International Journal of Information Science and Management
Vol. 23, No. 2, 2025, 73-93
DOI: https://doi.org/10.22034/ijism.2025.2018586.1339 / DOR: https://dorl.net/dor/20.1001.1.20088302.2025.23.2.5.1

Original Research

Mapping the Landscape: A Bibliometric Analysis of Global Trends in Smart Library Research (1992-2023) Using Scopus

Samira Guechairi
Associate Prof. History and Library and Information Science Department - Social and Humanities Faculty - Blida 2 University, Blida, Algeria.
samiraguechairi@gmail.com s.guechairi@univ-blida2.dz
ORCID iD: https://orcid.org/0000-0002-7680-8925

Received: 23 December 2023
Accepted: 26 October 2024

Abstract

Using the Scopus database, this study provides a comprehensive bibliometric analysis of global trends in smart library research between 1992 and 2023. One hundred thirty-two documents were retrieved and analyzed through the biblioshiny package in R-Studio and VOSviewer for visualization and mapping. The findings highlight that the Journal of Library Science in China leads the field with 20 articles, and Wuhan University emerges as the most prominent contributor. China is the most productive country with 129 documents and the highest citation count at 389, while Zhang Y is the most prolific author. Co-authorship and citation analysis further illustrate collaborative networks, with a growing interest in the topic in recent years. These insights offer valuable implications for librarians, researchers, and funding agencies by providing a nuanced understanding of key contributors and trends in smart library research. To the best of the author's knowledge, this is the first bibliometric study to map global smart library literature within the Scopus database, offering a foundation for future research and collaboration.

Keywords: Bibliometric Analysis. Smart Library Research. Global Trends.

Introduction

The "smart library" concept has emerged from the broader notion of a "smart city". The application of this technology significantly overlaps with various scenarios, including smart logistics, smart homes, and smart buildings. All of these concepts encompass the utilization of information and communication technology to enhance individuals' living standards, thereby making a valuable contribution to sustainable development (Capdevila & Zarlenga, 2015). However, the smart library is fundamentally distinct from other application scenarios, relying on collections and users (Li, Shi, Xie & Gu, 2023).

The term "smart library" was first introduced to academic literature in 2003. It is defined as a series of mobile library services that operate without space limitations, assisting users in locating necessary books and materials (Aittola, Ryhänen & Ojala, 2003). According to Cao, Liang, and Li (2018), a smart library can also be a technology-equipped library accessible to the public but not staffed. This technology facilitates the remote management of library facilities, including automated doors, lighting, self-service kiosks, and public computers. Such advancements significantly extend library hours, allowing more individuals to utilize the library

conveniently. (Schöpfel, 2018) identifies four dimensions of smart libraries: smart services, smart people, smart governance, and smart places. Features such as RFID, the Internet of Things (IoT), and artificial intelligence further enhance their capabilities (Huang, Liu & Zhou, 2018).

Despite exploring smart libraries as a concept, there is a notable lack of comprehensive bibliometric analysis on the topic, particularly on a global scale. Most existing studies (Huang et al., 2018; Su & Li, 2021; Wang, 2023) have concentrated on regional contexts, particularly those related to China, or have been restricted to databases like CNKI and Web of Science. In light of the increasing relevance of smart libraries within the information and communication technology field, there is a significant deficiency in bibliometric analyses that capture global trends in this burgeoning area. Existing research has predominantly focused on regional studies or been limited to specific databases. This narrow approach fails to leverage the broader insights that a global perspective can provide. Moreover, while some studies have examined various aspects of smart libraries, the potential of employing advanced bibliometric tools, specifically the synergistic use of VOSviewer and Biblioshiny within the Scopus database, remains underexplored. Consequently, there is a need for a robust bibliometric analysis that not only elucidates the historical trajectory of smart library literature but also identifies key contributors, prevailing trends, and under-researched areas. This study aims to address these gaps, offering a foundational framework for understanding the landscape of smart library research from 1992 to 2023.

This research undertakes a bibliometric analysis of the literature on smart libraries within the Scopus database from 1992 to 2023. This study provides an enhanced visual and statistical analysis. Furthermore, it extends the research timeline beyond 2021 and presents a global perspective. This study highlights updated trends and insights, creating a robust foundation for future researchers. Therefore, this study on "smart libraries: bibliometric analysis" aims to augment existing literature substantially, presenting an expansive and contemporary perspective on smart libraries through the exploration of the following research questions:

RQ1: How has the literature on smart libraries evolved historically in Scopus, offering insights into potential future directions?
RQ2: Who are the most prolific authors and affiliated institutions in smart library research, and what trends can be identified?
RQ3: Which central journals shape the discourse around smart libraries, influencing research organizations?
RQ4: What conceptual structure has emerged, and what unexplored research areas require attention in smart library studies?

Literature Review

Studies on smart libraries in general

Smart libraries are an interesting topic, especially in recent years (Mohammed, Thabit, & Azeez, 2019), which analyzes the role of smart libraries in promoting sustainable development practices in the Middle East. The study of Duncan (2021) presents an overview of smart or technologically driven libraries and builds on the body of knowledge presently nonexistent on smart libraries in the Caribbean. Padhi and Nahak (2019) suggest that the ‘smart library’ requires ‘smart librarians,’ which gives a user-centric and user-friendly service. The role of librarians and libraries is changing in the present era due to the changing demands of their users.

The role of SL requires three things, i.e., smart users, SL staff, and SL services. Hussain and Ahmad (2021) present a comprehensive model of smart library technologies and applications based on a literature review of relevant studies published from 2016 to 2020 (Li, Tang, Xiao & Cai, 2021). The question that current smart libraries need to solve urgently is how to construct a high-quality and highly effective library portal.

The emergence of smart libraries has facilitated the redefinition of library services (Igwe & Sulyman, 2022). It highlights the emerging technologies used for smart libraries: cloud computing, big data, 3D printing, IoT, Artificial Intelligence, RFID, drones, etc. It concludes that smart libraries aid in space-saving, expand library working hours and services, and promote access to information. At the same time, remarks are made that a lack of technological know-how, technophobia, data privacy, security, etc., are challenges faced by smart libraries (Li et al., 2021). Evaluate the smart library portal website based on link analysis (Li et al., 2023), which evaluates e-book vendors in the era of smart libraries.

Several studies explore using smart library technologies like the Internet of Things (IoT) (Asim, Arif & Rafiq, 2022; Bi et al., 2022; Gao, 2022; Sadeghi-Niaraki, 2023; Shu, Wang, Jiang & Liu, 2021), artificial intelligence (AI) (Asemi, Ko & Nowkariz, 2021; Bi et al., 2022; Cox, Pinfield & Rutter, 2019) ambient intelligence (Gul & Bano, 2019), geographical information systems (GIS) (Aguilar-Moreno, Montoliú-Colás & Torres-Sospedra, 2016), radio frequency identification (RFID) (Daniel, Ramsurrun & Seeam, 2019; Yaman et al., 2020), augmented reality (AR) (Chen, Liu, Chiu, Lee & Wu, 2022), virtual reality (Xu, Wang, Bu & Ji, 2019), electronic resources management (ERM) (Gul & Bano, 2019), big data (Adetayo, Adeniran & Gbotosho, 2021) and data mining (Mercado & Lacorte, 2018; Yu, 2021).

Studies on bibliometric analysis in smart library

There is a vast literature on smart libraries that needs to be covered in a bibliometric study to maintain the main characteristics of this literature and explore the previous, current, and future trends in this topic. In this context, three main studies conducted a bibliometric analysis of smart libraries: Huang et al. (2018) studied smart library research in China using bibliometric methods on the CNKI database, covering 2010-2017. Their findings showed that smart library research began in 2010, grew steadily until 2016, and then stabilized, emphasizing the rising significance of smart libraries in China's academia. They highlighted the crucial role of top library science journals, though the study's focus on CNKI might give a somewhat limited view of the larger academic landscape. Su & Li (2021) used bibliometric techniques to represent smart library research in China visually, sourcing data from CNKI.net and using Citespace for visualization. They pinpointed key themes on library infrastructure, tech enhancements, and user-focused smart services. Like Huang et al., the research was primarily CNKI.net-focused and China-centric. Wang (2023) performed a global bibliometric analysis and network mapping on smart libraries using the Web of Science, covering 2003-2021. Tools like BibExcel, VOSviewer, and Biblioshiny aided the research. A key result was China's leading role in publications and citations, especially Wuhan University's H-index prominence. However, relying only on the Web of Science could overlook significant works in other databases.

