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Research on Digital Preservation: An empirical analysis

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Abstract:

Digital preservation is an evolving area of research for libraries, archives, and museums across the globe over the last two decades. Due to the growing recognition of the need to address various issues dealt with digital preservation, this field of study has generated quite a range of scholarly communications on several aspects. The present paper aims to examine critically the extant literature on "digital preservation and libraries" for the period from 2001 to 2019 and to assess the evolving trajectory and trends. Out of a total of 1292 extracted records from the Scopus database, a total of 710 articles are considered for the study purpose after the exclusion of non-relevant articles. Employing bibliometric indicators the study primarily assessed the publication pattern, document types, the most prolific authors, most contributing institutions, and focus areas of study as well as the geographical distribution of publications. Along with this, the VOSviewer software is used for co-author network analysis. The findings of the current analysis reveal that the highest number of papers published in the source journal "Lecture Notes in Computer Science" while the U.S.A. is in the top spot among the countries and author Nelson, M. L. from the U.S.A. has published the maximum number of research papers. It also provides information on various forms of publication on digital preservation and the impactful papers. Though there are studies on the assessment of digital libraries and digital repositories, a bibliometric assessment of literature on digital preservation is a novel attempt. As a metric study, it reflects the relative position of a country, an institution, and a researcher.

Keywords: Digital preservation, Digital library, Bibliometric study, VOSviewer, Prominent authors, Highly cited papers, Empirical study.

Introduction:

Digital preservation research has taken exponential growth in the last two decades as it covers both born-digital materials, analog-converted materials along with their policies, technologies, and strategies. Diversified studies have been carried out on various facets of digital preservation by professionals of different disciplines. Other than the print objects, the digital objects have a very short life span due to their electronic format which needs periodic up-gradation or migration. Thus, before it became too late, we should think about the preservation of digital objects. With the advent of digital technologies, digital preservation plays a vital role in libraries. Libraries are also consciously engaged in transition and dealing with the new age and expanding their fields of education and study in this field. Digital Preservation coalition (2006) defines digital preservation as "all activities need to access digital documents beyond the limits of technological obsolescence". The digitally preserved material may be in any form (text, image, or, video) accessed by any user from any domain. Digital Preservation an inevitable responsibility of the libraries and archives in this modern age of technology.

Literature Review:

Examining the patterns and characteristics of published literature on specific themes are regularly reported in various disciplines and has attracted the attention of the academic community across many disciplines. Studies related to theme-based bibliometric analyses have been followed for the literature review for the present paper and two groups of works are considered in this context. While one group of works are consisting of papers in various disciplines the second group reviewed the works published in the field of Library and Information Science, For instance theme based bibliometrics studies have been conducted in AIDS research (Macías-Chapula and Mijangos-Nolasco, 2002); AloeVera research (Sivasami, 2002; Gupta *et al.,* 2018); Cancer research (Patra and Bhattacharya, 2005); Physics research (Dhawan and Gupta, 2007); Chemo Informatics research (Willett, 2007); Tsunami research (Chiu and Ho, 2007); International literature in Supercapacitors (Lufrano and Staiti, 2009); Computer Science research (Gupta, *et al.*, 2010); Knowledge management research (Akhavan *et al.*, 2011); Diabetes Research (Gupta, *et al.*, 2011) Pneumonia disease research (Gupta and Gupta, 2014); Liver disorders research (Gupta, *et*

al., 2014); Research on the Mekong River (Sui *et al.*, 2015); Opinion mining and sentiment analysis research (Piryani, *et al.*, 2017); Dry eye disease research (Boudry, *et al.*, 2018); Agriculture research (Peter and Mini Devi, 2018); Hepatocellular carcinoma research (Miao, *et al.*, 2018); Complexity science in healthcare (Churruca *et al.*, 2019). Through these studies, authors have explored the growth and impact of publications, most productive authors. distribution of subject category and Sub-fields of research, top contributing institutions, countries, major journals contributing to the field, and highly cited papers in the field.

