010 to 2014, and 307 articles were found. The researchers covered the number of papers, authorship pattern, country contributions, types of documents, etc. The findings reveal that out of the 307 contributions, 119 were contributed by single authors, while the remaining 188 were joint authors. The maximum number of documents were contributed in 2011. The highest number of articles were shared from India. Jeyasekar and Saravanan (2014) studied the digital investigation of the journal from the Google Scholar database between 2001 and 2013. The data was retrieved and analyzed using Publish or Perish and VOS viewer software. The research exposed that the literature growth followed a linear pattern, and the degree of collaboration was 0.46. Six papers have received more than 100 citations per paper, and the journal *Digital Investigation* has the highest g-index value. Zhao and Zhang (2011) looked at the co-word network created by keywords in texts and their co-occurrence relationships, a Mapping Knowledge domain representing the cognitive and intellectual structure of science. 6068 and 1250 papers were retrieved from the China National Knowledge Infrastructure (CNKI) and Science Direct databases between 1994 and 2010. Hu, Hu, Deng, and Liu (2013) researched the intellectual structure of China's digital library (DL) from 2004 to 2011. According to the findings, the research structure of DL in China is a scale-free network, with a few research topics contacting other research topics receiving greater attention and producing more precise results to the margin with ontology.

Among the top ten terms with a high total co-word frequency, for example, copyright (132), Ontology (124), and personalized service (119) were found. Multivariate statistical and social network analyses are used in co-word analysis to produce 13 keyword clusters, a two-dimensional map, cluster centrality, and density, a strategic diagram, and a relation network. (Nguyen & Chowdhury, 2011) conducted digital library research from 37 conference volumes of three major international DL conferences (JCDL, ECDL, ICADL) from the Scopus database. The resulting topic list was organized into a DL knowledge map, which included a list of 21 core topics and 1015 subtopics representing DL research. According to the findings, the three issues first appeared in ICADL in 1998. This study will provide a comprehensive overview of DL research for DL researchers, practitioners, and educators. (Mahesh & Mittal, 2008) found 63 published research related to digital libraries in India; the data were searched from the Library and Information Science Abstracts (LISA), Library, Information Science and Technology Abstracts (LISTA), and Emerald Insight databases. The study reveals that, apart from a few studies on copyright issues and digital library management, most articles focus on the development of digital libraries and digital collections. Studies like Digital Rights Management, Security, and Digital Library Policy should have touched on the issue. (Das & Dutta, 2004) studied the need for digital library systems to be audited and controlled. The authors identify audit and control elements that improve a digital library's efficiency and effectiveness.

### Objectives of the Study

For the study on digital libraries, the following objectives have been set

1. To determine the year-wise growth of digital library research from 2007-2021
2. To identify the language type of publications of digital library
3. To identify the document types of publications of digital library

4. To identify the many types of digital library publications and their sources
5. To find out the significant articles contributed by authors on digital library
6. To determine the scientific collaborations among the major countries/regions and institutions/organizations of digital library
- 7.

### **Materials and Methods**

In the present context, this manuscript is a bibliographical and analytical study that contributes to scientometric investigations, especially indicators of productivity, scientific collaboration, and thematic co-occurrence. The data source used for scientometric studies worldwide was a joint set of databases within the Web of Science (Amees, Hossain & Batcha, 2020). The Web of Science Core Collection (1989 present), owned by Clarivate Analytics, is part of the Web of Science database. The database includes three main citation databases: Science Citation Index Expanded (SCI), Arts and Humanities Citation Index (A&HCI), and Social Sciences Citation Index (SSCI).

Using the Web of Science database as a source, on 25 June 2021, the words used in the search query and the Boolean operators were identified. The words 'AND' were used as the Boolean operators. The search term "digital library/libraries" or words with a similar meaning were chosen as the primary data source for analysis. We used TITLE- Digital libraries AND TITLE-ABS-KEY (digital, library, information, technology, AND digitization) AND PUBYEAR < 2007 AND PUBYEAR >202.

Where:

TITLE: Search in the topic title

TITLE-ABS-KEY: Search in the topic title, complete the record, and cite references simultaneously

PY <AND PUBYEAR>: restricts the search to a time range based on the year of publications.

The base bibliographic information used for the digital library for this study includes bibliographic data, cited records, and references for 5855 documents published between 2007 and 2021 from the Web of Science database. The downloaded data was examined using MS Excel, VOS viewer (Rahaman, Hossain & Batcha, 2020), and Biblioshiny (Hossain & Batcha, 2021) were chosen as software tools for the scientometric analysis. We employed keyword co-occurrence analysis to extract study topics and find connections between them directly from the content of abstracts. The primary items of three fields (authors, institutions, and organizations) were shown using a Sankey diagram to show how they are related.