We observed that two of these studies, i.e. Huang et al. (2018) and Su & Li (2021), were local analyses based on literature on China, while Wang (2023) analyzes smart libraries globally. Still, the study is limited to the WOS database. As a result, this study fills this gap in

research by examining literature on smart libraries in the Scopus database between 1992 and 2023 using biblioshiny from RStudio and VOSviewer to visualize and map scientific literature.

Research Gaps

• One limitation is that two studies are focused solely on China, leaving a gap in understanding the global landscape of smart library research.

• Additionally, both CNKI and Web of Science were used in the previous studies. The literature lacks studies that utilize other prominent databases like Scopus.

• Then, while VOSviewer and Citespace were used in the previous studies, there is a gap in combining multiple tools like VOSviewer and Biblioshiny for a more comprehensive analysis.

Contributions of the study

• Our study will use the Scopus database to provide insights from one of the largest abstract and citation databases of peer-reviewed literature. This can capture a broader range of publications and offer a more comprehensive view of the field.

• Using a comprehensive tool combining VOSviewer and Biblioshiny will allow for a richer bibliometric analysis. While VOSviewer is excellent for visualization, Biblioshiny can provide deeper statistical insights, enhancing the depth and breadth of the study.

• Our study offers a more global perspective on smart libraries, filling the gap left by the China-centric studies.

• Since the latest study covers 2021, our research can provide more recent trends and insights into the field of smart libraries.

• With data from Scopus, we can potentially compare and contrast findings with those derived from CNKI and Web of Science, offering a more holistic view of the research landscape.

• By leveraging multiple tools, our study can offer a refined methodology that future researchers can adopt or build upon.

In conclusion, our study on "smart libraries: bibliometric analysis" using the Scopus database and tools like VOSviewer and Biblioshiny will significantly contribute to the existing literature by filling identified gaps and providing a more comprehensive and updated view of the topic.

Materials and Methods

This study aims to provide a bibliometric analysis on the “smart library” topic to provide comprehensive information about global trends of smart library research between 1992-2023, such as the most productive authors, countries, academic institutions, journals, the number of articles, and citations to be considered in smart library studies—besides, the citation trends and co-citation network between references. We use the Scopus database as a source of data on smart library because it is one of the largest databases in the world that provides data for researchers, institutions, countries, decision-makers, etc. (Yanti & Santoso, 2023). Moreover, there is a gap in previous studies that use the WOS or CNKI database as a source for data collection. So, we search in Scopus on title, abstract, and keywords with these keywords: (“smart library” or “intelligent library”). This is the formula used in Scopus:

TITLE-ABS-KEY (“smart library” OR “intelligent library”) AND (LIMIT-TO (SUBJAREA. “SOCI”)

As mentioned in Figure 1, we extracted 426 documents in all areas. So, we limited the subject area to social science to find papers in "library and information science" as a social science subfield in Scopus. It extracted 132 documents without limit on document type, language, or other criteria. Data collection was carried out on 20/08/2023.

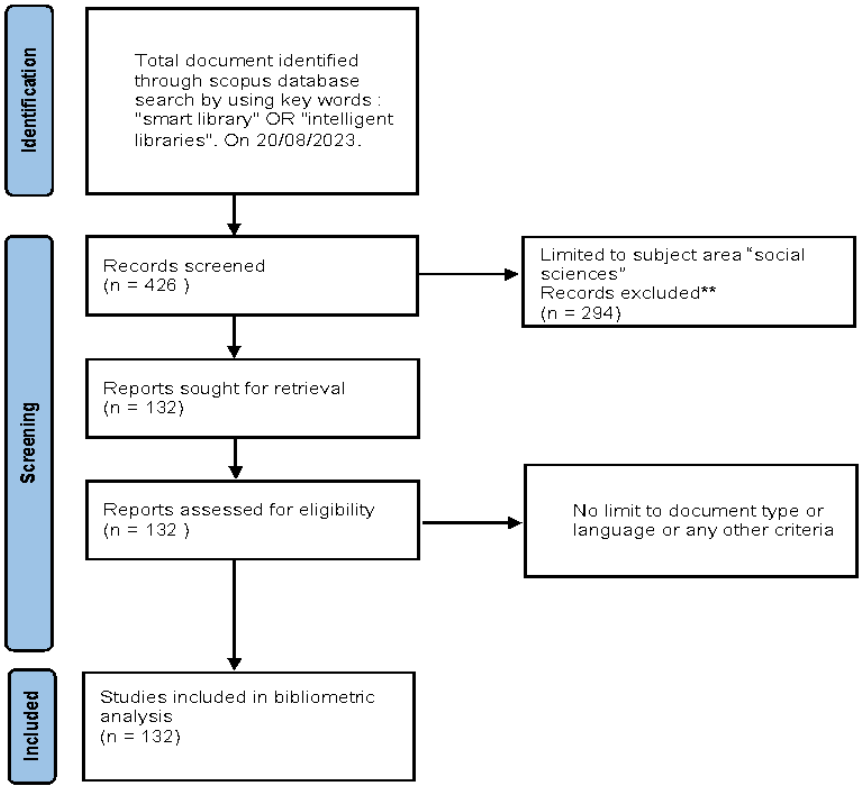


Figure 1: PRISMA flow chart for selecting documents for this study

As tools for bibliometric study on smart libraries, we use the Biblioshiny tool based on the R language (R Studio), which provides detailed information using a CSV file. Biblioshiny is a Shiny web-based application that works within the Bibliometrix R package. This application is an open-source tool for quantitative research to conduct bibliometric analysis. This tool was developed by Aria & Cuccurullo (2017). The Bibliometrix R package provides descriptive and other research structure analyses after converting and uploading bibliographic data in R. The descriptive analysis provides snapshots of annual research development, productive authors, papers, countries, and most relevant keywords (Aria & Cuccurullo, 2017).

We also used VOSviewer software to map the literature of this study, as it is a powerful tool for creating a visualization map according to the area of interest. VOSviewer converts the data into an interconnected map (Al Husaeni & Nandiyanto, 2021). Although VOSviewer is intended primarily for analyzing bibliometric networks, the program can, in fact, be used to create, visualize, and explore maps based on any type of network data (van Eck & Waltman, 2020).

Results

Main Information

Table 1 shows that this study's time span was 1992-2023, with 132 documents and 4399 references. There are 468 Author Keywords and 288 Authors. The study also contains 104 articles, 16 conference papers, six reviews, and six other documents.

Table 1
Descriptive statistic

Description	Results
Timespan	1992:2023
Sources (Journals, Books, etc.)	58
Documents	132
Annual Growth Rate %	9.96
Document Average Age	3.14
Average citations per doc	7.22
References	4399
Keywords Plus (ID)	344
Author's Keywords (DE)	468
Authors	288
Authors of single-authored docs	39
AUTHORS COLLABORATION	
Single-authored docs	41
Co-Authors per Doc	2.5
International co-authorships %	10.61
DOCUMENT TYPES	
Article	104
Book	1
book chapter	4
conference paper	16
conference review	1
Review	6

Analysis by year

Table 2 shows the distribution of articles and citations from 1992 to 2023 (August) with total citations per article, number of articles, total citations per year, and citable years.

