Original Research Article

Sustainable Libraries for Books and Bytes: A Bibliometric Study of Web of Science Database

*Sustainable Libraries for Books and Bytes: A Bibliometric Study of Web of Science from 2005-2004

Abstract

The concept of sustainable libraries, which integrate traditional books and digital resources to adapt to technological and environmental changes. This paper emphasizes the importance of sustainable practices in library management, including eco-friendly building designs, digital collections, and waste reduction. The paper also delves into a bibliometric study on sustainable libraries, analysing academic literature to identify trends, influential contributions, and research growth patterns. For the bibliometric analysis and visualization VOSviewer software is used based on 248 literature data onsustainable libraries papers gathered from the Web of Science core collection from 2005 to 2024on the subject discipline of Library and Information Science. The year 2021 has the highest number of records, with 25 entries, and the most prolific author was found to be Henrik Jochumsen, with a total link strength of 32.This study also provides insights into the global distribution of research on sustainable libraries, highlighting key countries, document types, and open access modes.

Keywords: Sustainable Libraries, Bibliometric, VOSviewer, Sustainability, Library

Introduction:

The future of sustainable libraries will involve a fusion of traditional books and digital bytes, adapting to the changing landscape of technology and environmental awareness.This paper will typically involve prioritization to build modern collection spaces; physical book collections shall give way for digital media [such as e-books, audiobooks] and e-resources to be expanded and promoted in favour of improving accessibility. Libraries will be transformed as active community spaces including multiple-purpose space for events and coordination projects thereby promoting sustainability and engagement. Hybrid libraries were designated after the term coined by Chris Rusbridge first in 1998. Hydro Library incorporates physical references as well as electronic resources. Hybrid collections will cater to accommodating diverse user preferences while also considering the two formats' environmental impacts. Books are required for so many things in human life and society that they serve as the source of knowledge, protector of culture, and medium for

personal growth. Furthermore, by far the most influential society advances that help create more technological progress and contribute in a substantial way in furthering science comes through spreading knowledge across many fields. Such libraries can be seen to be sustainable in that a new way of thinking is being manifested concerning how libraries are managed and designed in the long term. That is to put sustainability focus in multiple aspects of operations, like energy-efficient building designs and renewable sources plus environmentally friendly materials used, waste reduction, physical sustainability and paying attention to the fact that even digital sustainability will play.By adopting green technologies, promoting resource conservation, and fostering community awareness about sustainability, sustainable libraries serve as models of environmental stewardship. They not only reduce their carbon footprint but also contribute to the broader goal of sustainable development, demonstrating how cultural institutions can lead by example in addressing global environmental challenges.The vision of sustainable libraries for the future lies at the intersection of traditional books and digital bytes, emphasizing adaptability, accessibility, and environmental responsibility.

*This citation not mentioned in References

Table 1 Concepts for Sustainable libraries

Concept	Description
Green Infrastructure	**Eco-friendly Building Design**: Incorporate sustainable architecture and renewable energy sources. **Energy-efficient Operations**: Use solar panels, natural lighting, and energy-saving technologies.
Digital Libraries and E-Resources	**Digital Collections**: Transition to digital collections to reduce the environmental impact. **E-books and Audiobooks**: Promote e-books and audiobooks as sustainable alternatives to physical copies.
Waste Reduction and Resource Management	**Recycling and Upcycling Programs**: Implement programs to recycle old books and electronics. **Paperless Operations**: Move towards digital library cards, receipts, and notifications.
Community Engagement and Education	**Sustainability Workshops**: Offer programs that educate the community on sustainability. **Collaborative Spaces**: Design spaces for community collaboration on sustainability projects.
Sustainable Collections Management	**Digitization of Rare Collections**: Preserve collections through digitization to reduce physical handling.

	Sustainable Acquisition Policies: Prioritize digital formats and sustainably sourced materials.
Technology and Innovation	**Smart Library Systems**: Utilize smart technologies for energy management and resource allocation. **Cloud Computing**: Leverage cloud computing for data storage to reduce physical infrastructure needs.
Impact on Library Patrons	**User Experience**: Provide a comfortable, eco-friendly environment for patrons. **Education and Awareness**: Foster a culture of sustainability through library programs.

*Should be in centre of the table

A bibliometric study on sustainable libraries involves the systematic analysis of academic literature to identify and quantify patterns, trends, and influential contributions within the field of sustainable library practices. This type of study uses bibliometric methods, such as citation analysis, co-citation analysis, and keyword analysis, to assess the development of research topics, the impact of specific publications, and the relationships between different areas of study.

