BIBLIOMETRIC ANALYSIS OF FIRE RISK MANAGEMENT

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Abstract

Fire risk is a very common risk, especially in dry and warm regions of the world. Thus, India has a climate that supports a higher risk of fire accidents. Hence the increasing role of AI in fire risk management has become very important. This shows the major work done in the field of fire risk management in the entire research literature. In this article, we have prepared a bibliometric analysis to provide a statistical overview of previously published research papers on fire risk management. The study selected 1,594 research documents from the Scopus database published during the last 15 years. These documents are related to the subject area of environmental science; engineering; agricultural and biological science; earth and planetary sciences; business, management, and accounting; social sciences; economics, econometrics, and finance; and multi-disciplinary areas. The selected documents are analyzed using the bibliometric methods of literature review. It is performed using software like Vos-Viewer and the biblioshiny package of R Studios. The result of the study helps in understanding the most important contributors to the research field and understanding the directions they have given to the entire research arena.

Keywords: Fire Risk and Bibliometric Analysis

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1. Introduction

Fire risk is faced by almost every country in every corner of the world. This risk rises with changes in climatic conditions. For example, places with warmer and dry climates have a higher risk of fires as compared to cold and wet places. Fires are not a new phenomenon. They play a major role in world history as there are multiple devastating fire examples such as the 1666 great fire of London, and the 1871 fire of Chicago which had catastrophic consequences for both the economy and heritage (Ferreira et al., 2016).

Fires in urban areas have entirely different reasons and consequences. A few of the major reasons behind such fires are mentioned in various different studies by many fire researchers. As (Yoshioka et al., 2020) in its study mentioned that densely build urban areas can play a major role in large urban fires. While (Manzello, 2019) in one study stated that other natural calamities like a major earthquake, extremely windy conditions, or tsunami attacks can also result in urban fires. These urban fires can be reduced or avoided if enough separation is maintained between houses after land readjustment, and houses are replaced with ones compatible with the latest building regulations, etc.(Yoshioka et al., 2020).

While on the other hand, forest fires have a whole different concept as compared to urban fires. The most important for a forest fire is climate change (Clark2, 1990, Moriondo et al. 2006) also suggests that climate change has a very considerable impact on the forest fires. While (Földi & Kuti, 2016) pointed out dryness due to draught to be the major reason behind forest fires.

Forest fire prediction constitutes a significant component of forest fire management. It plays a major role in resource allocation, mitigation, and recovery efforts(Sakr et al., 2010).Systems for forest fire danger prediction represent an essential tool to predict forest fire risks, back up the forest fire monitoring and extinction phase, and assist in the fire control planning and resource allocation (Alonso-Betanzos et al., 2003).

Due to the extensive research conducted in this field, there is a need to synthesize the research conducted in the field and identify current themes and focused subject areas. To address this need, a bibliometric analysis was used. It examines the overall number of papers, attempts to highlight the basic developments of the topic, and suggests potential research directions in this still-emerging area of knowledge (Moral-Muñoz et al., 2020).