Table 2
Distribution of articles and citations by year

Year	TC/Article	N articles	TC/Year	Citable Years
1992	1	1	0.03	32
2006	6	1	0.33	18
2008	11.33	3	0.71	16
2009	8	1	0.53	15
2013	24	1	2.18	11
2014	6	1	0.6	10

Year	TC/Article	N articles	TC/Year	Citable Years
2015	52	1	5.78	9
2016	10.5	4	1.31	8
2017	4	3	0.57	7
2018	26.86	7	4.48	6
2019	15.69	13	3.14	5
2020	14.3	20	3.58	4
2021	1.58	31	0.53	3
2022	1.46	26	0.73	2
2023	0.16	19	0.16	1

TC/Articles: Total citation per article. TC/Year: total citation per year

The classification of publications in the domain of smart libraries can be separated into two distinct periods, as illustrated in Figure 2. The first phase extends from 1992 to 2015, whereas the next expansion phase encompasses 2016 to 2023. The first scientific paper on smart libraries within the Scopus database dates back to 1992. Over the subsequent three decades, there was an unpredictable increase in the number of publications. Nevertheless, there has been a notable increase in scholarly focus on this topic, leading to significant growth in academic publications.

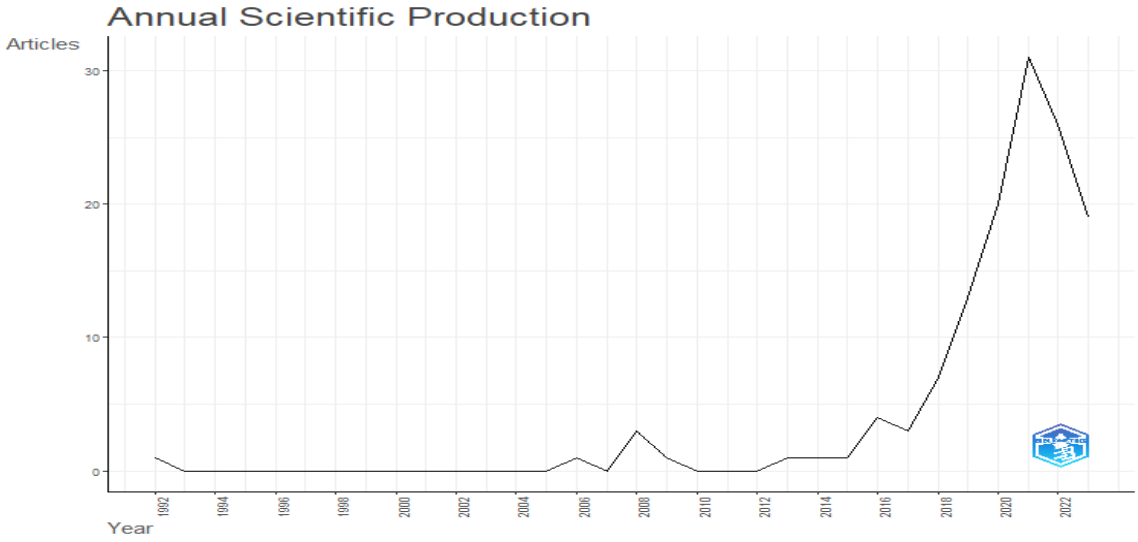


Figure 2: Annual scientific production

Analysis by sources

The analysis of the Scopus database revealed that the subject of "smart libraries" is covered in 58 different journals. Out of these journals, around 77% (45 journals and conferences) contained only one article related to smart libraries, while approximately 10% (6 sources) published two articles on this specific topic. Notably, 12.06% (7 sources) demonstrated a strong level of interest in this subject by publishing between 3 and 20 papers. Table 3 provides an overview of the leading academic journals regarding the number of articles about smart libraries.

Table3

Most productive journals in smart library

Sources	H-index	Scimago SJR quartile 2022	Number of publications	percentage
Journal of Library Science in China	4	Q3	20	15.15%
Journal of Library and Information Science in Agriculture	3	Q3	17	12.87%
Library Hi Tech	44	Q2	14	10.60%
Electronic Library	44	Q2	8	06.06%
Library Hi Tech News	22	Q2	7	05.30%
Library Philosophy and Practice	25	Q2	6	04.54%
Journal of Librarianship and Information Science	35	Q1	3	02.27%
2nd International Conference on Next Generation Computing Applications 2019. Nextcomp 2019 – Proceedings	5	No quantified	2	01.51%
IFLA Journal	24	Q2	2	01.51%
Journal Of Academic Librarianship	64	Q1	2	01.51%
Library and Information Science Research	64	Q1	2	01.51%
Library Management	38	Q2	2	01.51%

Table 3 provides a clear overview of the journal with the most publications on "smart libraries." The Journal of Library Science in China leads with 20 publications, making up 15.15% of the total articles analyzed. As per Scimago SJR 2022, it holds an H index of 4 and is in the Q3 quartile. The Journal of Library and Information Science in Agriculture follows with 17 publications, contributing to 12.87% of total articles and also ranks in the Q3 quartile. Three journals, "Journal of Librarianship and Information Science," "Journal of Academic Librarianship," and "Library and Information Science Research," are in the top quartile (Q1) and have published 2-3 articles on the subject. Huang et al. (2018) identified "The Journal of Library and Information Sciences in Agriculture" as the most productive on the topic, aligning with this study's findings on "smart libraries."

Applying Bradford's Law to sources

This section evaluates source productivity according to Bradford's Law. Bradford's Law posits that documents on a "subject" display a dispersed distribution, described by a specific mathematical function. This distribution suggests that increasing research papers on a topic necessitates a similar growth in academic journals. Journals can be classified to distribute articles in a 1: n: n^2 ratio, with "n" being the Bradford multiplier (Hjørland & Nicolaisen, 2005). Consequently, this law defines three zones. The first zone includes core journals contributing one-third of the articles; the second zone also provides one-third. This pattern persists across subsequent zones (Table 4).

Table 4 presents core journals on the "smart libraries" topic according to Bradford's law of scattering. The top sources for smart libraries include three journals, making up 5.17% of total sources. The second zone has 12 journals accounting for 20.68%, and the last zone contains 43 sources, representing 74.13%. Prominently, three journals, "Journal of Library Science in China," "Journal of Library and Information Sciences in Agriculture," and "Library Hi Tech,"

contributed 51 articles, establishing themselves as essential sources in smart libraries. The analysis from Table 4 and Figure 3 confirms Bradford's Law, highlighting source distribution and emphasizing both concentration and diversification in the academic landscape of the field.

Table 4
Three zones of Bradford's Law

Zone	One third	N articles	N sources	Rate %
Zone 1 (core)	33%	51	03	5.17
Zone 2	33%	38	12	20.68
Zone 3	33%	43	43	74.13