### **Results**

#### **Which year was the highest article contributions?**

The evolution of articles published on digital libraries from January 2007 to June 2021 is displayed in Figure 2 using an Excel sheet. During 15 15-year years, 5855 publications were found in the Web of Science database on digital library literature. It can be observed that the most significant number of papers was published in 2020 (n-628 papers), 2019 (n-513 papers), and 2015 (n-417 papers), conversely. We can see in the Figure that scientific production in digital libraries has a slow increase from 2012 to 2015; however, changes in the tendency might be seen in some years. There was a significant increase from 2008 to 2020 (n-408, 5113, and

628 papers). The lowest number of publications was 268 in 2021 at the time that the search was conducted. It is seen in the figure; keep in mind that the year 2021 has dramatically decreased because of the data downloaded in June 2021.

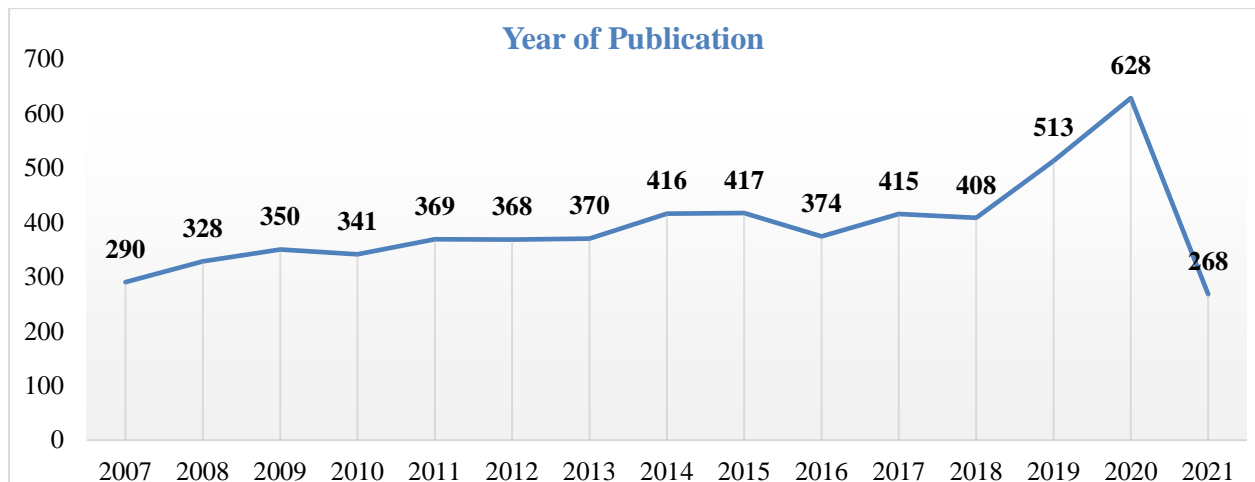


Figure 2: Year-Wise Growth of Publication in Digital Library Research in WoS Database from 2007 to 2021

### Language types of publication

Analysis of 5855 articles indicates that all articles were published in 19 languages. Figure 3 presents data on language, which brought out the digital library research output all over the countries. The number of published papers was incomplete for 2019 as the data was collected up to April 29, 2019. English language 5512 dominates in the first place among these nineteen languages, followed by Spanish 153 and Portuguese 153 of documents contributed by the researcher on digital library scientists. They stood in the second and third ranks. The remaining language (Afrikaans, Dutch, Estonian, Korean, Russian, Slovak, Swedish, and Turkish) publications have a very low value of 1 article in the Digital Library. German and French languages have above thirty records each produced in their languages. The vast majority of the papers were written in English. This may be because the scholars were most preferred in the English language for their papers published. As a result, English is the most commonly used English language worldwide.