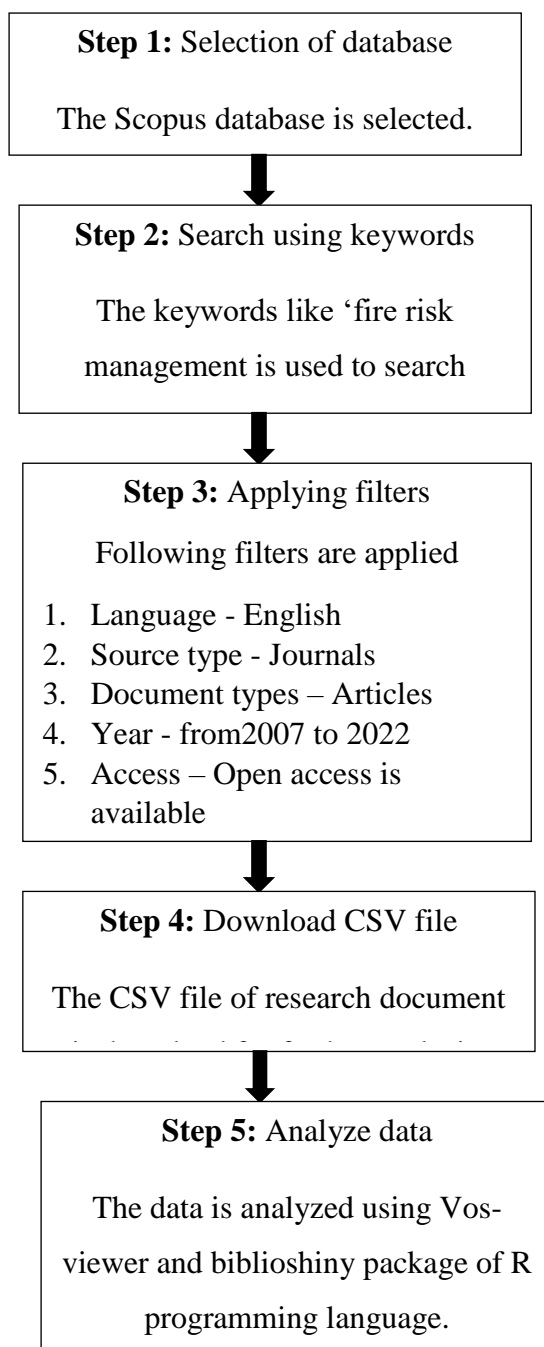In this study, the following research questions (RQs) are addressed:
- **RQ 1:** Who are the most relevant and influential researchers in this field?
- **RQ 2**: Which countries substantially contribute to scientific research?
- **RQ 3:** Which keywords are most frequently used in the entire research literature?
- **RQ 4:** What are the most impactful sources, documents, and authors?
- **RQ 5:** What is the co-authorship, co-citation, and co-occurrence trends in the entire research area?

The remainder of this article was separated into parts. The second part discusses the methodology applied to reach the findings. Then, in part 3, we disclose and evaluate the results. In part 4, we discussed the conclusion, implications, and limitations of the research.

2. Research methodology

Bibliometrics are mostly used for scientific research across an entire range of disciplines (Egghe, 2006,Hirsch, 2005,Tounekti et al., 2022). Through bibliometric analysis, we can identify the most influential articles based on the reputation of the journal and its ranking (Naatu & Alon, 2019). As per the latest trends, we also used vos-viewer and the Biblioshiny package of the R programming language software to conduct the bibliometric analysis (Secinaro et al., 2020,Xie et al., 2020).

The figure below shows the process used for the bibliometric analysis. This is as per the methodology suggested by (Dahiya et al., n.d.).

Step 1: Selection of database

The Scopus database is selected.

Step 2: Search using keywords

The keywords like 'fire risk

management is used to search

Step 3: Applying filters

Following filters are applied

1. Language - English
2. Source type - Journals
3. Document types – Articles
4. Year - from2007 to 2022
5. Access – Open access is
   available

Step 4: Download CSV file

The CSV file of research document

Step 5: Analyze data

The data is analyzed using Vos-

viewer and biblioshiny package of R

programming language.

After the analysis, the results are presented and discussed. At the end the conclusion of the study is presented followed by the limitations it holds.

3. Results and outcomes

The bibliometric analysis has two broad analyses i.e., Performance analysis and science mapping (Gutiérrez-Salcedo et al., 2018). Thus, accordingly this section is divided into two broad sections.

1) Performance analysis

Performance analysis is a bibliometric analysis technique that describes the performance of a research domain(Donthu et al., 2021,Kumar et al., 2022). This section shows the annual scientific production, most relevant authors and sources, most productive countries, Most impactful author, sources and documents, and most frequent keywords.