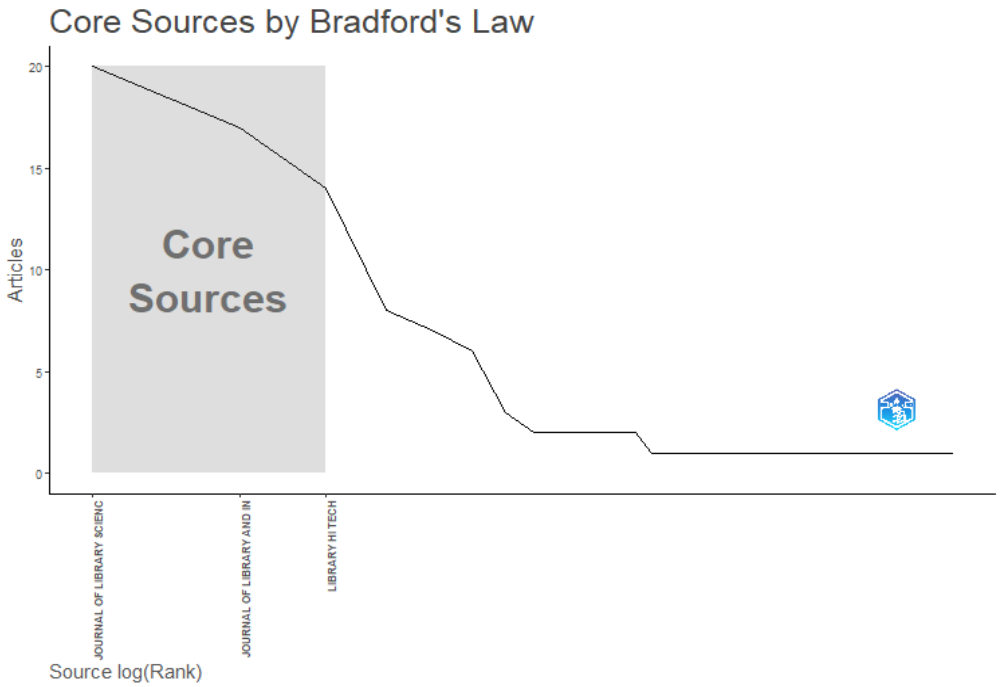


Figure 3: core sources by Bradford's law

10 Most cited documents on smart library

Table 5 showcases the top 10 most cited documents in smart libraries. To be clear, of the 132 articles chosen for the bibliometric analysis (Rafique, Almagrabi, Shamim, Anwar & Bashir, 2020), the article received the most citations with 159 citations. Cox et al.'s (2019) paper has received the second-highest number of citations, totaling 71. According to the citation analysis, the work authored by Waheed, Hassan, Aljohani & Wasif (2018) holds the third-highest number of citations, totaling 58. These highly cited papers encompass many topics, from user acceptance of mobile apps to AI's role in libraries, learning analytics, and the concept of smart libraries. Their collective influence has significantly shaped the direction of research and discussions in smart libraries.

Table 5
10 Most cited documents on smart library

Number	Paper	Title	Total Citations	TC per Year	Normalized TC
01	(Rafique et al. 2020) COMPUT EDUC	Investigating the Acceptance of Mobile Library Applications with an Extended Technology Acceptance Model (TAM)	159	39.75	11.1188811
02	(Cox et al., 2019) LIBR HI TECH	The intelligent library: Thought leaders' views on the likely impact of artificial intelligence on academic libraries	71	14.2	4.5245098
03	(Waheed et al., 2018) BEHAV INF TECHNOL	A bibliometric perspective of the learning analytics research landscape	58	9.66666667	2.15957447
04	(Cao et al. 2018) ELECTRON LIBR	How to make the library smart? The conceptualization of the smart library	53	8.83333333	1.97340426
05	(Noh. 2015) . J ACAD LIBRARIANSH	Imagining Library 4.0: Creating a Model for Future Libraries	52	5.77777778	1
06	(Gul & Bano. 2019). ELECTRON LIBR	Smart libraries: an emerging and innovative technological habitat of the 21st century	48	9.6	3.05882353
07	(Simović. 2018) LIBR HI TECH	A Big Data smart library recommender system for an educational institution	43	7.16666667	1.60106383
08	(Asemi et al. 2021) LIBR HI TECH	Intelligent libraries: a review on expert systems. artificial intelligence. and robot	35	8.75	2.44755245
09	(Hoy. 2016) MED REF SERV Q	Smart Buildings: An Introduction to the Library of the Future	27	3.375	2.57142857
10	(Kwanya, Stilwell & Underwood, 2013) J LIBRARIANSH INF SCI	Intelligent libraries and apomediator: Distinguishing between Library 3.0 and Library 2.0	24	2.18181818	1

Analysis by affiliation/country

Figure 4 delineates affiliations that contribute significantly to smart library research. Wuhan University stands out with eight articles, followed closely by Central China Normal University with seven. The Renmin University of China and Wuhan University of Technology have contributed six articles, emphasizing their academic influence. Semeion Centro Ricerche di Scienze della Comunicazione, with its five articles, indicates interdisciplinary participation,

albeit on a smaller scale. These institutions highlight China's dominant role and the multi-faceted nature of smart library research.

The distribution points to a global engagement, led predominantly by Chinese institutions, reflecting China's emphasis on technological progress. The variety of affiliations, encompassing non-academic entities, speaks to the cross-disciplinary character of this research. Such diversity hints at potential collaboration opportunities, fostering a richer exchange of perspectives. In sum, the affiliations spotlight the global importance of smart library research, with select institutions marking the evolving multidisciplinary research landscape.

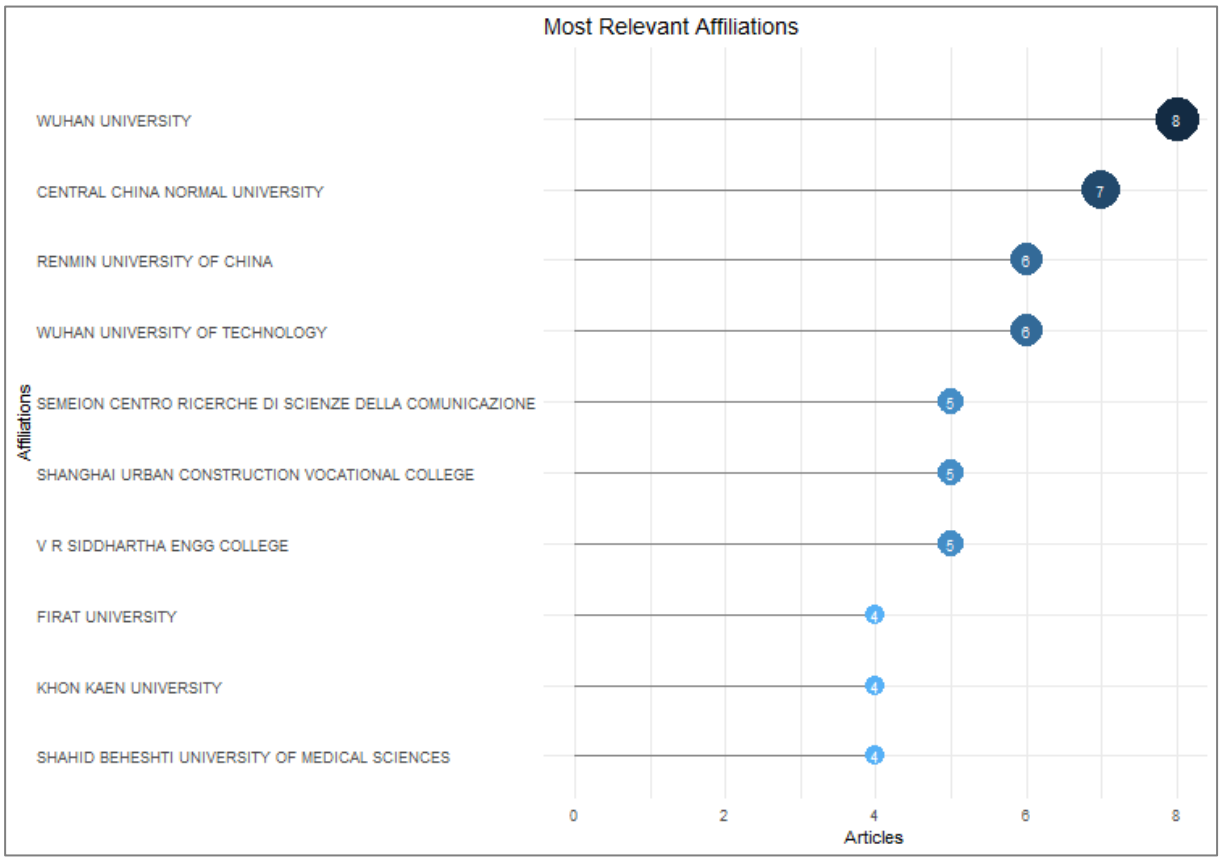


Figure 4: Most relevant affiliations on smart library

The most relevant country's scientific production

The number of 129 publications underscores China's dominance in smart library research, affirming its leading role in this academic sector. Notably, India has also made significant contributions with 27 publications, followed closely by Indonesia and Pakistan with 19 each, while the USA has produced 11. The total compilation, consisting of 286 publications from various countries, highlights the global importance of smart libraries, with Asian nations, particularly China and India, emerging as significant research hubs in this field.

China's leading role can be linked to its technological advancements and substantial investments in digital infrastructure. At the same time, India's contributions are concurrent with its growing IT sector and focus on digital literacy. The noteworthy outputs from Indonesia and Pakistan hint at possible regional collaborations. The increasing involvement of Asian countries in disseminating scholarly research signals a potential shift in the epicentres of library science research (Figure 5).