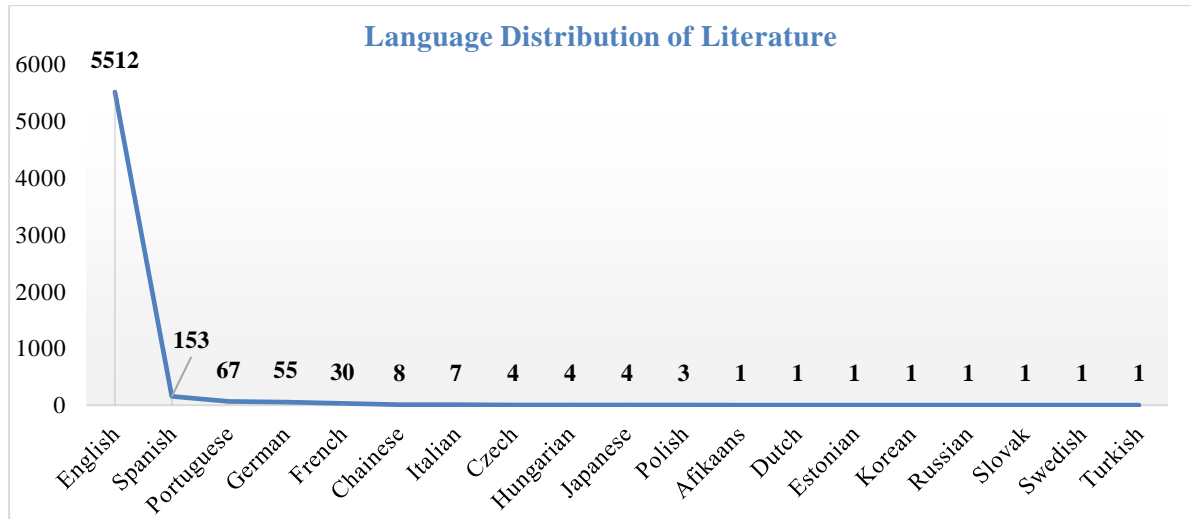


Figure 3: Language Type of Publication in Digital Library Research

**Documents type of publication**

Figure 4 presents the data on the distribution of research output by the type of publication document. The study observed 5855 publications in all digital library research at the international level. The eighteen document types were found in all digital library-related documents shown in Figure 4. There are 4421 articles, accounting for 75.50 % of the total publications and other documents (n-1434 papers,24.49%), followed by Review, which occupies second place with 699 records, Book Review (284 records) in the third position, Proceedings Paper (158 records) and Editorial Material (144 records). The remaining language (Biographical Item, Database Review, Record Review, and Retraction) publications very low value i.e., one paper found in the digital library literature.

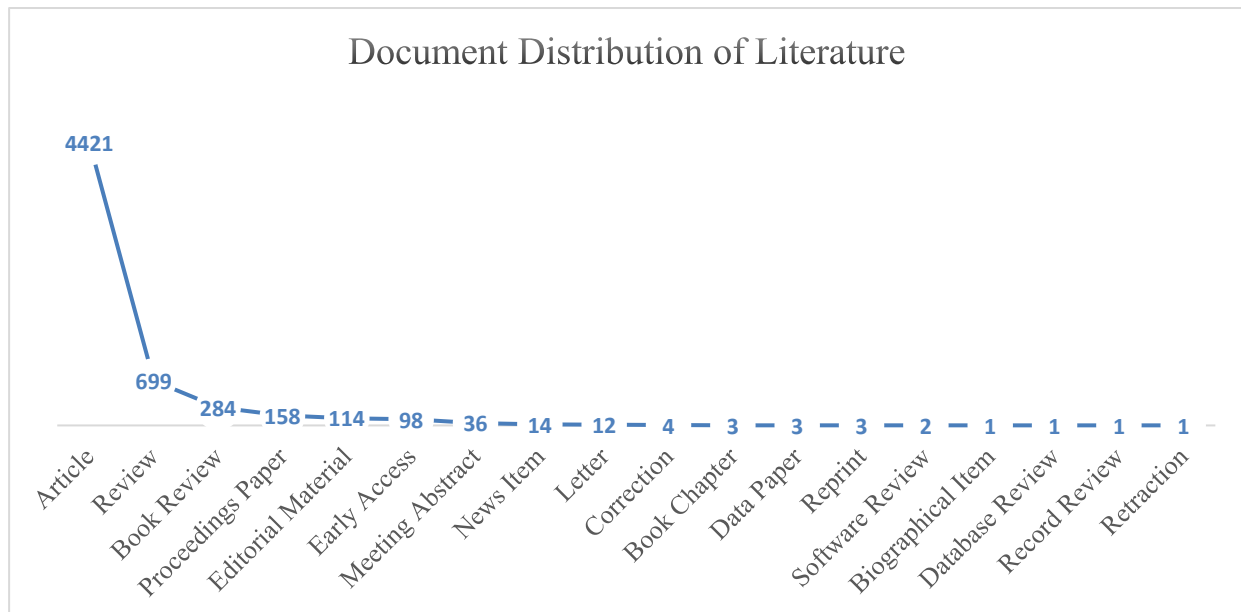


Figure 4: Documents Type of Publication in Digital Library Research Sources Types of Publications

### Sources wise distribution

All the 5855 articles were published in 1630 journals from various countries. The top 10 journals/sources are displayed in Table I. This table shows that the worldwide Electronic Library has a concentration of 270 articles of the overall literature, followed by Library Hi-Tech, Program-Electronic Library and Information Systems, Journal of Academic Librarianship, and Journal of Documentation with 198, 91, 90, and 90 papers, respectively. It's worth noting that the top 10 journals in Table 1 account for 52.14 percent of the entire digital library research.