Review of related literature

Libraries are increasingly pivoting from physical to digital resources to accommodate the growing demand for digital media ("bytes"). Authors such as **Connaway et al. (2017)** discuss the role of digital libraries in enhancing accessibility and resource-sharing. However, this shift necessitates a focus on sustainable practices, including the adoption of renewable energy sources for powering servers and implementing long-term digital preservation strategies.The literature emphasizes the role of libraries in addressing the United Nations Sustainable Development Goals (SDGs), particularly Goal 11 (Sustainable Cities and Communities) and Goal 13 (Climate Action). Studies by **Aulisio (2013)** and **Jankowska (2010)** highlight initiatives such as green library certifications, sustainable architectural designs, and energy-saving operations. Moreover, digital transformation within libraries is viewed as a dual-faceted phenomenon: while digital resources reduce physical material waste, they also raise concerns about the carbon footprint of data centers and electronic waste.

Environmental sustainability in libraries has been widely discussed, particularly in the context of green building initiatives. **Jankowska and Marcum (2010)** identify sustainable architectural practices, such as Leadership in Energy and Environmental Design (LEED) certifications, as pivotal in reducing the carbon footprint of library facilities. Examples of green libraries, such as the San Francisco Public Library's eco-friendly design and the National Library of Singapore's energy-efficient operations, showcase the potential for libraries to lead in sustainable infrastructure. Furthermore, research highlights the importance of adopting renewable energy sources, efficient

lighting systems, and waste reduction strategies to minimize environmental impacts **(Antonelli, 2008)**.

Digital preservation techniques, such as migration and emulation, are essential for ensuring long-term access to digital resources **(Conway, 2010)**. The social dimension of library sustainability emphasizes equitable access to knowledge, inclusivity, and community engagement. Libraries are seen as critical to building informed, resilient communities. **Aulisio (2013)** notes that sustainable libraries promote lifelong learning and digital literacy, ensuring marginalized populations can participate in the digital age. Moreover, the integration of multicultural programming and accessible spaces exemplifies libraries' commitment to fostering social equity.As libraries transition toward digital platforms, the sustainability of digital collections and infrastructure is becoming increasingly relevant. The development of sustainability frameworks and policies tailored to library contexts is another growing area of interest. The International Federation of Library Associations and Institutions (IFLA) has outlined the role of libraries in achieving the United Nations Sustainable Development Goals (SDGs). This includes initiatives to track the environmental impact of library operations and promote sustainability literacy among users **(IFLA, 2018).** Studies have also emphasized the need for standardized metrics to evaluate the sustainability of library services, infrastructure, and digital practices **(Matthews, 2011).**

*** Add two or three recent literature reviews, as many studies have been published in 2024**

Objectives of the Study

- To find the list of available literature on Sustainable Libraries from 2005-2024.
- To study the research growth pattern in Sustainable Libraries from 2005-2024 in the field of Library and Information Science
- To identify prominent institutions, organisations, countries, and authors with significant research contribution in this field.
- To find out the Keyword Co-Occurrence Analysis of Sustainable Libraries related literature
- To find out the document type and open access mode on the research papers on this area.

*Both have the same meaning, delete the last one highlighted, and place it as a second objective.

Research Methodology

Journal articles published on topic Sustainable Libraries published between 2005 and 2024 in the English language were scanned fromthe Web of Science (WOS) core collection database on date 18th August 2024. "Sustainable Libraries" was used as the keywords to reach the relevant

publications in the core discipline of Library and Information Science. As WOS is a high quality trusted international indexing database, it is considered as the data source for research.

Publications indexed only at SCI were taken for the study. Again, Publications included under the category of Library and Information Science were considered for the study. Publications in the disciplines of Engineering, Environmental Science, Computer Science etc. were excluded from the study. A total of 248 data was collected from the Web of Science in the last 20 years (2005-24) on the " Sustainable Libraries " publication of the category of Library and Information Science is analysed and interpreted on the basis given parameter.Science mapping tool VOSviewer, is used to analyze the Co-authorship, Co-occurrence, etc. Larger bibliometric maps are displayed in an easy-to-interpret way by using VOSviewer. Web of Science Analyser also used for the Analysis.

Analysis and interpretation

The Chronological Growth of Publication on Sustainable Libraries

Publication Years	Record Count	% of 248
2024	15	6.048
2023	23	9.274
2022	14	5.645
2021	25	10.081
2020	19	7.661
2019	17	6.855
2018	16	6.452
2017	12	4.839
2016	13	5.242
2015	8	3.226
2014	14	5.645
2013	9	3.629
2012	12	4.839
2011	6	2.419
2010	10	4.032
2009	9	3.629
2008	6	2.419
2007	5	2.016
2006	5	2.016
2005	10	4.032

Table-2 Chronological Growth of Publication on Sustainable Libraries

*The Table number and title should be place at the top of the table and table should in a centre of the page

The table 2represents the distribution of records by publication year within a dataset of 248 records. The year 2021 has the highest number of records, with 25 entries, accounting for 10.08% of the total. This is followed by 2023, which has 23 records or 9.27%. The year 2020 is also notable with 19 records, making up 7.66%, while 2019 has 17 records, or 6.86%. The years 2018 and 2024 each contribute 16 and 15 records, respectively, representing 6.45% and 6.05% of the dataset.