➢ Annual scientific production

The annual production refers to the number of documents produced in each year over a period of time.
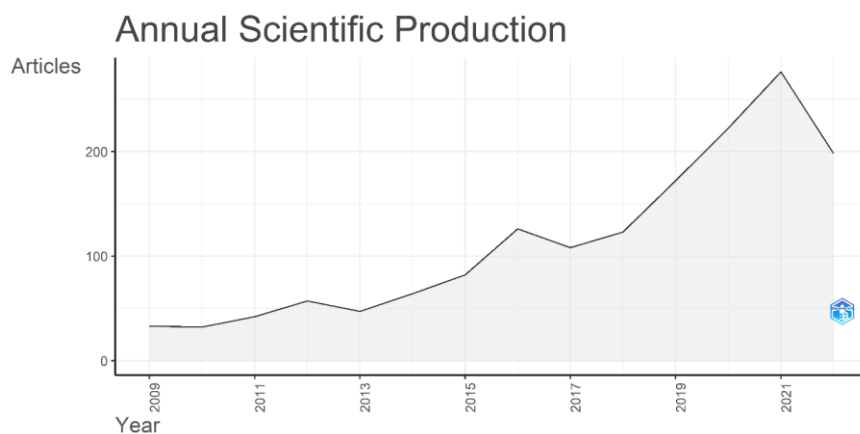
Graph 1: Annual scientific production

The graph shows that there is a continuous increase in the production of scientific documents. Only 2013 and 2017 saw a relative decrease from the last year. The Annual growth rate comes out to be 14.78%.

➤ Most relevant authors

The relevance of authors are judged by the number of documents published by them. The higher the number of documents published by them; more is the relevance they have in the entire research domain.
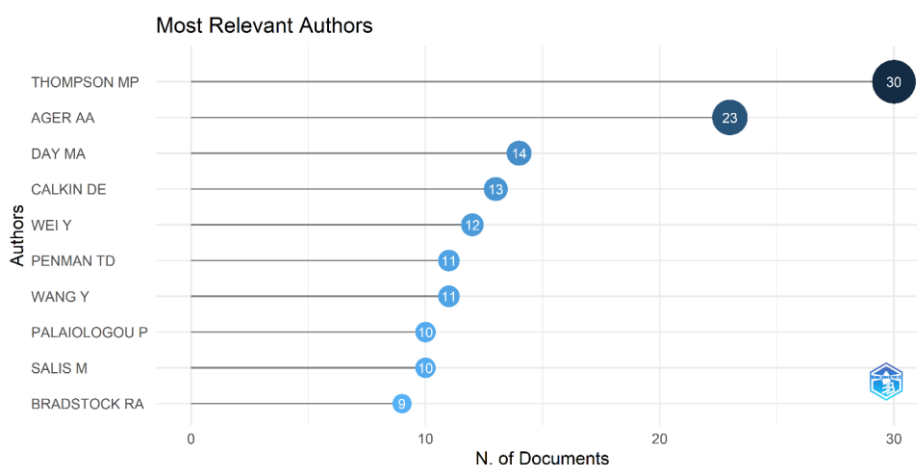
Graph 2: Most relevant authors with the number of documents published by them.

The graph shows that Thompson MP is the most relevant author with 30 document publications. It is followed by Ager AA with 23 publications and Day MA with 14 publications.

➤ Most productive countries

The productiveness of the country here is studied using the number of documents produced by the countries. Higher productivity is sown by the higher number of documents produced in a country.

Countries	Number of documents
United states	574
Australia	203
United Kingdom	164
Spain	137
China	112
Canada	104
Italy	97
Portugal	74
Germany	60
Netherlands	56

**Table 1: Top 10 most productive countries**

The table shows that the United Statesare the most productive country with 574 publications. It is followed by Australia with 203 publications, the United Kingdom with 164 publications, and Spain with 137 publications. Except for China, all countries in the top 10 are from developed parts of the world. This shows that research is more concentrated in that part of the world. While India stands at 19th position with 25 document publications.