*Table 1*

*Top 10 Sources Published in Digital Library from 2007 to 2021*

Rank	Name of Sources	Articles	H-index	G-index	Citation	IF
1	Electronic Library	270	20	26	1738	1.453
2	Library Hi Tech	198	15	24	1147	2.357
3	Program-Electronic Library and Information Systems	91	10	17	442	0.566
4	Journal of Academic Librarianship	90	12	23	675	1.287
5	Journal of Documentation	90	14	21	631	0.853
6	Plos One	85	29	47	2518	3.24
7	Professional De La Information	85	8	12	278	2.253
8	Online Information Review	75	9	6	347	2.325
9	Information Research-An International Electronic Journal	69	9	5	221	0.574
10	Library Trends	67	9	12	281	0.259

As for citations, Plos One appears to have the most citations (2518) in their paper publications, with 29 H-index and 47 G-index. Electronic Library has the second largest number of citations received (1738) with 20 H-index and 26 G-index. Library Hi Tech has received 1147 citations with H-index (15) and G-index (24), and it occupies the 3<sup>rd</sup> rank in research output in their article publications among the top ten sources in Digital Library research output. This indicates that the production of digital library research in terms of journals is highly dispersed. In general, the more times a journal is referenced, the more significant its impact on the field and the higher its reputation. The impact factor (IF) assessment is still the most objective and extensively utilized form of evaluation. Plos One has the highest IF with 3.24, followed by Library Hi Tech with 2.357, Online Information Review with 2.325, and Profesional De La Informacion with 2.253.

### Who was major roles in digital library research?

This study examined the following data to question the evolution of digital library research and trends in its dissemination:

- The top-ranked authors
- The Author's Co-citation Analysis

### The top-ranked authors

In this analytical study, there were a total number of 17392 name occurrences of the authors contributing 5855 papers in the field of digital library research during the fifteen years. The first ten authors are listed below in Table 2. This table ranks authors by the number of documents. Findings revealed that out of 5855 papers, 171 (0.98%) were written from 2007 to 2021 by the top ten authors. Some papers result from group efforts, while single authors write others. It was fascinating to learn who was the most productive author in the discipline of digital libraries for fifteen years.

Among the 17392 authors, Zhang Y, who had 24 papers, was the most productive scholar of the digital library. Next, the author of g J has published 20 articles, and this author-publication position is at second rank. The author Wang Y has published 17, and it occupies the third rank in research output. As can be seen from the table, Fourie I, Herrera-Viedma E, Kim H, Kim J, and Li J, each with 16 documents, appeared in the next positions, respectively.

Table 2  
Top 10 Ranked List of Prolific Authors on Digital Library

Rank	Authors	Articles	H-index	G-index	Citations
1	Zhang Y	24	11	21	444
2	Wang J	20	8	14	224
3	Wang Y	17	12	16	760
4	Fourie I	16	7	14	209
5	Herrera-Viedma E	16	10	16	385
6	Kim H	16	10	15	447
7	Kim J	16	9	15	261
8	Li J	16	9	14	378
9	Goncalves Ma	15	7	9	109
10	Seadle M	15	6	8	120

Total citations, h-index, and g-index are used to measure and quantify the fluence of authors in digital library research. It shows the most influential authors that received the highest number of citations, such as Wang Y (760), followed by Kim H (447) and Zhang Y (444). As for the h-index and g-index, Wang Y has got highest 12 h-Index. Wang Y and Herrera-Viedma E have got highest 16 G-index.

### The author's co-citation analysis

Figure 5 depicts the co-citation network of all authors in the DL research, which may be used to identify author relationships, illustrate whose publications were referenced by the same articles, and investigate the evolution of research communities. This study employed "citation" and "author." to develop and depict a co-authorship bibliometric network. The VOS Viewer tools set the minimum number of research publications and citations received by an author to three and 50. Finally, 20 out of 625 authors met the meet threshold.