Several years, such as 2022 and 2014, each have 14 records, contributing 5.65% to the total. The years 2016 and 2017 have 13 and 12 records respectively, making up 5.24% and 4.84%. The earlier years in the dataset, including 2010 and 2005, each have 10 records, accounting for 4.03% of the total. Years like 2013, 2009, and 2015 have fewer records, with counts ranging from 9 to 8, representing about 3.63% and 3.23%, respectively. The least represented years include 2011 and 2008, each with 6 records (2.42%), and 2007 and 2006, each with 5 records (2.02%).

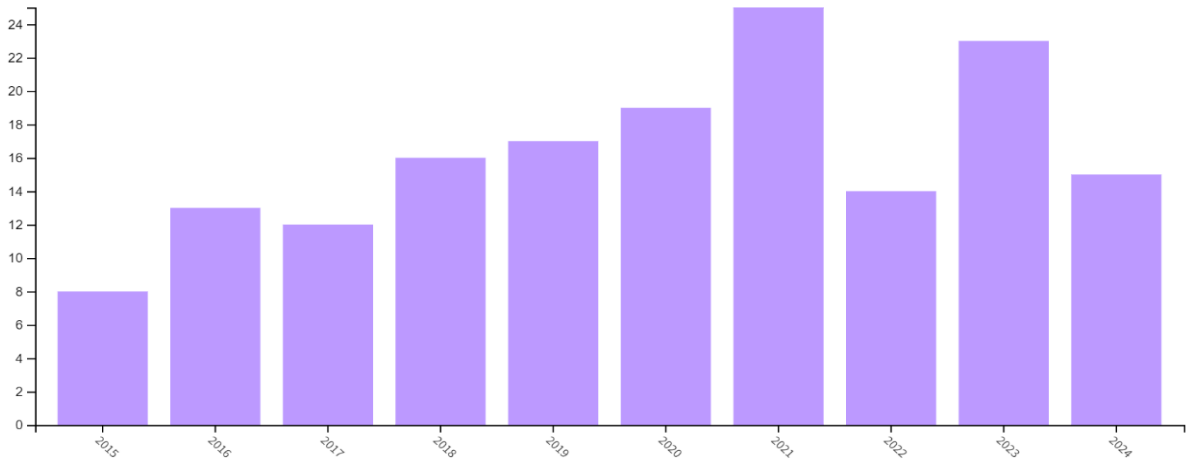

Figure-1 Chronological Growth of Publication on Sustainable Libraries

Types of Documents retrieved on Sustainable Libraries

Document Types	Record Count	% of 248
Article	222	89.516
Early Access	15	6.048
Book Review	12	4.839
Review Article	11	4.435
Proceeding Paper	5	2.016

Editorial Material	3	1.210

Table-3 Types of Documents on Sustainable Libraries

*Table name Place at the top of the table

The table-3 presents the distribution of document types in a dataset containing 248 records. Articles make up the largest portion, with 222 entries, accounting for 89.52% of the total. Early Access documents follow, representing 15 records or 6.05%. Book Reviews are the next most common, with 12 entries comprising 4.84%. Review Articles are slightly less frequent, making up 11 records, or 4.44% of the dataset. Proceeding Papers are relatively rare, with 5 entries, equating to 2.02%. Lastly, Editorial Material is the least represented, with only 3 records, constituting 1.21% of the total.