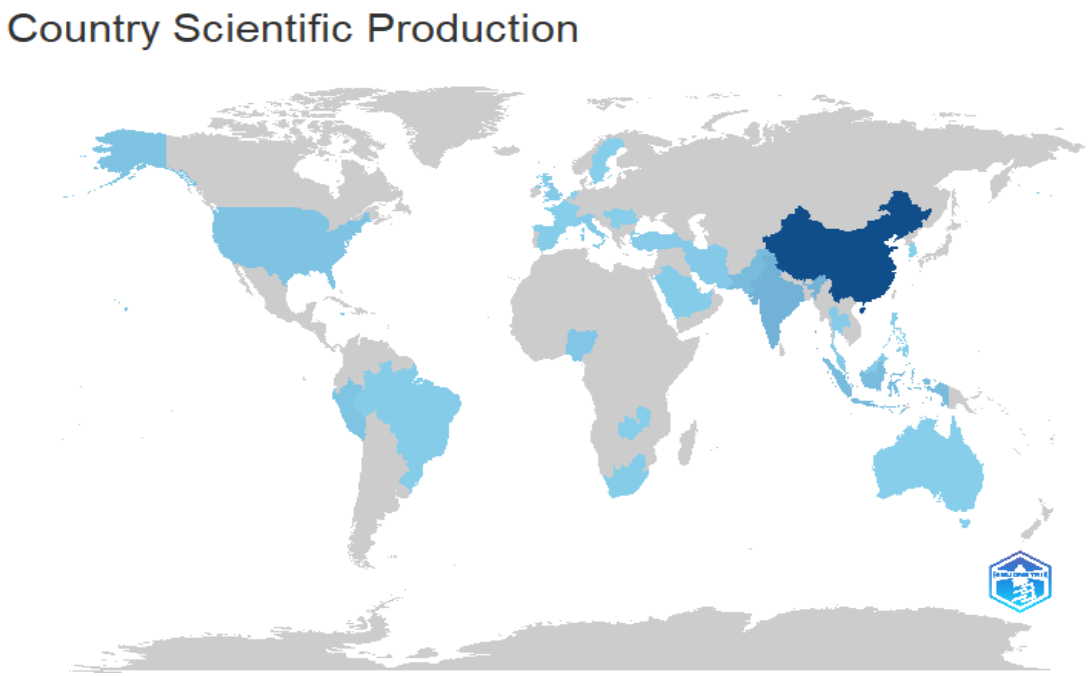


Figure 5: Most relevant countries on smart library

Most cited countries on smart libraries

A bibliometric analysis of country-wise contributions in "smart libraries" research yields nuanced insights into publication volume and impact. China is the leading contributor, with 389 citations, emphasizing its extensive research output. However, regarding average article citations, indicative of the impact or quality of articles, Korea, Serbia, and South Africa surpassed with 52, 43, and 24 citations, respectively, implying their lesser volume but higher impact. The United Kingdom balances volume and quality, with 74 and 37 average citations per article. In contrast, countries like Indonesia and Nigeria demonstrate lower average article citations, reflecting less influence in the "smart libraries" discourse (Table 6). This analysis accentuates the necessity to weigh both volume and quality in assessing a country's scholarly impact in specific research areas.

Table 6
Most cited countries in smart library

Country	TC	Average Article Citations
China	389	10.2
United Kingdom	74	37
Pakistan	68	8.5
India	66	8.2
Korea	52	52
Serbia	43	43
Usa	40	10
Iran	36	18
South Africa	24	24
Indonesia	13	4.3

Country	TC	Average Article Citations
Nigeria	10	3.3
Romania	8	8
Italy	6	6
Jamaica	6	3
Turkey	2	2

Analysis by authors

Table 7 presents a list of authors and the number of articles they have contributed to in the context of smart library research. Zhang Y. has produced the highest number of publications, totaling four. Their average output per association is 1.25 articles, suggesting a sustained and steady activity level. Chen's three research articles demonstrate a consistent one-to-one correspondence between articles and relationships, suggesting an equitable contribution from each piece. Chen Y. has made a noteworthy academic contribution, with an average of around 1.67 publications per association. The implications of the chart are evident, as it effectively showcases the different levels of author involvement in the field of smart library research. Specific authors demonstrate an equitable level of participation per article, whereas others exhibit involvement. These patterns indicate the presence of individual research interests, the dynamics of collaboration, or specific areas of competence.

Table 7

Most productive authors on smart library

Authors	Articles	Articles Fractionalized
Zhang Y	4	1.25
Chen H	3	1
Chen Y	3	1.66666667
Liu J	3	0.66666667
Liu W	3	1.08333333
Liu Y	3	1.66666667
Sayogo DS	3	1
Shahzad K	3	1.33333333
Yuli SBC	3	1
23 authors	2 articles	
256 authors	1 article	
Total: 288 authors	Total: 330 articles with multiple authors	

Authors' productivity through Lotka’s law

Based on Table 8 and Figure 6 above, comparing the current study results with the application of Lotka's Law, a significant disparity in productivity results is evident. Specifically, this discrepancy is observed when considering that 60% of authors produce a single article, while 25% of those who create one article also produce a second one. 11% of individuals produce three articles, and the trend continues in this manner. The formula applied is based on the inverse square law, represented as 1/N^2, where '1' denotes the number of authors and 'N'

signifies the number of articles. This relationship is inferred from the data in the table and the figure above.

1. The proportion of Lotka's authors' Law that contributed one article is 60%, whereas in the current study, it is 88.88%, a significant proportion compared to Lotka's Law.
2. The proportion of Lotka's authors' Law who contributed two articles is 25%, while in the current study, it is 7.9%.
3. The proportion of the law that Lotka's authors contributed to three articles is 11%, while in the current study, it is 2.7%.
4. The proportion of Lotka's authors' Law that contributed four or more articles is 6%, while in the current study, it is 0.3%.

Thus, the current study differs from Lotka's Law. This deviation can be attributed to various factors, including differences in scientific disciplines and fields, which might influence the observed discrepancies, among other potential reasons.

Table 8
Authors' productivity through Lotka's Law

N. of articles	N. authors in this study	percentage%	N. authors on Lotka's law	%
1	256	88.88%	173	60
2	23	7.98%	72	25
3	08	2.77%	32	11
4	01	0.34%	18	6%