So far as Library and Information Science discipline is concerned researchers have explored the publication characteristics of literature on "digital library", "institutional repository", "digital preservation", "cultural heritage preservation". By conducting a bibliometric study, Singh, *et al.*, (2007) depicted the growth of literature on digital libraries from 1998 to 2003. A maximum number of articles on digital libraries were published in 2003 and D-Lib magazine was the highest productive journal where the USA remain in top position publishing the maximum number of journals for the topic digital library. Bhardwaj (2014) critically analyzed the research done on institutional repository through a bibliometric analysis and concluded that most of the institutions involved in the creation of the institutional repository are representing from the USA. The developing countries not only fall behind in establishing institutional repositories but also lagging in publishing research on this aspect. Perry (2014) has provided a comprehensive sketch on the current state of digital preservation through a literature review and opined that a shared repository would be beneficial for the same type of institutions so far as cost-effectiveness is concerned. The literature growth on cultural heritage preservation in digital repositories from 2005 to 2015 is presented through a bibliometric analysis by Valetutti, (2015) which shows that 2013 has the highest number of publication where scholarly professors are publishing the highest number of articles other than archivist and librarians and the journals "Slavic & European Information Services" and "The Journal of the Society Archivist" have the maximum number of publication on cultural heritage preservation. Though all these studies dealt with different aspects of digital libraries and digital preservation, the characteristics of literature growth have not been attempted so far for which the present study has been carried out.

Research Questions:

Although there is abundant space to investigate a lot more prospects in the scholarly correspondences of digital preservation, this paper attempts to make some substantial inferences in the area. Thus, the objectives of the study have been aligned in the form of the following research questions:

RQ1. What is the trend in the distribution of digitally preserved research publications during the study period?

RQ2. What types of documents are prominent in the literature of digital preservation?

RQ3. Who are the prominent authors in digital preservation?

RQ4. What are the focus areas of the highly cited research papers in the field of digital preservation?

RQ5. What are the most preferred sources for the publication of scholarly communications on digital preservation?

RQ6. Which are the most productive countries in the digital preservation literature?

RQ7. Which institutions have significant contributions to Digital Preservation?

RQ8. How many authors meet the threshold value in the map of the co-authorship network, and which authors have the highest networking strengths?

Research Methodology:

All the scholarly communications published on digital preservation with regard to libraries during the period from 2001 to 2019 indexed in SCOPUS were extracted. Out of the total extracted data with a limitation to research articles only, a total of 710 articles were taken for the study purpose. Figure – 1 depicts the data filtration process adopted for this study. For bibliometric analysis, the foremost step is to identify the keywords, which can be used to select the research papers from the database. The keywords like "digital preservation" and "digital preservation in libraries" were given in the search field of the SCOPUS database. Initially, 1292 documents were obtained by using these search terms which were further refined by excluding the articles which do not match with the objectives. The refined result is led by 710 articles that are found to be befitting for the study purpose. Bibliographic data points like the titles of publications, type of literature, source of publication, names of authors, authors' affiliations with regard to country and institution were recorded and tabulated as per the research objectives of the study. Furthermore, the result is

analyzed on the basis of some of the bibliometrics indicators such as year-wise publication pattern, document types, most prolific authors, top-ranking sources of scholarly communications, and geographical distribution of contributing authors. The VOSviewer software is used for the study of network analysis of co-authors.
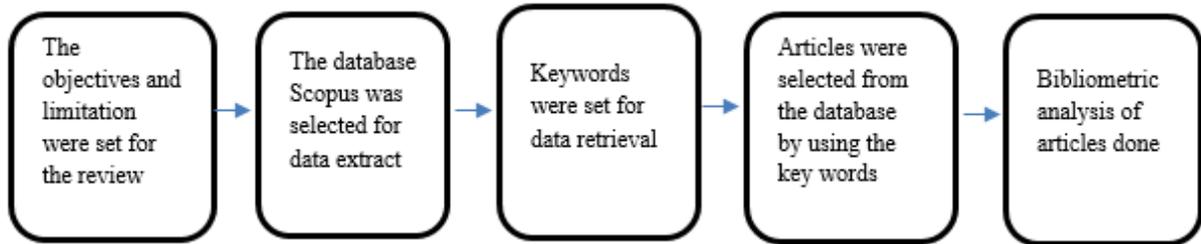