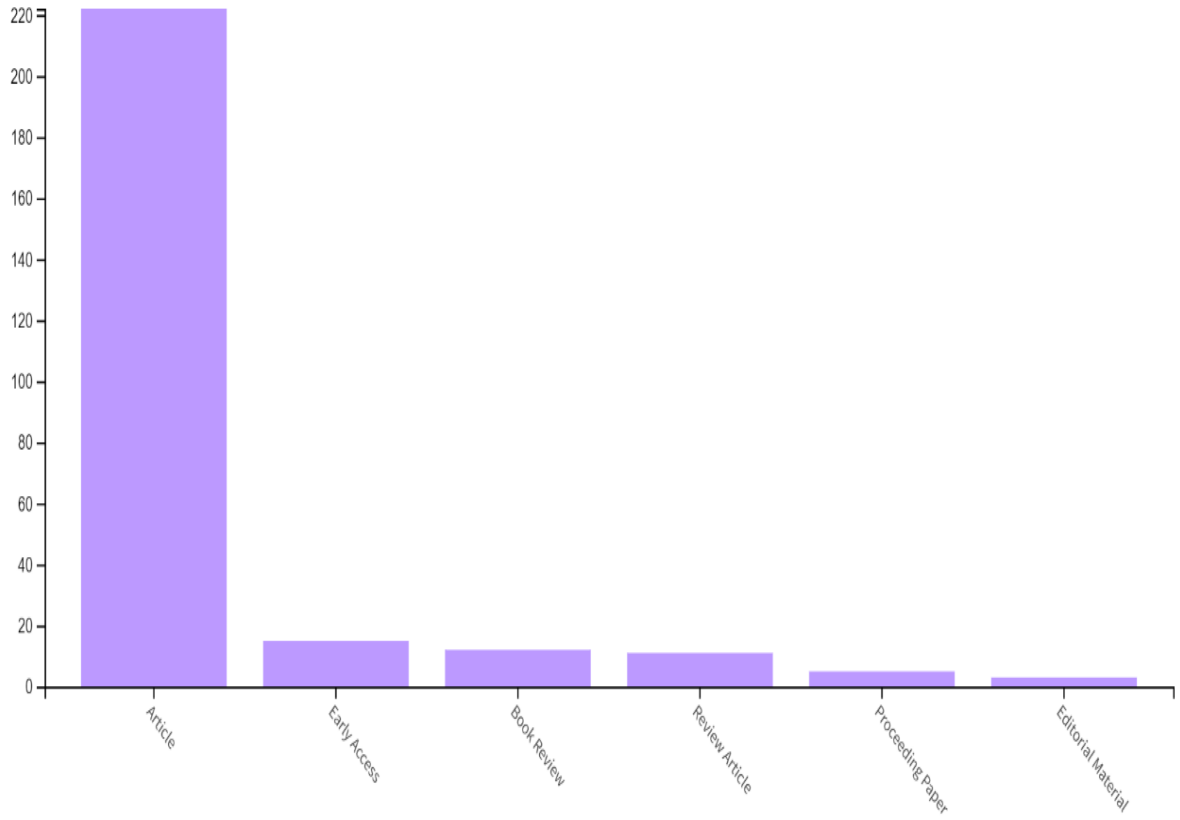

Figure-2- Types of Documents on Sustainable Libraries

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Co -authorship of authors

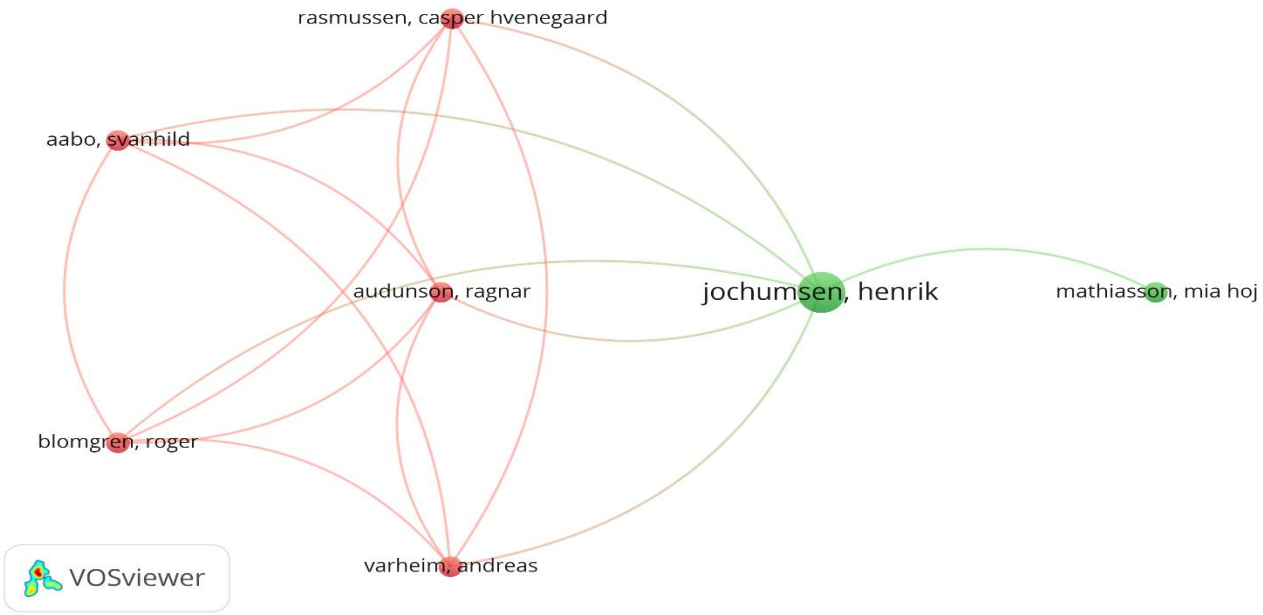

Figure-3- Author Analysis of the Sustainable Libraries related Publication

The authors' co-authorship produced with the latest version of VOSviewer. The figure is produced using the co-authorship type of analysis and the authors as the units of analysis. After using the complete counting process and setting a maximum of 2 authors per document, 28 authors are connected, with a minimum of 2 authors per document. The co-authorship ties with other authors are computed for these 28 authors out of 529 total authors. The size of the circle (or node) corresponds to the quantity of papers published under the author's name, and it represents a single author. It is discovered that there are seven connected objects using this approach. Two clusters comprise these seven writers. When authors are grouped together with similar colours, it signifies their close cooperation, and the lines that connect them show that they have collaborated. The most prolific author was determined to be Henrik Jochumsen, with a total link strength of 32.