➢ Most impactful documents

The impact of the document is assessed by the number of citations received by that document. The higher number of citations shows the higher influence of the documents on the work of other authors in the research area.
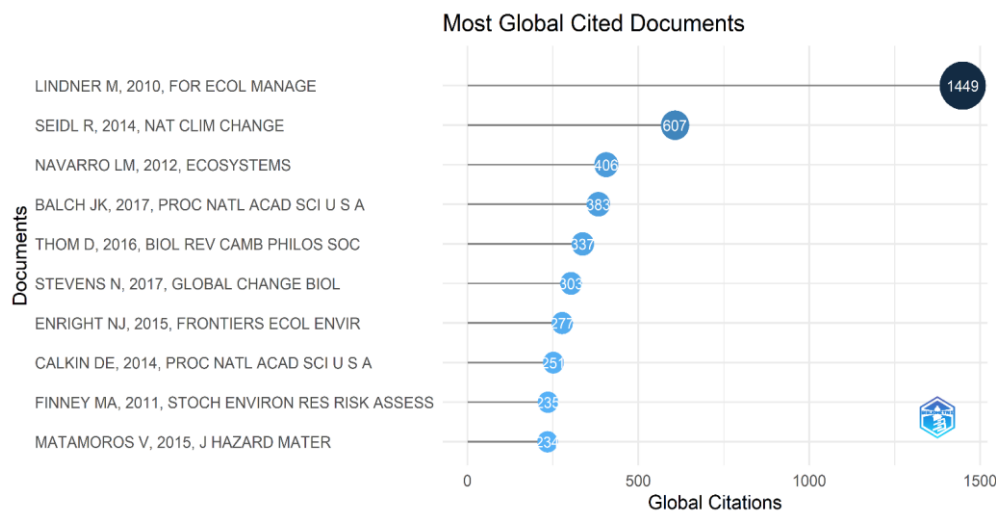
Graph 4: Top 10 most cited documents globally

The graph shows that the document titled 'Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems' authored by(Lindner et al., 2010) is the most impactful document by receiving 1,449 citations globally. It is followed by a document titled'Increasing Forest disturbances in Europe and their impact on carbon storage'by (Seidl et al., 2014) with 607 citations.

➢ Most impactful author

The impact or influence of an author is majorly assessed by the number of citations received by the author. The authors with a high number of citations have a high impact on the research area.

Authors	Number of Citations
Seidl r.	2436
Netherer s.	1672
Garcia-gonzalo j.	1580
Lindner m.	1480
Corona p.	1458
Barbati a.	1456
Marchetti m.	1454
Delzon s.	1449
Kolström m.	1449
Kremer a.	1449
Lexer m.j.	1449
Maroschek m.	1449

Table: Top 12 most influential authors.

The graph shows that Seidl R. has the highest number of citations i.e, 2,436. It is followed by Netherer S. with 1,672 citations and Garcia-gonzalo j. with 1,580 citations. It can be noted that all top 10 authors have more than 1,000 citations.

➢ Most impactful source

The impact of the source is assessed by the number of citations received by the sources.

| Sources	Citations
Forestecologyandmanagement	2056
Plosone	1050
Internationaljournalofwildlandfire	1037
Forests	840
Ecologicalapplications	490
Environmental researchletters	464
Fire	462
Journalofappliedecology	380
Ecosphere	370
Ecologyandsociety	346

Table: Top 10 most impactful sources

The table shows that Forest ecology and management is the most influential source with 2,056 citations. It is followed by Plosone with 1,050 citations and the international journal of wild land fire with 1,037 citations.

➢ Most relevant keywords
The relevancy of the keywords depends on the frequency with which they appear in the research literature. Words with higher occurrence are said to be the more relevant keywords.
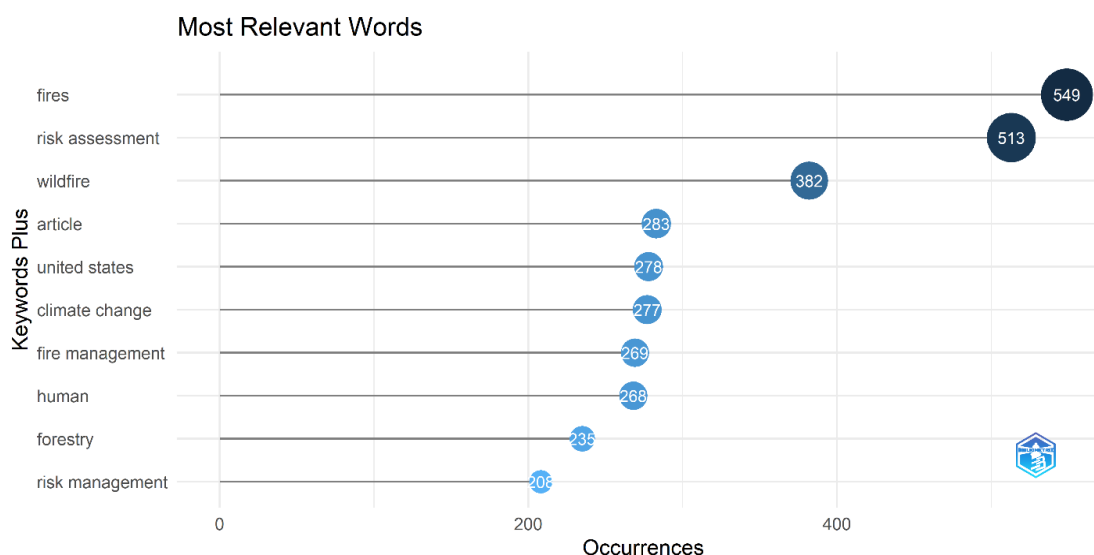
Graph 5: Top 10 most relevant keywords