Figure 1. Data filtration process for the corpus

Observation and Findings:

RQ1. *What is the trend in the distribution of digitally preserved research publications during the study period?*
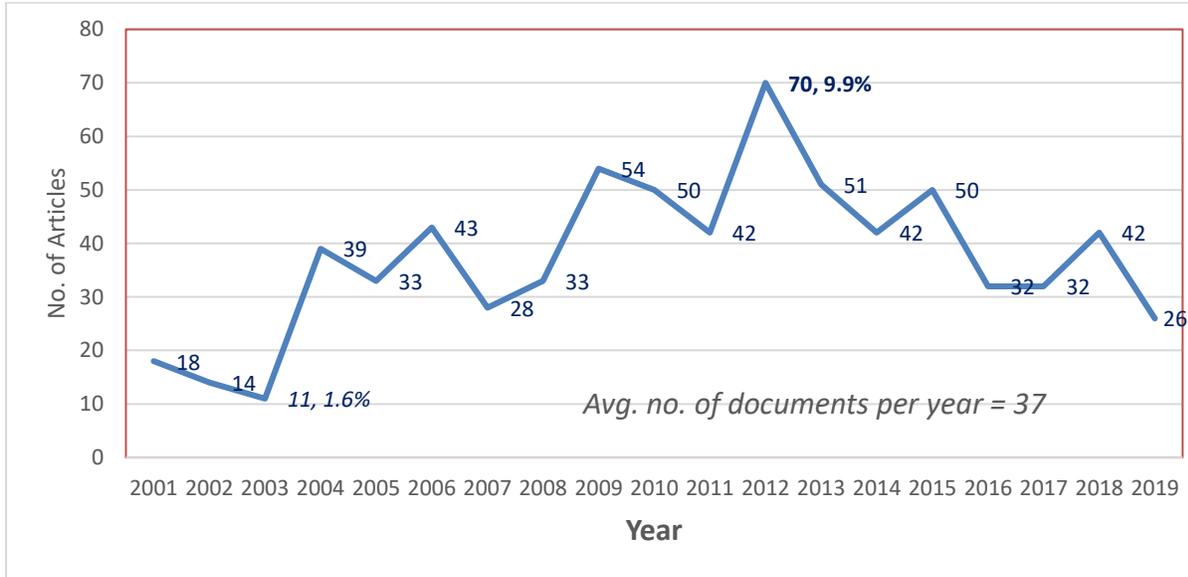

Figure 2. Year-wise distribution of scholarly communications on digital preservation

The first research question concerning the chronological distribution of digital preservation research publications distributed between 2001 and 2019 is represented in Figure 2. It reflects that the highest number of articles were published in the year 2012 i.e., 70 (9.9%), and the lowest

number of documents published in the year 2003 i.e., 11(1.6%). It is further observed that, during the study period, an average of 37 documents were published annually.

RQ2.   What types of documents are prominent in the literature of digital preservation?