* This table and analysis show the co-authorship of authors. The list of the most prominent authors is not included here, It can be easily analyzed using the Web of Science. The total number of authors and the top ten most prolific authors should also be mentioned

Prolific Affiliation on Sustainable Libraries

Affiliations	Record Count	% of 248
UNIVERSITY OF SOUTH AFRICA	7	2.823
INDIANA UNIVERSITY SYSTEM	5	2.016
NORTHUMBRIA UNIVERSITY	5	2.016
STATE UNIVERSITY SYSTEM OF FLORIDA	5	2.016

UNIVERSITY OF TECHNOLOGY SYDNEY	5	2.016
CALIFORNIA STATE UNIVERSITY SYSTEM	4	1.613
CORNELL UNIVERSITY	4	1.613
INDIANA UNIVERSITY BLOOMINGTON	4	1.613
UNIVERSITY OF COLORADO SYSTEM	4	1.613
UNIVERSITY OF COPENHAGEN	4	1.613
UNIVERSITY OF NORTH CAROLINA	4	1.613
UNIVERSITY OF STRATHCLYDE	4	1.613
UNIVERSITY SYSTEM OF OHIO	4	1.613
CARNEGIE MELLON UNIVERSITY	3	1.210
HARVARD UNIVERSITY	3	1.210
KENT STATE UNIVERSITY	3	1.210
KENT STATE UNIVERSITY KENT	3	1.210
KENT STATE UNIVERSITY SALEM	3	1.210
MONASH UNIVERSITY	3	1.210
ROBERT GORDON UNIVERSITY	3	1.210
STELLENBOSCH UNIVERSITY	3	1.210
UNIVERSITI MALAYA	3	1.210
UNIVERSITY OF BORAS	3	1.210
UNIVERSITY OF CALABAR	3	1.210
UNIVERSITY OF CALIFORNIA SYSTEM	3	1.210

Table-4 Prolific Affiliation on Sustainable Libraries

*should be placed at the top of the table and table should be the centre of the page

The table-4 shows the distribution of affiliations among a dataset of 248 records. The University of South Africa has the highest representation with 7 records, accounting for 2.82% of the total. Several institutions have equal representation, each with 5 records, making up 2.02% of the dataset. These include Indiana University System, Northumbria University, State University System of Florida, and University of Technology Sydney.Next, several universities each have 4 records, comprising 1.61% of the total. These include California State University System, Cornell University, Indiana University Bloomington, University of Colorado System, University of Copenhagen, University of North Carolina, University of Strathclyde, and University System of Ohio.

Also many institutions are tied with 3 records each, making up 1.21% of the dataset. These include Carnegie Mellon University, Harvard University, Kent State University (including Kent and Salem campuses), Monash University, Robert Gordon University, Stellenbosch University, Universiti Malaya, University of Borås, University of Calabar, and the University of California System.

* Change the title into "Most Prolific Affiliated Institutions (Top 25 Only)". In the analysis, mention the total number of institutions that contributed to Sustainable Libraries research literature

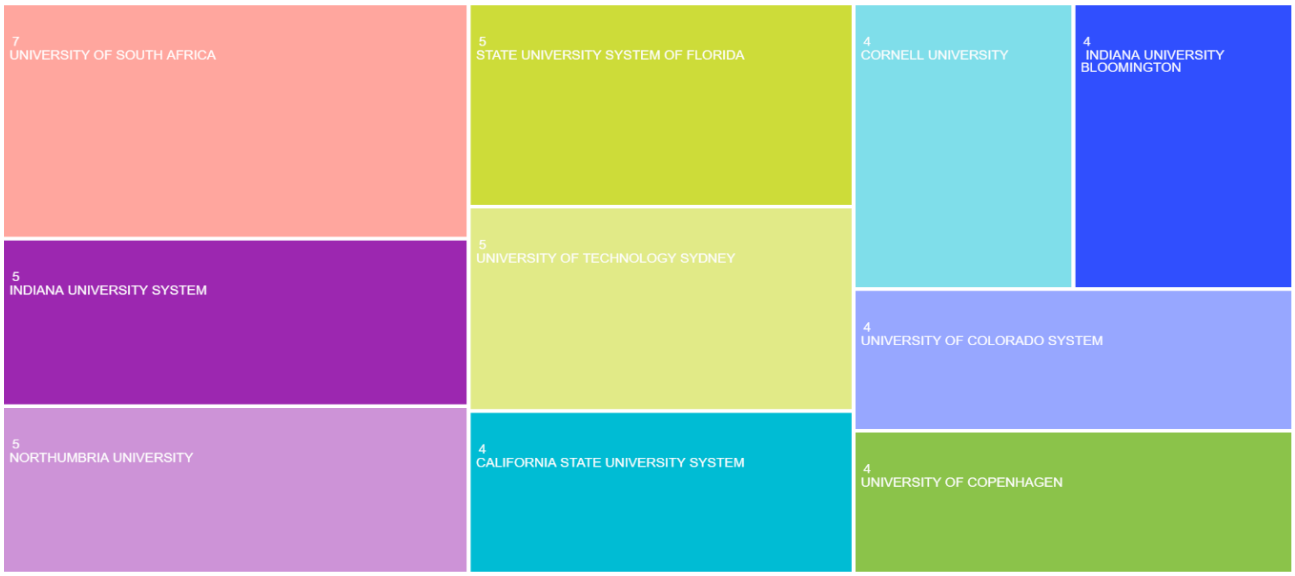

Figure-4- Prolific Affiliation on Sustainable Libraries

*It should be placed at the bottom centre of the figure

*As per the objective, did not find 'Prominent Organization tables and analysis', if it's not added remove that it from Objective