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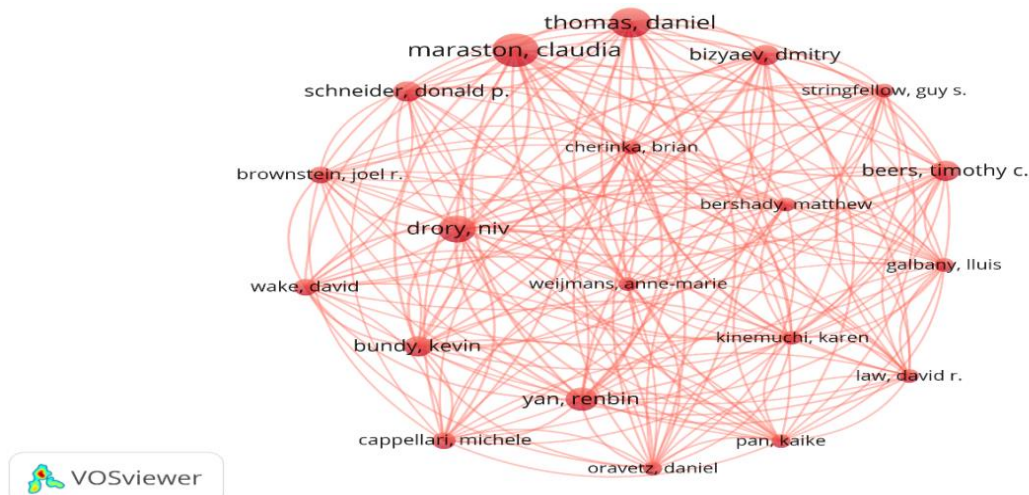


Figure 5: Authors Co-Citation Network Analysis of Digital Library-Related Publications

Figure 5 depicts a co-citation bibliometric network in which nodes represent authors and lines connecting them represent publications and citation links. It should be noted that the authors of publications may not be displayed in their whole in the VOS Viewer tool, and the missed information can be seen in Table 2. The author's co-citation network is depicted in Figure 4, which has 1 cluster, 190 links, and a total link strength of 171695. Most of the authors are clustered in a single group. The largest cluster (red color) comprises 20 authors, indicating that the researcher has chosen 20. The cluster only one (Red) is focused on “Maraston, Claudia,” “Drodry, Niv,” “Thomas, Daniel,” and “Yan, Renbin” et al.

### What were the major countries/regions' and institutions'/organizations' scientific collaborations?

This study investigated the following data to question the evolution of digital library research and trends in organizations and countries.

- Organizations publishing papers
- Country Collaboration Top papers

#### Organizations publishing papers

Authors write most publications citing the digital library, many from prestigious universities worldwide. Table 3 shows the institutions that have contributed the most publications to each digital library research. As for papers, ten organizations/institutions contributed 800 records (17.62%) from 2007 to 2021. The University of California System, with 140 papers, is the most productive institution in the field of DL.

Table 3

*Top 10 Organizations Publishing Papers on Digital Library Research*

Rank	Name of Organizations	Articles	H-index	Citation	Country
1	University of California System	143	37	5549	USA
2	University of London	89	21	2135	UK
3	Pennsylvania Commonwealth System of Higher Education Pcshe	87	26	2614	USA
4	Centre National De La Recherche Scientifique Cnrs	86	31	4008	France
5	Chinese Academy of Sciences	76	23	2013	China
6	University of Illinois System	68	16	801	USA
7	University College London	64	18	1473	UK
8	University of Texas System	64	19	1784	USA
9	Harvard University	62	19	3300	UK
10	University of North Carolina	61	17	1364	USA

Findings revealed that the authors affiliated with the University of California System appear to have the most significant number of citations (5549), with 143 articles and 37 H-index in their article publications, as shown in Table 3. Notable university from Centre National De La Recherche Scientifique Cnrs has the second-highest number of citations (4008) with 86 articles and 31 H-index in their article publications among the top ten organizations in digital library research output. Harvard University has received 3300 citations from 62 articles and got a 19 H-index, and it occupies the third rank in research output. It can be found that in the above table, most of the organization's articles are from the United States.

**Country collaboration top papers**

The publications on digital library research came from 89 different regions across the globe. In this part, we look at the distribution of output in the discipline of DL research among other countries from 2007 to 2021. As illustrated in Table 4, the works were published by authors from 89 different nationalities, according to the results. The USA was the leading contributor, accounting for 1445 pieces of literature. Followed by Chania with 754 publications, England with 410 publications, Spain with 263 publications, and Germany with 223 publications.