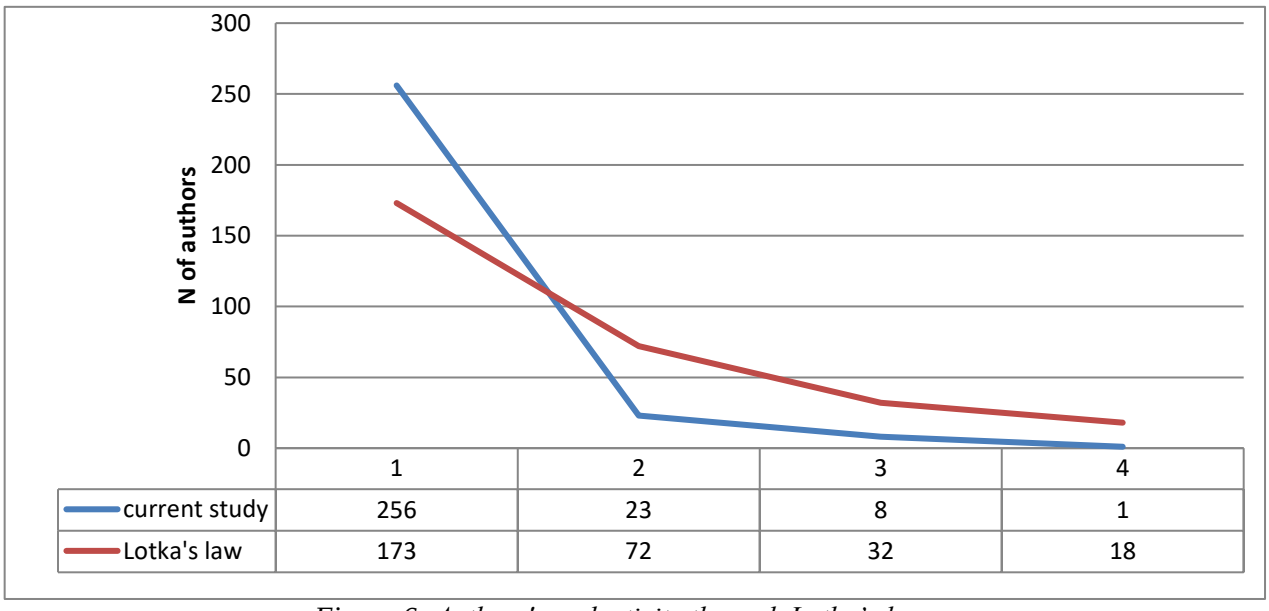


Figure 6: Authors' productivity through Lotka's law

Keywords Co-Occurrence Analysis of Publications

The application of keyword co-occurrence analysis to the topic of "Smart Libraries" reveals the presence of four distinct clusters (Table 9 and Figure 7), each representing a unique study theme. Cluster 1 (red) places significant emphasis on fundamental library research, particularly on user-centric studies. This is evident in the frequent usage of terms such as "library," "human," and "human experiment". Cluster 2 (Green) focuses on recent library

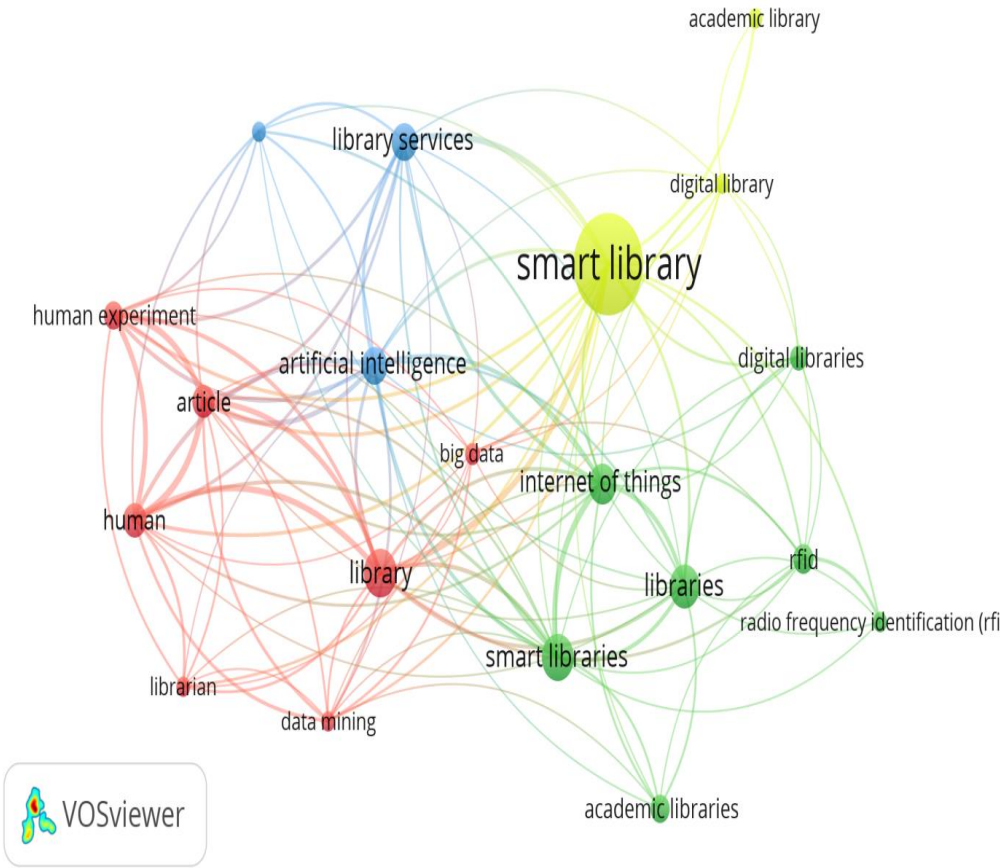
solutions, emphasizing the importance of automation and connectivity. It is evident from the use of phrases such as "smart libraries," "Internet of things," and "RFID". Cluster 3 (Blue) signifies a convergence of artificial intelligence, information technology, and library services inside a technological nexus. Cluster 4 (Yellow) distinguishes itself by emphasizing the notion of "smart library," albeit with references to certain libraries. One notable trend identified within the clusters is the development of the "smart library" concept, which represents integrating technology into conventional library services.

Table 9

Main keywords on « smart libraries

Clusters	Keywords occurrences
Cluster 1 Red	Article (10). big data (10). data mining (05). human (11). human experiment (8). librarian (5). library (18)
Cluster 2 Green	Academic libraries (8). digital libraries (7). internet of things (14). libraries (15). radio frequency identification RFID (5). RFID (9). smart libraries (17)
Cluster 3 Blue	Artificial intelligence (12). information technology (12). library services (12)
Cluster 4 Yellow	Academic library (5). digital library (5). smart library (50)

Moreover, the existing body of literature significantly focuses on improving user experience within technology-driven libraries. The subjects discussed in this literature highlight the substantial interconnection in this landscape.



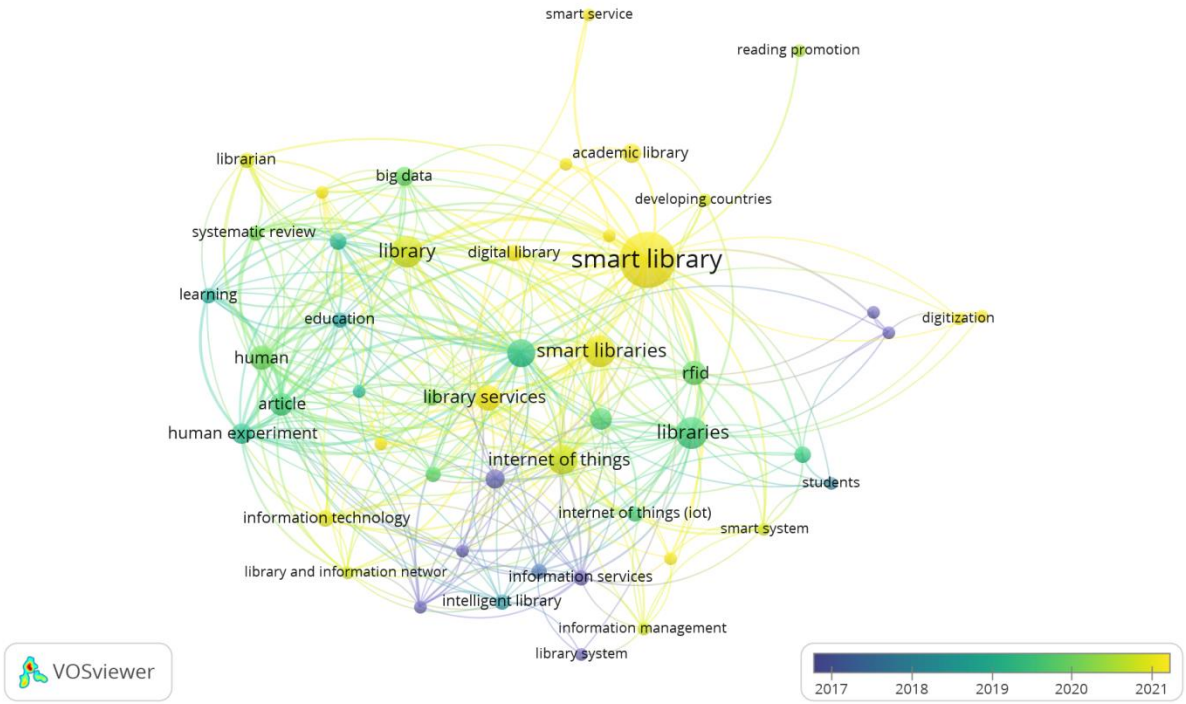


Figure 7: Keywords occurrence on "smart library" using VOSviewer

The research on "Smart Libraries" between 2016 and 2023 demonstrates a transition from fundamental technology integration towards the specialized exploration of improved systems and user experiences. Notably, talks on libraries in general predominate, while topics such as "artificial intelligence" and "data mining" highlight the convergence of technology and library science (Figure 8). The user-centric movement that has been taking place in research is shown by the concurrent emphasis on "Human" and "Human experiment". The term "smart library" indicates the most recent concentrated focus. This dataset recommends conducting further

research into user experiences in technologically enhanced library spaces, the resurgence of the theme of "Technology," and the implications of specialized discourses such as "Data mining" within the framework of smart libraries. These are all suggestions for future areas of research.