Top 10 Prolific Country on Sustainable Libraries

Sl.No	Countries/Regions	Record Count	% of 248
1	USA	88	35.484
2	AUSTRALIA	25	10.081
3	ENGLAND	18	7.258
4	NIGERIA	16	6.452
5	PEOPLES R CHINA	15	6.048
6	SOUTH AFRICA	14	5.645
7	GERMANY	11	4.435

8	CANADA	9	3.629
9	PAKISTAN	8	3.226
10	SCOTLAND	7	2.823
10	SWEDEN	7	2.823

Table-5 Top 10 Prolific Country on Sustainable Libraries

* Country change into Countries and table title should be place in the top of the table

The table provides an overview of the distribution of records across various countries and regions, detailing the number of records and their percentage out of a total of 248. The United States leads significantly, with 88 records, accounting for 35.484% of the total. Australia follows as the second most represented country, contributing 25 records, which make up 10.081% of the total. England ranks third with 18 records, constituting 7.258%.Nigeria and the People's Republic of China are close, with 16 records (6.452%) and 15 records (6.048%), respectively. South Africa also features prominently with 14 records, representing 5.645% of the total. Germany has 11 records, equating to 4.435%, while Canada has 9 records, or 3.629% of the total.Pakistan follows with 8 records (3.226%). Scotland and Sweden both have 7 records, each contributing 2.823% to the overall total, tying for the tenth position. The table highlights the global distribution of records, with a notable concentration in the USA, and a diverse spread across other regions.

*mention the total number of countries that contributed to Sustainable Libraries research literature

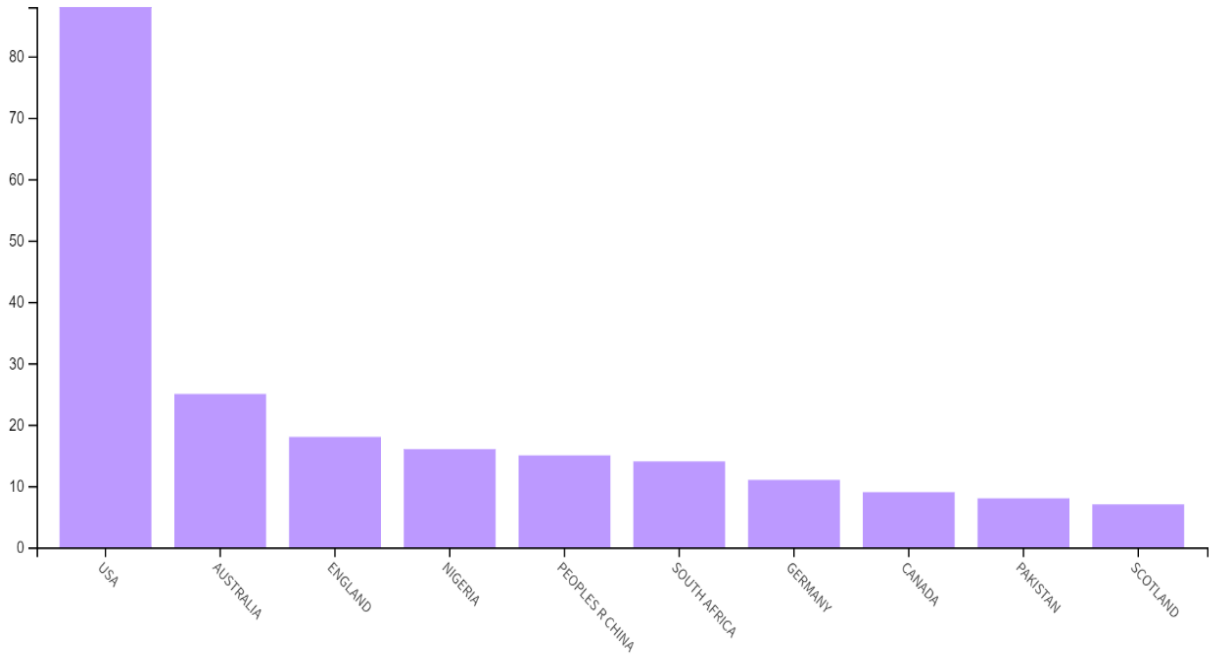

Figure-5 Prolific Country on Sustainable Libraries

The Keywords co-occurrence

Keywords co-occurrence can effectively reflect the research. In the literatureSustainable Libraries,