Table 4

*Top 10 Country Collaboration Papers on Digital Library Research*

Rank	Country	Articles	H-index	Citations
1	USA	1445	82	24691
2	China	754	49	9254
3	England	410	55	9021
4	Spain	263	40	4584
5	Germany	223	44	3583
6	Australia	216	39	3438
7	Canada	199	38	2860
8	France	189	38	2140
9	India	176	23	1909
10	Italy	152	19	1894

For each digital library study, authors from institutions in the United States had the most significant number of citations in scholarly works (Table 4). The USA is at the top, receiving 24691 citations, Chania with 9254 citations, and England with 9021 citations. The USA has the highest 82 H-Index, and the second-highest country is England, with a 55 H-index among the top 10 countries in DL. The analysis found that papers from most countries worldwide, including developed and developing countries, cited each resource at least once.

### The country co-authorship analysis

Table 4 and Figure 6 show the most influential countries/regions active in the domain of DL literature research. Using the VOS viewer software, we created an all-over-the-country co-authorship network map by examining scientific research co-authored between countries. We set the threshold at 3, and 89 countries have met it. These 20 circles are divided into two clusters by the VOS viewer software, with 185 links and 2033 total link strength. The size and font of country nodes are clustered differently based on their number of published papers and citations, as seen in Figure 6. Countries with a large number of publications and citations have a larger node and font size, while countries with mutual citations have a strong relationship. For instance, in green color, the USA is the most significant node, and in red color, the larger node is England.

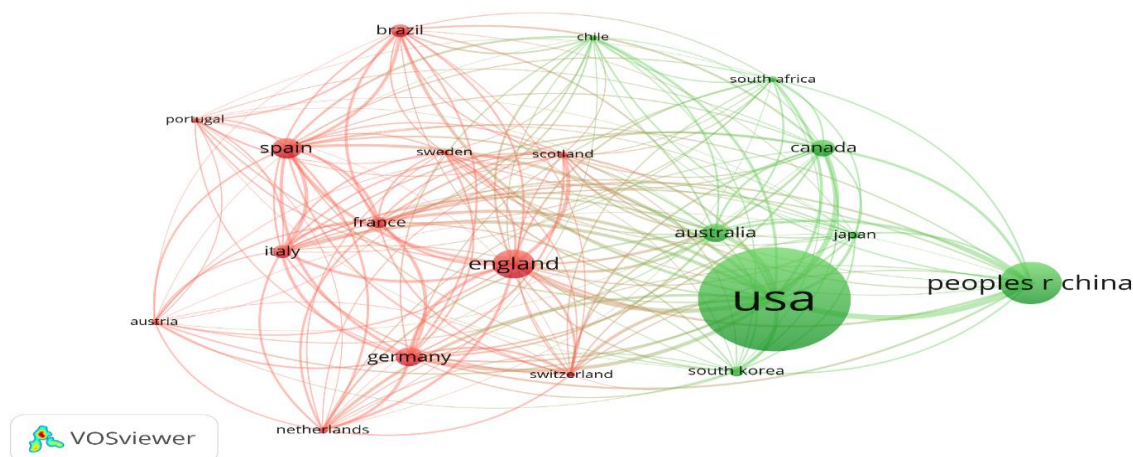


Figure 6: Country Network Analysis of Digital Library-Related Publications

The United States, China, and England are the most significant nodes, as seen in Figure 5. The 11 countries that made up the first cluster (Red color) are England, Germany, Spain, France, Italy, Brazil, Austria, Portugal, Netherlands, Switzerland, Scotland, and Sweden. The second cluster consisted of 8 countries (Green color): the USA, China, Australia, Canada, South Korea, Japan, South Africa, and Chile.

### What was the major key used in the digital library?

#### The keyword co-occurrence analysis

A keyword is more suitable for providing a high level of document description and the keyword analysis co-occurrences could reflect research hotspots. The size of the nodes and words in Figure 7 displays the weights of the nodes. The keyword “digital library” has the highest frequency of 677. Other keywords with a high frequency include “model” (161), “information” (170), and “technology” (151). The minimum occurrence of primary keywords

was set 3 times in the VOS viewer to create a bibliometric map. Only 20 keywords out of 2489 met the threshold in the initial results, and many general words were eliminated.