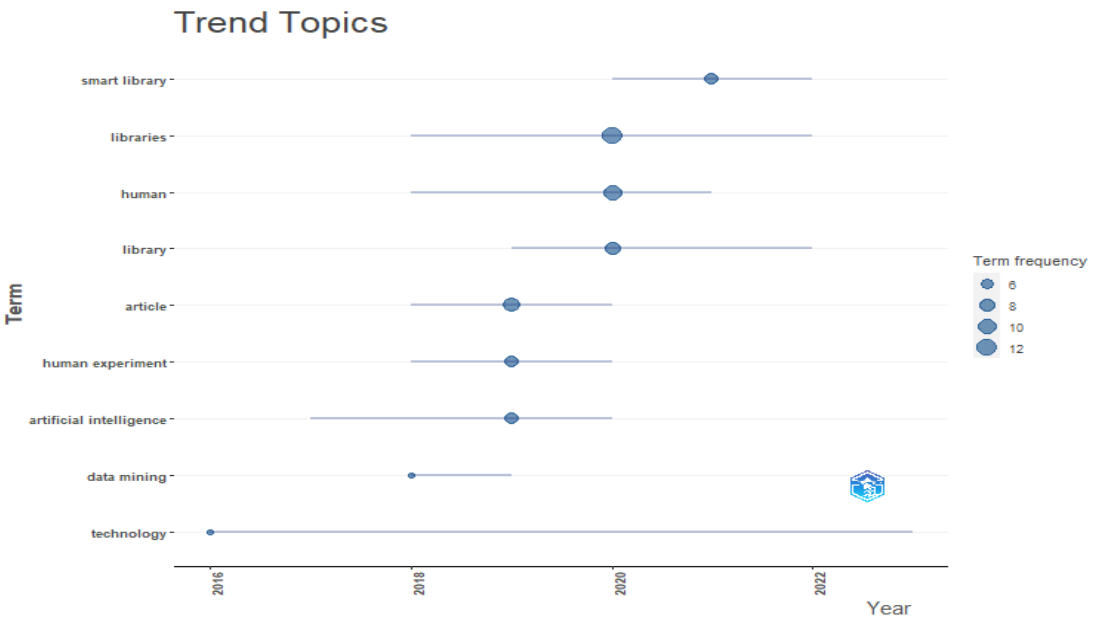


Figure 8: Trends topics on "smart library" using biblioshiny

Discussion

This study presents a comprehensive bibliometric analysis of global trends in smart library research from 1992 to 2023, utilizing the Scopus database and tools such as VOSviewer and Biblioshiny. By analyzing 132 documents and 4,399 references, the research provides significant insights into the evolution and key contributors to smart library literature. A notable finding is the surge in smart library publications since 2017, underscoring the growing importance of integrating advanced technologies like AI, IoT, and Big Data into library services. Consistent with prior studies by Huang et al. (2018) and Su & Li (2021), China remains a dominant contributor in output and influence. However, unlike these earlier studies that focused heavily on China, this research expands the analysis to include other regions, highlighting contributions from countries like India, Indonesia, and Pakistan. This broader global perspective marks a departure from previous studies, addressing a gap in the literature by offering a more inclusive view of smart library research.

In addition, this study demonstrates a methodological advancement through the combined use of VOSviewer and Biblioshiny, offering richer bibliometric insights compared to studies that relied solely on a single tool. This combination allowed for a more nuanced exploration of co-authorship networks, citation patterns, and keyword co-occurrence, thus contributing to the refinement of bibliometric research methodologies. Furthermore, including the most recent data, spanning 2022-2023, makes this study the most up-to-date analysis of smart libraries, offering fresh insights into the latest developments in the field.

Our research also contrasts with earlier bibliometric studies by leveraging Scopus, one of the largest and most comprehensive citation databases. This expands the literature previously confined to CNKI and Web of Science (Wang, 2023). Thus, it provides a more holistic understanding of the smart library landscape. Future comparative analyses using multiple

databases could offer even deeper insights into the variations in bibliometric results across platforms. While this study addresses several research gaps, including providing a global and up-to-date perspective, it has limitations. The exclusive use of Scopus data means that the findings may not capture the full spectrum of smart library research. Future studies could benefit from incorporating multiple databases like Web of Science, CNKI, and Google Scholar to build a more complete picture. Additionally, integrating altmetrics could provide a more robust understanding of how smart library research resonates on social media and other digital platforms.

Conclusion

This study substantially contributes to the growing literature on smart libraries by filling essential research gaps, providing a more comprehensive and global perspective, and advancing bibliometric methodologies. These findings are valuable for librarians, researchers, and policymakers, offering a roadmap for future research and helping to shape the role of smart libraries in the rapidly evolving landscape of library and information science. As smart libraries continue to integrate cutting-edge technologies, future studies should explore their impact on librarianship and user engagement, further advancing the field.

Acknowledgement

No grant from any public, commercial, or non-profit funding agency was offered to conduct this research.

Author Declaration

The author declares no conflict of interest relating to data presented in this article. Its contents, including any opinions and/or conclusions expressed, are solely those of the author.

References

Adetayo, A. J., Adeniran, P. O. & Gbotosho, A. O. (2021). Augmenting traditional library services: Role of smart library technologies and big data. *Library Philosophy and Practice (e-journal)*. 6164. Retrieved from https://digitalcommons.unl.edu/libphilprac/6164

Aguilar-Moreno, E., Montoliú-Colás, R. & Torres-Sospedra, J. (2016). Tecnologías de posicionamiento en interiores al servicio de una biblioteca universitaria: Hacia la smart library. *El Profesional de La Información*, 25(2), 295-302. https://doi.org/10.3145/epi.2016.mar.17 [in Spanish]

Aittola, M., Ryhänen, T. & Ojala, T. (2003). SmartLibrary-location-aware mobile library service. In L. Chittaro (Ed.), *Human-Computer Interaction with Mobile Devices and Services* (Vol. 2795, pp. 411–416). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-45233-1_38

Al Husaeni, D. F. & Nandiyanto, A. B. D. (2021). Bibliometric using Vosviewer with publish or perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post Covid-19 Pandemic. *ASEAN Journal of Science and Engineering*, 2(1), 19-46. https://doi.org/10.17509/ajse.v2i1.37368

Aria, M. & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Asemi, A., Ko, A. & Nowkarizi, M. (2021). Intelligent libraries: A review on expert systems, artificial intelligence, and robot. *Library Hi Tech*, 39(2), 412–434. https://doi.org/10.1108/LHT-02-2020-0038

Asim, M., Arif, M. & Rafiq, M. (2022). Applications of Internet of Things in university libraries of Pakistan: An empirical investigation. *The Journal of Academic Librarianship*, 48(6), 102613. https://doi.org/10.1016/j.acalib.2022.102613

Bi, S., Wang, C., Zhang, J., Huang, W., Wu, B., Gong, Y. & Ni, W. (2022). A survey on artificial intelligence aided internet-of-things technologies in emerging smart libraries. *Sensors*, 22(8), 2991. https://doi.org/10.3390/s22082991

Cao, G., Liang, M. & Li, X. (2018). How to make the library smart? The conceptualization of the smart library. *Electronic Library*, 36(5), 811–825. https://doi.org/10.1108/EL-11-2017-0248