Based on the forms of the published articles, figure III illustrates the classification of the types of publications on digital preservation and provides an answer to the second research question. Out of the total 710 numbers of publications, the highest is Research Papers (331) that accounts for 46.6% of the total contributions followed by papers in Conference Proceedings 288 (40.6%), Reviews 38 (5.35 %), and Book Chapters 25 (3.5%). The categories like Conference Review (17), Book (6), and Note (3) papers though appeared in the literature but the number is very less and contributing a total of 3.7 percentage only.
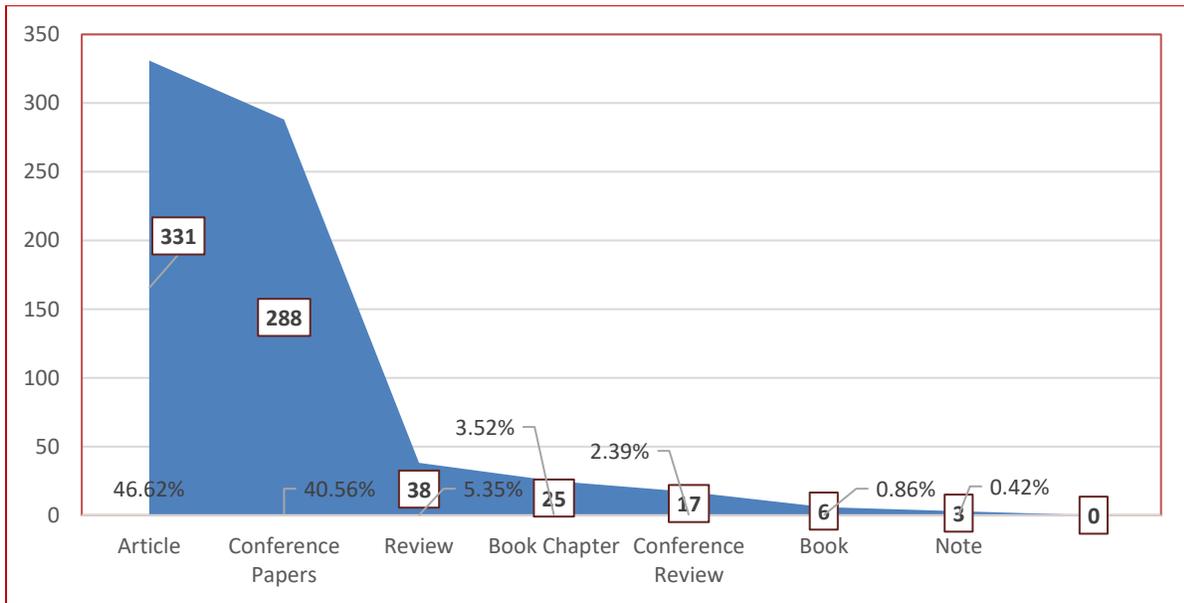
Figure 3. Documents types on digital preservation

RQ3.   Who are the prominent authors in digital preservation?

To respond to the third research question concerning the influential authors on *digital preservation,* the highly prolific authors along with their respective h-index is presented in Table – 1 It is observed that Nelson, M. L. from the USA tops the list among the prolific authors with a contribution of 20 publications. He is followed by Rauber, A. from Austria with 19 contributions and Becker, C from Canada with 16 contributions. H-index is specified h publications earned at

least h citations. In general, the greater the h, the greater is the author's diffusion and reputation within the scientific/ professional community. Of the most prolific authors, Rauber, A.who occupied the second position has the highest h-index 26 (Rank 2) followed by Weigle, M.C. h-20 (Rank 7), and Nelson, M.L. h-18 (Rank 1).

Table 1. Top 10 authors published their documents in Scopus on Digital Preservation

Sl. No.	Name of the Author	Documents Published	*h-*index	Institution Affiliated to
1	Nelson, M. L.	20	18	Old Dominion University, U.S.A.
2	Rauber, A.	19	26	Technische Universitat wien, Austria
3	Becker, C.	16	15	University of Toronto, Canada
4	Caplan, P.	11	7	Florida Centre for Library Automation, U.S.A.
5	Antunes, G.	08	8	Instituto de Engenharia de sistemas, Portugal
6	Strodl, S.	07	5	SBA Research, Austria
7	Weigle, M.C.	07	20	Old dominion university, U.S.A.
8	Borbinha, J.	06	13	Universidade de Lisboa, Partugal
9	Brunelle, J.	06	5	MITRE Corporation, U.S.A.
10	Duretec, K.	06	3	Technische Universitat wien, Austria

RQ4. *What are the main focus areas of the highly cited research papers in the field of digital preservation?*

Table 2 depicts the details of the top-cited papers along with the focus areas of research in the domain of digital preservation. '*The LOCKSS peer-to-peer digital preservation system*' by Maniatis, P. et al. with a total citation of 117 tops the list focusing on the theme 'model for digital preservation'. The second most cited paper is '*Digital preservation: a time bomb for digital libraries*' by Hedstrom, M. with a total citation of 96 dealt with digital preservation strategies. The third most cited paper is '*DataONE: Data observation network for earth preserving data and enabling innovation in the biological and environmental science'* by Michener et al. with a total citation of 50 analyses about the DataONE network which facilitates easy and secure storage of data and helps in data discovery.