The graph shows that fire is the most frequent keyword with 549 occurrences. It is followed by risk assessment with 513 occurrences and wildfire having 382 occurrences.

2) Science Mapping
Science mapping refers to the study of the literature by providing a graphical representation of the relationship between the research units in a particular research domain(Donthu et al., 2021,Kumar et al., 2022) This section contains analysis of Co-authorship of authors, Co-occurrence of keywords, and co-citations od authors.

➢ Co-authorship of authors
Co-authorship analysis shows the relationship between two authors. It analyze the connections in terms of authoring the paper together by two or more authors.

There are total of 6,126 authors who have jointly or separately authored research documents. This is a very huge data to draw meaningful results from. Therefore, to reduce the data, a threshold of 6 documents has been set. This reduces the data from 6,126 to 36. Not all 36 authors have links. The largest set of authors having links is of 14.
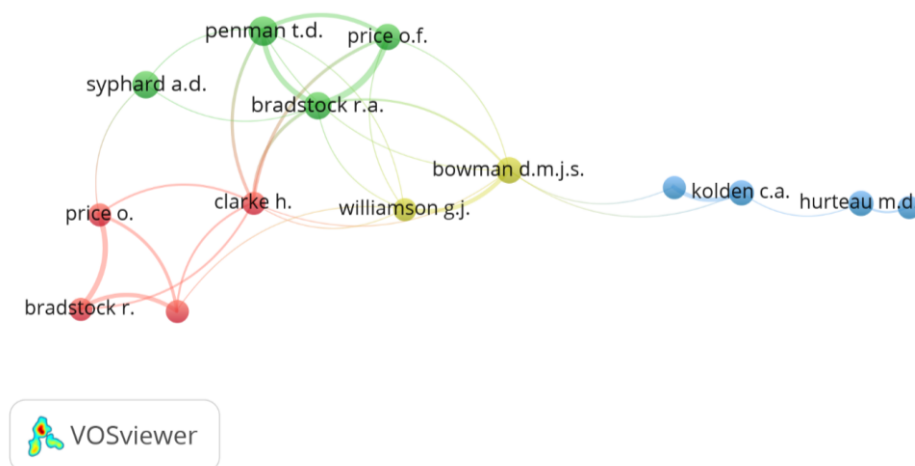
Network diagram 1: Co-authorship of Authors

The network diagram shows that Bradstock r.a. and Price o.f. are the most co-authored authors with the link strength of 6. It is followed by Bradstock r.a. and Syphard a.d. with link strength of 5 and Abatzoglou j.t. and Kolden c.a. with link strength of 4.

➤ Co-occurrence of Keywords
The co-occurrence analysis with "keyword" as a unit study the relation between the keywords.

Here the occurrence of two keywords togethers is analyzed.