970 obtained keywords altogether by taking minimum keyword occurrence is 5. Out of the 970 keywords are selected for analysis, for each term a relevance score will be calculated. The default choice is to select 60% relevance, so 35 keywords are selected. The VOSviewer program creates the Sustainable Libraries keyword co-occurrence network. The size of the nodes and words in Figure indicates the weight of the nodes. The weight and node and word sizes are proportionate. The distance between two nodes indicates the strength of their relationship. A closer relationship is indicated by a smaller distance. Two keywords that have appeared together are indicated with a line joining them. They are more likely to show up together if the line is thicker. All of the clusters that have nodes of the same colours belong to the same cluster. The relevancy of the terms is used to cluster them. The keywords are ranked by their frequency of occurrence and their total link strength, which likely represents the strength of their association with other keywords or concepts.

*Add the figure number

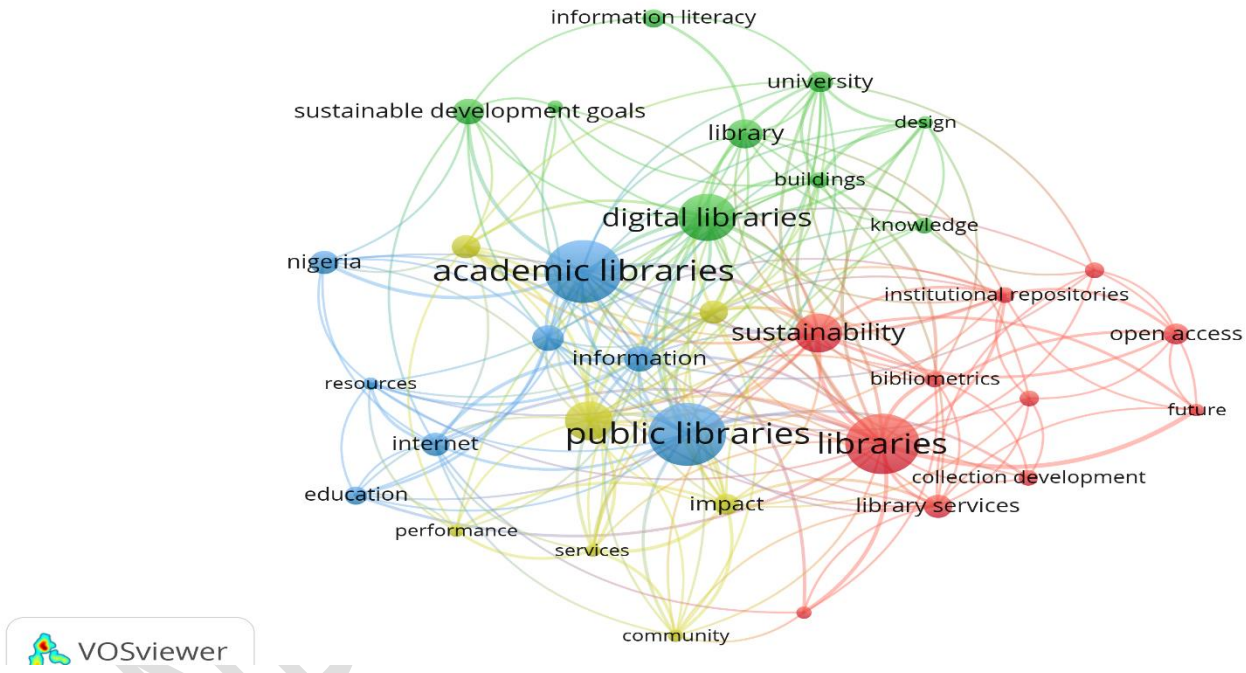

Figure- 6- Keyword Co-occurrence of the Sustainable Libraries related Publication

Top 10 keywords of the Sustainable Libraries related Publication

Rank	Keywords	Frequency	Total Link Strength
1	Academic Libraries	24	32
2	Public Libraries	24	27
3	Libraries	23	47
4	Digital Libraries	18	31
5	Sustainable Development	15	33
6	Sustainability	15	32
7	Information	10	29
8	Technology	10	19

9	Model	9	25
10	Management	9	20

Table-6- Top 10 keywords of the Sustainable Libraries related Publication

"Academic Libraries" and "Public Libraries" top the list with the highest frequency of 24, having total link strengths of 32 and 27, respectively. The term "Libraries" itself appears frequently as well, with a frequency of 23 and the highest total link strength of 47, indicating its broad relevance and strong connections within the context. "Digital Libraries" follow with a frequency of 18 and a link strength of 31, highlighting the significance of digital transformation in the library sector.

"Sustainable Development" and "Sustainability" also feature prominently, each with a frequency of 15, but slightly different total link strengths of 33 and 32, respectively, emphasizing their importance in the discourse. The keywords "Information" and "Technology" appear with a frequency of 10, reflecting their role in modern library systems, with total link strengths of 29 and 19. Lastly, "Model" and "Management" both have a frequency of 9, with link strengths of 25 and 20, indicating their relevance in the strategic and operational aspects of library management in the context of sustainability and technological integration.