Table 2. Most cited papers and themes of research on digital preservation

Sl. No.	Author	Title	Year of Pub	Theme/ Focus area of study	Source	TC*
1	Maniatis, P., Roussopoulos, M., Giuli, T.J., Rosenthal, D.S.H. & Baker M.	The LOCKSS Peer-to-peer digital preservation system	2005	A model for digital preservation	ACM Transactions on Computer Systems	117
2	Hedstrom, M	Digital preservation: a time bomb for digital libraries.	1998	Strategies for Digital preservation	Computers and the Humanities	96
3	Michener, W., Vieglais, D., Vision, T., Kunze,J., Cruse, P., & Janee, G.	Data ONE: Data observation network for earth-preserving data and enabling innovation in the biological and environmental sciences	2011	Federated data network	D Lib Magazine	50
4	Conway, P.	Preservation in the age of google: digitization, digital preservation and dilemmas	2010	Challenges for digital preservation	Library Quarterly	48
5	Ainsworth, S.G., Alsum,A.,SalahEldeen, H, Weigle, M.C., Nelson, M.L.	How much of the web is archived?	2011	Web archiving and digital preservation	Proceedings of the ACM/IEEE joint conference on digital libraries	44
6	Strodl, S., Becker, C., Neumayer, R., Rauber, A.	How to choose a digital preservation strategy: Evaluating a preservation planning procedure	2007	PLANETS preservation planning approach& OAIS Model	Proceedings of the ACM international conference on Digital Libraries	39
7	Hockx-Yu, H.	Digital preservation in the context of institutional repositories	2006	Issues and challenges on digital preservation with JISC's view on digital repositories	PROGRAM	34
8	Waugh, Adrew., Wilkinson, R.., Hills, Brendan, Delloro, J	Preserving digital information forever	2000	Preservation approach adopted in Victorian Electronic Record Strategy	Proceedings of the ACM international conference on Digital Libraries	33
9	Chowdhury, G.	From digital libraries to digital preservation research: the importance of users and context	2010	current research in digital preservation that aims to handle the users and context information for future digital preservation System	Journal of Documentation	32
10	Li, Y.,& Banach, M.	Institutional repositories and digital preservation: Accessing current practices at research libraries	2011	Digital preservation of Institutional Repository(IR) materials among ARL member institutions	D-Lib Magazine	28
* TC -Total Citation (521)					Average Citatuion = 52.1	

Then the fourth most cited paper is '*Preservation in the age of google: digitization, digital preservation, and dilemmas*' by Conway, P. with a citation of 48 dealt with impacts, challenges, and threats for digital preservation. This is followed by the paper, '*How much of the web is archived*' (Ainsworth, *et al.,* 2011) with a total citation of 44 presents the result from a specific survey on web archival. The sixth most cited paper is '*How to choose a digital preservation strategy: evaluating a preservation planning procedure*' (Strodl, *et al.,* 2007) with 39 citations analyses about the PLANETS's preservation planning strategy, including ways and decisions to preserve digital artifacts. This is followed by the paper entitled '*Digital Preservation in the context of Institutional repositories*' (Hockx, Yu, 2006) with a citation of 34 dealt with data preservation problems and concerns with JISC 's view of digital repositories. The eighth highest cited paper is 'Preserving digital records forever' (Waugh, A. *et al.,* 2000), with a total of 33 citations describes about the Victorian Digital Record Strategy introduced in Australia. The ninth highest cited paper is 'From digital libraries to digital preservation research: the importance of users and context' (Chowdhury, 2010) with a total citation of 32 analyzed the challenges of digital capturing, storing, and retrieving user group information. It points out some current research in digital preservation that aims to handle the users and context information for building future digital preservation systems The tenth highly cited paper is on 'Institutional repositories and Digital preservation: Accessing current practices at research libraries' (Li, Y., 2011), examined existing practices of digital preservation and reported the current status of digital preservation.