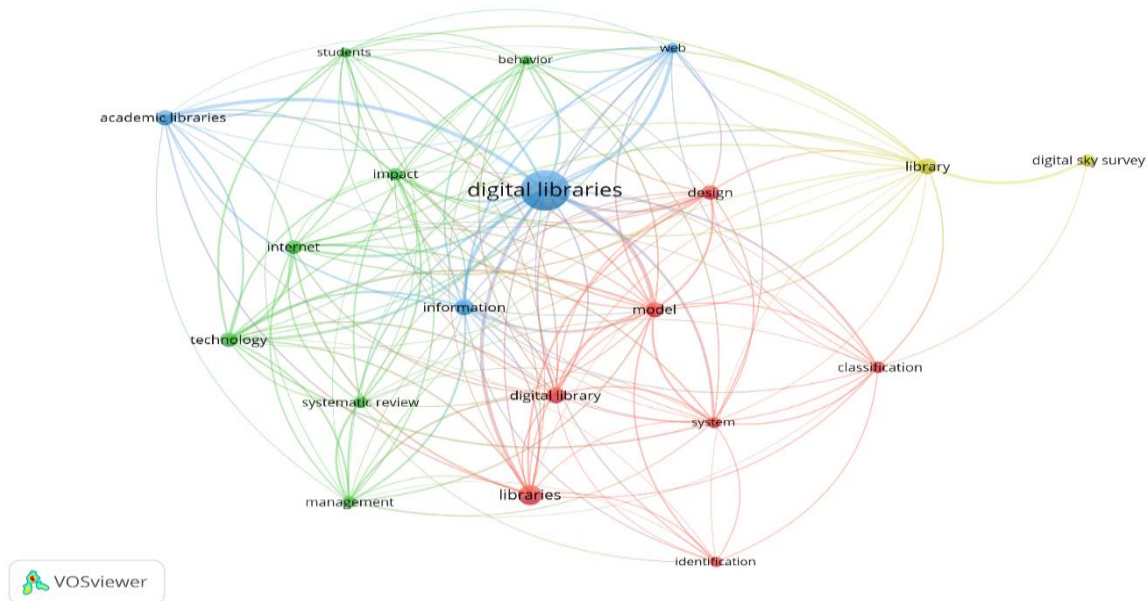


Figure 7: Keywords Co-occurrence Network Analysis of Digital Library-Related Publications

The four primary groupings represent four distinct perspectives on digital library research. The 1<sup>st</sup> cluster (Blue) is focused on digital libraries, academic libraries, the web, and information. The 2<sup>nd</sup> cluster (Green) is focused on technology, internet, impact, students, behavior, system review, and management. The 3<sup>rd</sup> cluster (Red) is focused on design, model, digital library, libraries, classification, system, and identification. The fourth cluster (Yellow) is concentrated in the library and digital sky survey.

### What was the relationship between authors, institutions, and countries?

#### Sankey diagrams (three fields)

Figure 8 displays a Sankey diagram plot for the top 10 authors and affiliations and productive countries from 2007-2021 [10 authors (Left), top 10 institutions (Middle), and top 10 countries (Right)] in DL research. Among countries, the USA and China showed relatively significant author contributions. The major contributing affiliations were Pennsylvania University, the University of Toronto, and Chinese Academic Science.

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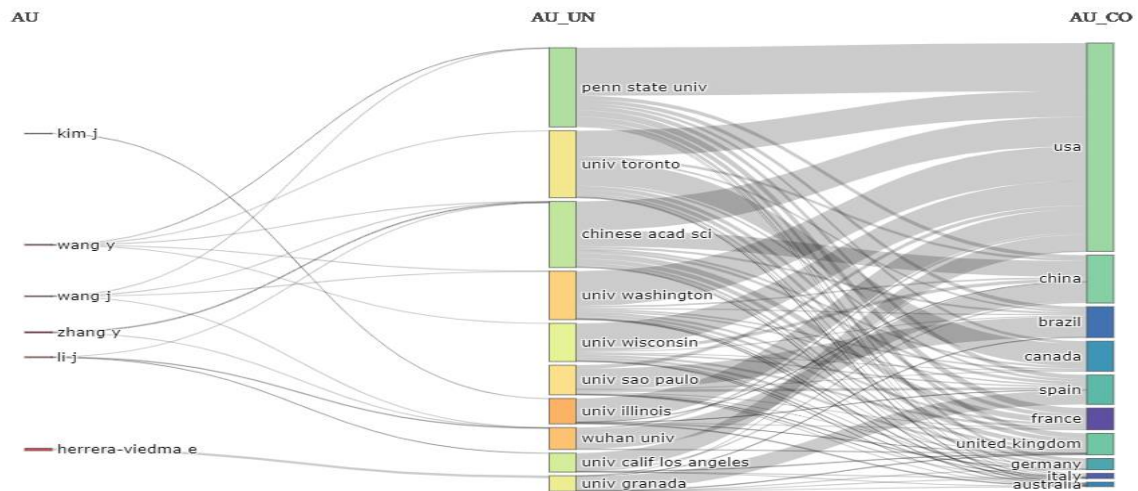


Figure 8: Relationship Among Top 10 Authors (Left), Top 10 Institutions (Middle), and Top 10 Countries (Right) Summarized by Sankey Plot

### Research implementation

Recent technological advancements have made our lives easier and created a social divide known as the digital divide. According to this study, subject gateways, digital reference services, free access to e-books and e-journals in various areas, e-print archives, and free digital libraries are all examples of recent global digital library advances that users in poor nations can access. The article concludes with an action plan that library and information professionals in developing and developed countries may employ to utilize digital information resources and services. This will help to bridge the digital divide, albeit to a lesser extent.