There are total of 12,086 keywords. It is very huge data to analyzed using network diagram. To draw a meaningful result, the data is reduced by setting a threshold of 100 occurrences. The data is reduced to 16 keywords.
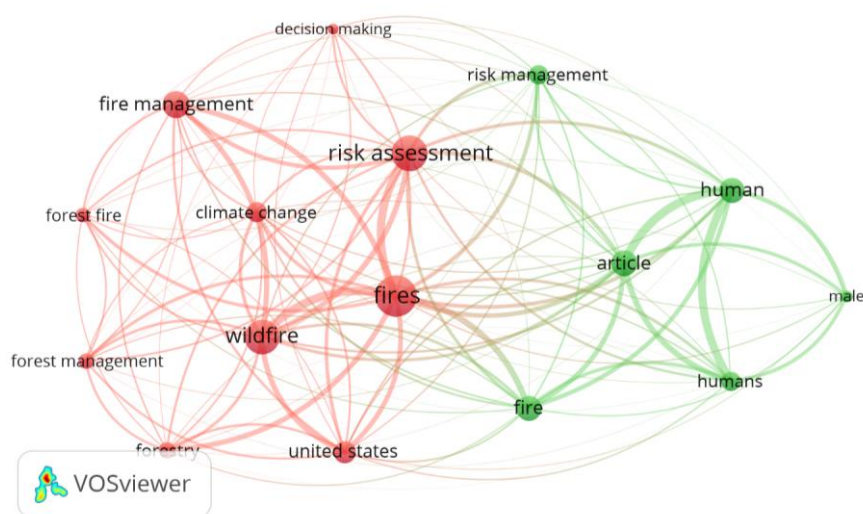


Network Diagram 2: Co-occurrence of keywords

The diagram shows the co-occurrence between keywords in the form of lines, thickness of which shows the links between them. Article and human is the most co-occurringwords with link strength of 202. They are followed by fires and wildfire with link strength of 196 and fire and risk assessment with the link strength of 191.

➤ Co-citation of author
The citations are the references given to the authors when their work is used in another

author's research. The co-citations show the citation received by two authors together in the work of third author.

There are total of 99,750 authors. This huge data is very difficult to analyzed using network diagram. To get meaningful results, data is reduced by setting threshold of 250 citations. This reduces the data from 99,750 to 24 authors.
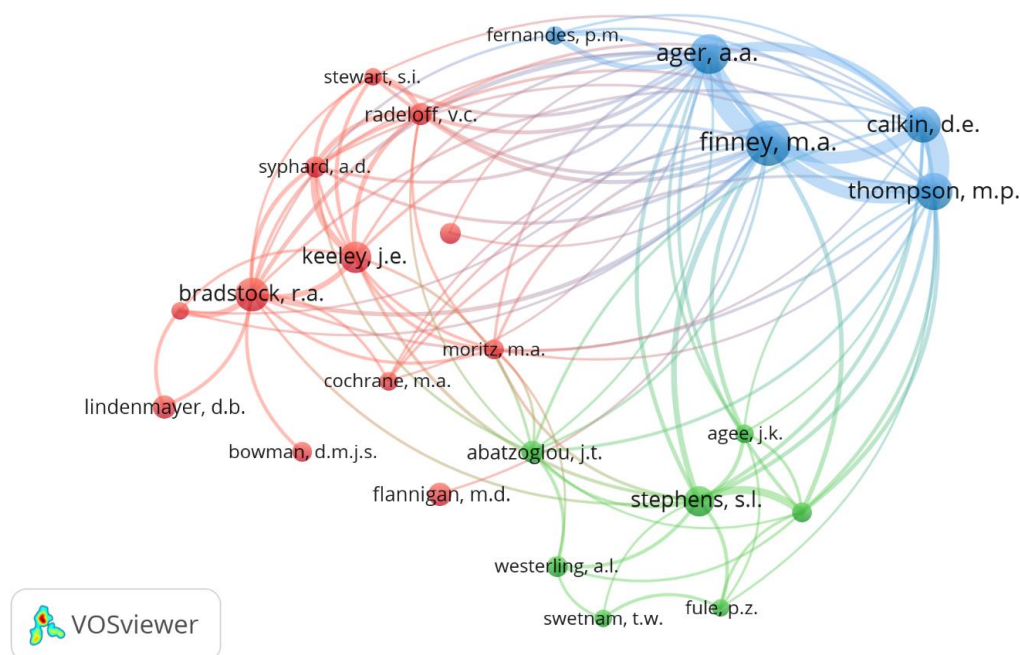
Network Diagram 3: Co-citation of authors

The co-citation is shows by the links between the nods (which represents the authors). The width of link shows the link strength which represents strength of co-citations between the authors. The authors with highest co-citation are Thompson m.p. and Calkin d.e. as they have the link strength of 5,841. They are followed by ager a.a and Finny m.a. with link strength of 4,839.