RQ5. *What are the most preferred sources for the publication of scholarly communications on digital preservation?*

Table 3 represents the top sources in which the scholarly communications on digital preservation were published during the study period and gives a response to research question five. 'Lecture Notes in Computer Science' tops the rank by publishing as much as 60 research papers followed by 'Proceedings of the ACM IEEE joint conference on digital library' by producing 54 number of publications. The third core journal is "Library HiTech" which has published 23 articles. These three sources have produced more than half of the literature published by the top ten sources. Similarly in the context of the total number of literature, these top ten ranked sources have produced around 36 percent of total literature on digital preservation.

Table 3. Top sources producing scholarly communications on digital preservation

Sl. No.	Source of Research Papers (RPs)	No.of RPs
1	Lecture Notes in Computer Science	60
2	Proceedings of the ACM IEEE joint conference on digital library	54
3	Library HiTech	23
4	Proceedings of ACM international conference on digital libraries	20
5	DLib Magazine	20
6	ACM International Conference Proceedings Series	17
7	Serials Librarian	16
8	Library Quarterly	14
9	Library Trends	14
10	CEUR Workshop proceedings	13

RQ6. *Which are the most productive countries in the digital preservation literature?*
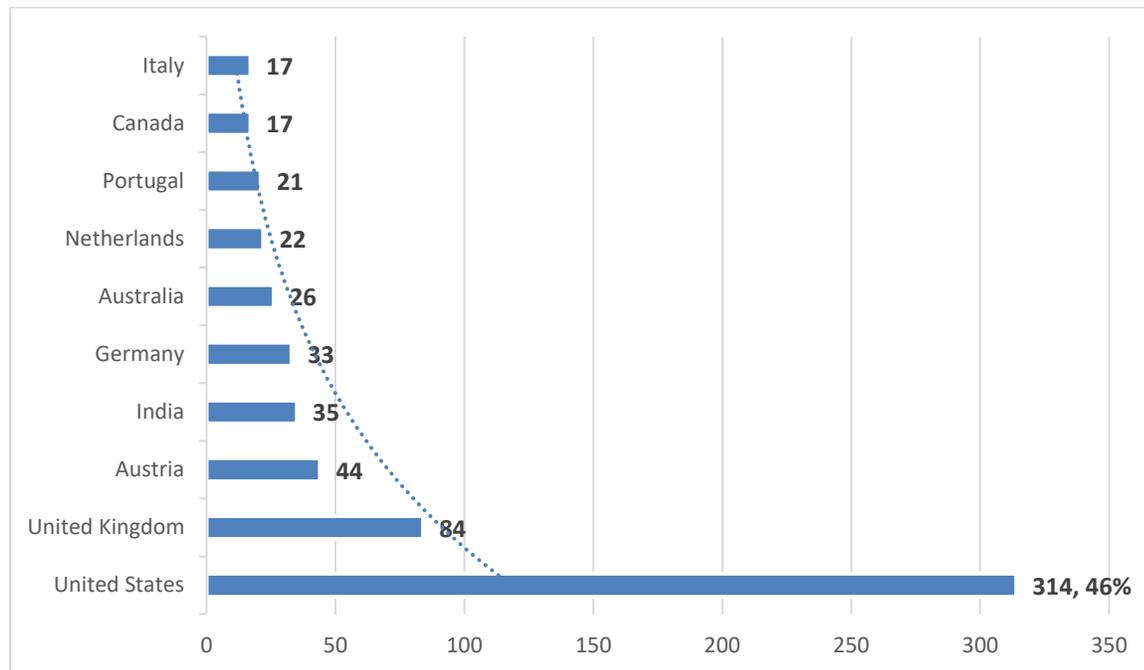

Figure 4. Country-wise contributions of authors

Figure 4 represents the most productive countries in the digital preservation literature pertaining to the research question 6. The result shows that from a total of 710 research contributions, the United States of America tops the list by producing as much as 314 documents (44 percent). The second and third ranks are occupied by the United Kingdom and Austria with 84 (12%) and 44

(6%) respectively followed by India in the fourth position by producing 35 documents (5%). The exponential trendline in figure IV indicates that there is a substantial fall in the literature on digital preservation from the top-ranking country namely the USA. This indicates that the literature producing pattern of the rest of the world (other than the USA) on digital preservation needs to be improved with a higher magnitude of international collaboration.