### Discussions

Equitable access, reduced distance barriers, timeliness, shared resources, and content delivery characterize digital libraries. Information technology has changed the world and become a crucial tool for retrieving information. Library collections are not only limited to printed documents but also electronic resources, increasing their use. Therefore, it is essential to develop a digital library (Saleem, Shabana & Batcha, 2013). People realized the importance of digital libraries no matter what their feelings towards them were before. Innovative information knowledge collection, storage, process, and transfer methodologies made possible by digital libraries will promote scientific research and development, facilitate a distant-learning environment, and significantly influence the national economy (Okeji & Mayowa-Adebara, 2021).

Scientometrics is a quantifying method for developing global scientific production in a particular field of research. The use of scientometric indicators for decision-making continues to grow, leading to a rapid increase in scientometric studies. The research trends in the global digital library research output provided in tables, figures, and maps were evaluated using scientometric methods in this study. This study examines the global research output on digital libraries using scientometric techniques based on indexed databases in the Web of Science. The results showed that among all the periods, it is observed that the highest number of papers was published in 2020 with 628, 2019 with 513, and 2015 with 417 papers. The article (Jeyasekar

& Saravanan, 2014) has received the highest number of publications within flipped classroom studies.

Out of 1630 journals on DL, Electronic Library had the top in the number of publications. Plos One seems to have the highest citations received (2518) in their paper publication. The second-largest number of citations was obtained in the Electronic Library, with 1738 among the top ten sources of digital library research output. The use of bibliometric principles to evaluate, analyze, and provide a historical perspective on journal activity has been widespread. Most journal analyses involve determining such parameters as tracking journal impact factors over time and selecting the most frequently cited articles (Thompson & Walker, 2015). Based on citations, the most influential writers who received the highest number of citations, such as Wang Yi and Kim H, were the most prolific authors in DL research. In a previous study by Khan (2016) in the DESIDOC, B. M. Gupta was the most active author.

In the study among countries and affiliations, the USA, China, and England were the most productive countries; the USA, China, and Australia were the closest cooperation groups. The most productive institution was the University of California System, which belongs to the USA. Countries with many publications and quotes have larger nodes and fonts, while countries with mutual quotes have a stronger relationship. Co-authorship network analysis is a powerful method of retrieving information for health studies. This method contributes innovatively to evaluating the collaborative behavior of researchers, organizations, and countries (Sampaio, Fonseca & Zicker, 2016). For example, the USA is the significant node in green, and England is the big node in red color.

Among the countries, the United States and China were found to have major author contributions. The major contributors were the University of Pennsylvania, the University of Toronto, and the Chinese Academic Science. Furthermore, these findings help identify the research's strengths and weaknesses. It will be useful in guiding future publications related to the digital library. The presence of organizations from China as central in this network could reflect the resurgence of Chinese digital library research output experienced by the country in recent years (Zhao & Zhang, 2011). The keyword "digital library" has the highest frequency of 677. The four clusters represent four distinct perspectives on digital library research. The keywords in each cluster reflect the related research topics and the research directions of the digital library of worldwide research. For example, Cluster 1 is related to the application of Ontology and Semantic Web in Information Retrieval; Cluster 2 includes research topics on Data Mining, Information Recommendation, and Knowledge Discovery (Wang, Liu & Sheng, 2015).

### **Conclusion**

There have been studies on topics in digital libraries, such as studies of librarians and readers. International digital library research began with Technology studies before 2000, according to a chronological overview of global digital library research. International digital library research has focused on technology in the last two decades, especially data retrieval. Technology is divided into many branches based on other technologies, such as visualization technology, quote analysis method, cross-culture concepts, etc. To gain maximum support for the digital library's implementation, the government needs to ensure that all concerned participants are widely consulted by relevant stakeholders so that the online library version meets its intended goals. There is an urgent need for support from the government of research

all over the country by providing adequate funding to encourage and promote digital libraries for the quality of research and the quantity of output.

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### Declaration of Conflicting Interests

My co-authors and I have no interests that might be interpreted as influencing the research. “Conflicts of interest: none.”

### Contributors

It is acknowledged that all the authors contributed equally.

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