* There are two titles; one should be used as the title of the analysis and the other as the table title. The table title should be placed at the top of the table

Open Access Mode of Literature on Sustainable Libraries

Open Access	Record Count	% of 248
All Open Access	99	39.919
Gold	18	7.258
Gold-Hybrid	20	8.065
Free to Read	29	11.694
Green Published	26	10.484
Green Accepted	21	8.468
Green Submitted	23	9.274

Table-7 Open Access Mode of Literature on Sustainable Libraries

*Place in the top of the table and table should be centre of the page

The table-6 outlines the distribution of Open Access types within a dataset of 248 records. Nearly 40% of the records, specifically 99, fall under the category of "All Open Access." Among these, "Gold" Open Access, which typically involves publications in fully open-access journals, accounts for 18 records or 7.26% of the total. "Gold-Hybrid," representing articles available in hybrid journals, contributes 20 records, making up 8.07%. "Free to Read" materials, which are accessible without subscription but not necessarily open access, account for 29 records, or 11.69%.

In the various stages of "Green" Open Access, which involves self-archiving, "Green Published" records—where the final published version is available—constitute 26 entries or 10.48%. "Green Accepted" manuscripts, which are the peer-reviewed but not yet published versions, make up 21 records, or 8.47%. Lastly, "Green Submitted" versions, which refer to preprints submitted for publication, account for 23 records, representing 9.27% of the total dataset.

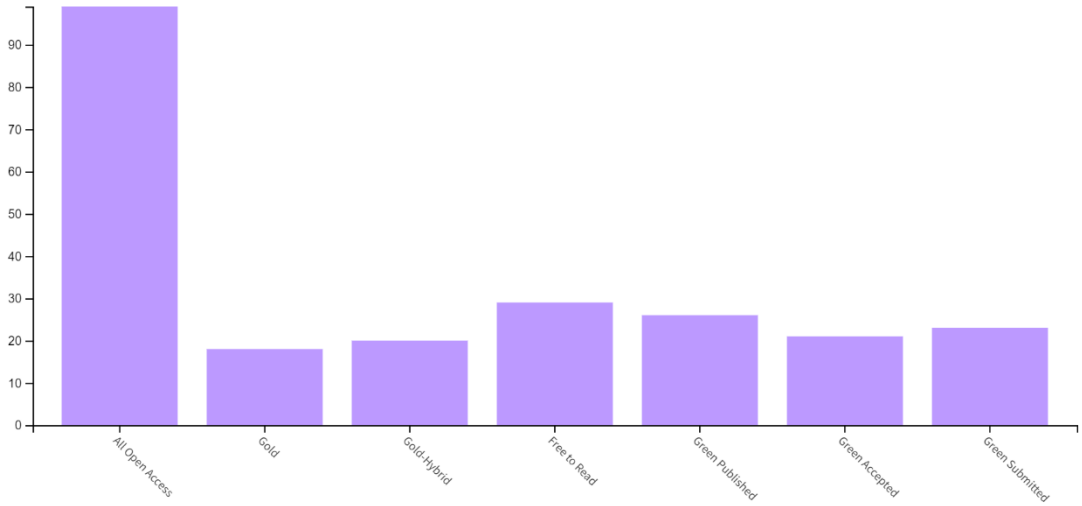

Figure-7 Open Access Mode of Literature on Sustainable Libraries

By mapping the intellectual landscape of sustainable libraries, this study contributes to the ongoing dialogue on how these institutions can continue to serve as essential pillars of education and culture in the 21st century.

Conclusion

The content highlights various aspects of sustainable library management, including the physical infrastructure, user experience, education and awareness programs, community engagement, sustainable collections management, and technology and innovation. It underscores the importance of providing a comfortable and eco-friendly environment for library patrons, offering educational programs on sustainability, and designing collaborative spaces for community engagement in sustainability projects. Additionally, the document advocates for sustainable practices in collection management, such as digitization of rare collections and prioritizing digital formats and sustainably sourced materials.

Moreover, the paper provide insight into the global distribution of research on sustainable libraries, providing insights into the bibliometric analysis of academic literature. It identifies influential authors, prolific affiliations, and the distribution of research across various countries and regions. The study also analyzes the types of documents related to sustainable libraries, including review articles, proceeding papers, and editorial materials, shedding light on the prevalence of different

document types in the academic discourse on sustainable libraries.Furthermore, the document explores the open access modes of literature on sustainable libraries, categorizing publications into "Gold," "Green," and "Hybrid" open access, and provides a detailed breakdown of the distribution of records across these modes. Overall, the document serves as a valuable resource for understanding the multifaceted dimensions of sustainable libraries, encompassing environmental considerations, community engagement, academic research, and the evolving role of libraries in the digital age.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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