RQ7. *Which institutions are most prominent at Digital Preservation?*

Table 4. Most productive institutions on digital preservation

Sl. No.	Name of the Institutions	Country	Documents
1	Technische Universal Wien	Austria	27
2	Library of Congress	United States	20
3	University of Illinois at Urbana Champaign	United States	18
4	Old Dominion University	United States	18
5	Stanford University	United States	15
6	The British Library	United Kingdom	14
7	The University of North Carolina at Chapel	United States	11
8	Instituto de Engenharia de sistemas e co	Portugal	10
9	University of Toronto	Canada	10
10	University of Michigan, Ann Arbor	United States	10

For the allocation of resources, institutional research ranking is of interest to the national and international granting agencies and the administration as well. High productivity rates can also improve the prestige, reputation, and ability of an institution to attract and retain desirable students and faculties. The rank list of the institutions was derived by applying the straight count method and the top ten most productive institutions is provided in Table 4 concerning research question 6 of the study. Out of a total of 327 institutions, Technische Universal Wien also known as Vienna University of Technology, Austria occupies the 1st rank with 27 affiliations followed by the Library of Congress (USA), the University of Illinois at Urbana Champaign (USA) at ravk 2nd and 3rd respectively. Out of a total of 327 affiliated institutions, 122 (37.3%) having only one contributor each, 97 (29.6%) institutions each have only two contributors, and 64 (19.8%) institutions each have only three contributors. All the top-ranked institutions are universities and research

organizations which indicates that most of the authors of digital preservation are faculties associated with Universities and other research institutes.

RQ8. *How many authors meet the threshold value in the map of the co-authorship network, and which authors have the highest networking strengths?*

The last research question raises two sub-questions. As regards the co-authorship network, the Vosviewer software is used to map it and it is presented in figure 5. It is found that out of a total of 1187 authors, only 22 authors meet the threshold value, and even those 22 points inside the network are not linked to each other. The largest set of joined items is made up of 13 items with 3 clusters. Cluster 1 is the largest one with 5 authors, and 4 authors are aligned with Cluster 2 and 3 each. There are some fairly big circles in the figure, and others are smaller. The relatively little big circles reflect the authors who have co-authored more than the others.
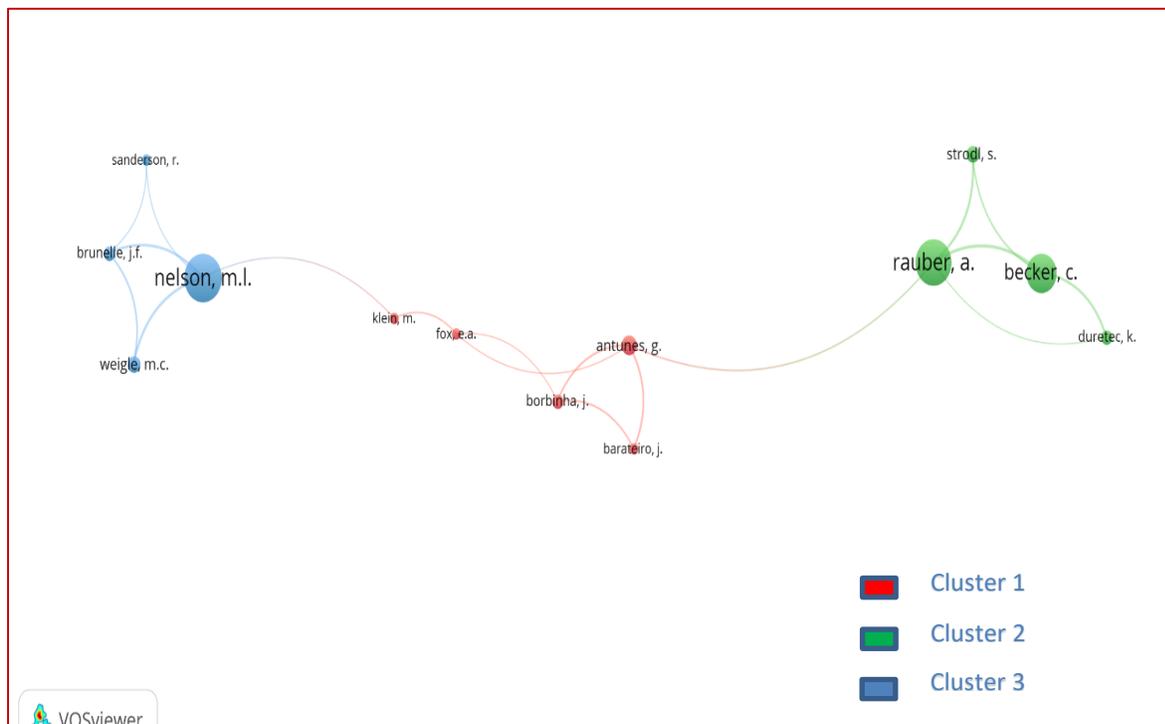