Capdevila, I. & Zarlenga, M. I. (2015). Smart city or smart citizens? The Barcelona case. *Journal of Strategy and Management*, 8(3), 266–282. https://doi.org/10.1108/JSMA-03-2015-0030

Chen, C.-C., Liu, C.-C., Chiu, T.-H., Lee, Y.-W. & Wu, K.-C. (2022). Role of Perceived Ease of Use for Augmented Reality App Designed to Help Children Navigate Smart Libraries. *International Journal of Human–Computer Interaction*, 39(13), 2606–2623. https://doi.org/10.1080/10447318.2022.2082017

Cox, A. M., Pinfield, S. & Rutter, S. (2019). The intelligent library: Thought leaders' views on the likely impact of artificial intelligence on academic libraries. *Library Hi Tech*, 37(3), 418–435. https://doi.org/10.1108/LHT-08-2018-0105

Daniel, O. C., Ramsurrun, V. & Seeam, A. K. (2019, September). Smart library seat, occupant and occupancy information system, using pressure and RFID sensors. In *2019 Conference on Next Generation Computing Applications (NextComp)* (pp. 1-5). IEEE. https://doi.org/10.1109/NEXTCOMP.2019.8883610

Duncan, A. S. P. (2021). Opportunities for academic smart libraries in the Caribbean. *Library Hi Tech News*, 38(5), 9–12. https://doi.org/10.1108/LHTN-06-2021-0035

Gao, Y. (2022, December). Construction of smart library service system based on internet of things data technology. In *2022 International Conference on Knowledge Engineering and Communication Systems (ICKES)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICKECS56523.2022.10059734

Gul, S. & Bano, S. (2019). Smart libraries: An emerging and innovative technological habitat of 21st century. *The Electronic Library*, 37(5), 764–783. https://doi.org/10.1108/EL-02-2019-0052

Hjørland, B. & Nicolaisen, J. (2005). Bradford's law of scattering: ambiguities in the concept of "Subject". In F. Crestani & I. Ruthven (Eds.), *Context: Nature, Impact, and Role* (Vol. 3507, pp. 96–106). Springer Berlin Heidelberg. https://doi.org/10.1007/11495222_9

Hoy, M. B. (2016). Smart buildings: An introduction to the library of the future. *Medical Reference Services Quarterly*, 35(3), 326–331. https://doi.org/10.1080/02763869.2016.1189787

Huang, K., Liu, S. & Zhou, Z. (2018, May). Bibliometrics analysis of research literatures on smart library in academic journals of China. In *2018 3rd International Conference on Information Systems Engineering (ICISE)* (pp. 67-72). IEEE. https://doi.org/10.1109/ICISE.2018.00020

Hussain, A. & Ahmad, P. (2021). Adoption of smart technologies in university libraries of pakistan: A qualitative review. *Library Philosophy and Practice (e-journal)*. 6055. Retrieved from https://digitalcommons.unl.edu/libphilprac/6055

Igwe, K. N. & Sulyman, A. S. (2022). Smart libraries: Changing the paradigms of library services. *Business Information Review*, 39(4), 147-152. https://doi.org/10.1177/02663821221110042

Kwanya, T., Stilwell, C. & Underwood, P. G. (2013). Intelligent libraries and apomediators: Distinguishing between Library 3.0 and Library 2.0. *Journal of Librarianship and Information Science*, 45(3), 187–197. https://doi.org/10.1177/0961000611435256

Li, T., Tang, J., Xiao, L. & Cai, M. (2021). Evaluation of smart library portal website based on link analysis. *Procedia Computer Science*, 188, 114-120. https://doi.org/10.1016/j.procs.2021.05.059

Li, X., Shi, X., Xie, R. & Gu, Z. (2023). Evaluating e-book vendors in the era of smart libraries. *Library & Information Science Research*, 45(3), 101254. https://doi.org/10.1016/j.lisr.2023.101254

Mercado, L. L. & Lacorte, A. M. (2018, November). Intelligent library systems with data analytics for enhanced customer relation management towards continuous quality improvement. In *2018 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)* (pp. 378-383). IEEE. https://doi.org/10.1109/ISRITI.2018.8864370

Mohammed, M. A., Thabit, T. & Azeez, O. S. (2019). The impact of smart libraries in enhancing the sustainable development practices. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3495740

Noh, Y. (2015). Imagining library 4.0: Creating a model for future libraries. *Journal of Academic Librarianship*, 41(6), 786–797. https://doi.org/10.1016/j.acalib.2015.08.020

Padhi, S. & Nahak, B. (2019). The role of smart library and smart librarian for e-library services. In *12th International CALIBER-2019 KIIT, Bhubaneswar, Odisha INFLIBNET Centre* (pp. 89-97). Retrieved from https://ir7.inflibnet.ac.in/server/api/core/bitstreams/f8b39ec9-b4c6-4d02-98a3-6722f1433818/content

Rafique, H., Almagrabi, A. O., Shamim, A., Anwar, F. & Bashir, A. K. (2020). Investigating the acceptance of mobile library applications with an extended technology acceptance model (TAM). *Computers & Education*, 145, 103732. https://doi.org/10.1016/j.compedu.2019.103732

Sadeghi-Niaraki, A. (2023). Internet of Thing (IoT) review of review: Bibliometric overview since its foundation. *Future Generation Computer Systems*, 143, 361–377. https://doi.org/10.1016/j.future.2023.01.016

Schöpfel, J. (2018). Smart libraries. *Infrastructures*, 3(4), 43. https://doi.org/10.3390/infrastructures3040043

Shu, Z., Wang, M., Jiang, Y. & Liu, J. (2021, December). Exploration of knowledge service path of university smart library based on Internet. In *2021 3rd International Conference on Internet Technology and Educational Informization (ITEI)* (pp. 22-25). IEEE. https://doi.org/10.1109/ITEI55021.2021.00014

Simović, A. (2018). A big data smart library recommender system for an educational institution. *Library Hi Tech*, 36(3), 498–523. https://doi.org/10.1108/LHT-06-2017-0131

Su, R. & Li, M. (2021). Visual analysis on Chinese smart library researches based on Citespace. *2021 International Conference on Big Data, Artificial Intelligence and Risk Management (ICBAR)*, (pp.120–126). Shanghai, China. https://doi.org/10.1109/ICBAR55169.2021.00034

van Eck, N. J. & Waltman, L. (2020). *VOSviewer Manual*. Leiden: Univeristeit Leiden, 1(1), 1-53. Retrieved from https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.15.pdf

Waheed, H., Hassan, S.-U., Aljohani, N. R. & Wasif, M. (2018). A bibliometric perspective of learning analytics research landscape. *Behaviour & Information Technology*, 37(10-11), 941-957. https://doi.org/10.1080/0144929X.2018.1467967

Wang, D. (2023). Bibliometric analyses and network mapping on the smart library in Web of Science from 2003 to 2021. *Library Hi Tech*, 42(5), 1601-1633. https://doi.org/10.1108/LHT-08-2022-0361

Xu, Y., Li, J., Wang, B., Bu, Y. & Ji, C. (2019, June). Analysis of automation systems and virtual reality applications in smart libraries. In *2019 IEEE/ACIS 18th International Conference on Computer and Information Science (ICIS)* (pp. 161-166). IEEE. https://doi.org/10.1109/ICIS46139.2019.8940162

Yaman, O., Ertam, F., Tuncer, T. & Firat Kilincer, I. (2020). Automated UHF RFID-based book positioning and monitoring method in smart libraries. *IET Smart Cities*, 2(4), 173-180. https://doi.org/10.1049/iet-smc.2020.0033

Yanti, M. & Santoso, A. D. (2023). Profiling COVID-19 research in the social sciences from Indonesia based on Scopus database. *Malaysian Journal of Library and Information Science*, 28(1), 89-107. https://doi.org/10.22452/mjlis.vol28no1.6

Yu, J. (2021, December). Construction of Smart Library Based on the Big Data Mining and Knowledge Discovery. In *2021 Smart City Challenges & Outcomes for Urban Transformation (SCOUT)* (pp. 57-61). IEEE. https://doi.org/10.1109/SCOUT54618.2021.00023