Figure 5. Co-authorship Network map on digital preservation using Vosviewer software

The total link strength of a node, which is the sum of link strengths of this node over all the other nodes, functions as a standard for weighing an attribute. Therefore, the authors with the high total link strengths were taken to have leading roles, and they, therefore, formed the network hub of

digital preservation research. The second part of RQ8 deals with the total link strengths (TLS), and Table 5 shows the top ten authors with the TLS across the 710 papers. Rauber, A. had the strongest total link strength (TLS: 19), followed by Becker, C. (TLS: 18) and Nelson, M. L. (TLS: 15).

Table 5. Link strengths of the authors

Sl. No.	Authors	Documents	Total Link Strength (TLS)
1	Rauber, A.	19	19
2	Becker, C.	16	18
3	Nelson, M. L.	20	15
4	Antunes, G.	8	12
5	Brunelle, J. F.	6	11
6	Weigle, M. C.	7	10
7	Strodl, S.	7	8
8	Barateiro, J.	5	8
9	Borbinha, J.	6	7
10	Duretec, K.	6	4

Conclusion and Key Findings:

The results of the current study show that a good number of researches have been carried out on digital preservation in the last nineteen years. A fine pattern of progress is observed in this field of research. Based on the objectives of the study it is found that maximum researches have been done in 2012. The topmost cited paper is 'The LOCKSS Peer-to-peer digital preservation system'. The other well-represented research areas based on the number of citations are digital preservation strategies and challenges, federated data network, web archival analysis, PLANETS preservation planning approach, JISC's view on digital repositories, Victorian electronic record strategy, digital preservation of institutional repositories, etc. The most prolific author is Nelson, M. L. from the USA who has produced the highest number of documents while the Technische Universal Wien, Austria tops the list among the most productive institutions. The co-authorship network shows that only 1.9% of authors met the threshold value forming three loosely connected clusters only. Similarly, the total link strengths (TLS) of prolific authors are not much impressive as those who should have taken the leading roles, for forming the network hub in digital preservation research. This indicates that there is a need for more collaboration in the literature of digital preservation. The study provides various insights for researchers, academicians, and practitioners in digital preservation as it portrays the research trends and patterns in this domain. It provides a set of

research areas which will be helpful for the new researchers to acquaint themselves with the type of contributions, data sets utilized, approaches made, and research methods applied in this study. The results will help practitioners, repository administrators, and data analysts to know the highest quality work in specific areas of digital preservation and to utilize the techniques, tools reported in those studies. The researchers and organizations will be encouraged to extend the intellectual growth in the area of digital preservation towards a mature domain in the Library and Information Science.

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