4. Conclusion

The study aims to perform the bibliometric analysis of the literature available in the subject area of fire risk management. The data is extracted from the Scopus database and finally, 1,594 documents have been selected for analysis. As the volume of data is huge, for literature review, bibliometric analysis is used.

The performance analysis shows that annual production is continuously rising. The most relevant author comes out to be Thompson m.p. while Seidl r. is the most impactful author in terms of total citations. Therefore, Thompson m.p .and Seidl r becomes the most productive author in the entire research area. United States is the most productive country as it published the highest number of documents and is followed by Australia.

The most relevant keywords are fire and risk assessment in terms number of occurrences while article and humans are the most co-occurring words together. This shows that currently these keywords are more used in the research domain.

5. References

1. Alonso-Betanzos, A., Fontenla-Romero, O., Guijarro-Berdiñas, B., Hernández-Pereira, E., Paz Andrade, M. I., Jiménez, E., Soto, J. L. L., & Carballas, T. (2003). An intelligent system for forest fire risk prediction and fire fighting management in Galicia. Expert Systems with Applications, 25(4), 545–554. https://doi.org/10.1016/S0957-4174(03)00095-2

2. Dahiya, A., Kumar, A., Duggal, S., Kumar, P., & Dhoundiyal, H. (n.d.). Analysing Research Trends in the Indian Hospitality and Tourism Sector: A Bibliometric Analysis for the Period 2000-21. Atna-Journal of Tourism Studies, 2022(2), 0–00. https://doi.org/10.12727/ajts.28.0

3. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

4. Egghe, L. (2006). Theory and practise of the g-index. In Dordrecht Scientometrics (Vol. 69, Issue 1). Springer.

5. Ferreira, T. M., Vicente, R., Raimundo Mendes da Silva, J. A., Varum, H., Costa, A., & Maio, R. (2016). Urban fire risk: Evaluation and emergency planning. Journal of Cultural Heritage, 20, 739–745. https://doi.org/10.1016/j.culher.2016.01.011

6. Földi, L., & Kuti, R. (2016). Characteristics of Forest Fires and their Impact on the

Environment. Academic and Applied Research in Military and Public Management Science, 15(1), 5–17. https://doi.org/10.32565/aarms.2016.1.1

7. Gutiérrez-Salcedo, M., Martínez, M. Á., Moral-Munoz, J. A., Herrera-Viedma, E., & Cobo, M. J. (2018). Some bibliometric procedures for analyzing and evaluating research fields. Applied Intelligence, 48(5), 1275–1287. https://doi.org/10.1007/s10489-017-1105-y

8. Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. www.pnas.orgcgidoi10.1073pnas.05076551 02

9. Kumar, S., Sharma, D., Rao, S., Lim, W. M., & Mangla, S. K. (2022). Past, present, and future of sustainable finance: insights from big data analytics through machine learning of scholarly research. Annals of Operations Research. https://doi.org/10.1007/s10479-021-04410-8

10. Lindner, M., Maroschek, M., Netherer, S., Kremer, A., Barbati, A., Garcia-Gonzalo, J., Seidl, R., Delzon, S., Corona, P., Kolström, M., Lexer, M. J., & Marchetti, M. (2010). Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. Forest Ecology and Management, 259(4), 698–709. https://doi.org/10.1016/j.foreco.2009.09.023

11. Manzello, S. L. (2019). Summary of workshop on global overview of large outdoor fire standards. https://doi.org/10.6028/NIST.SP.1235

12. Moral-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., & Cobo, M. J. (2020). Software tools for conducting bibliometric analysis in science: An up-to-date review. In Profesional de la Informacion (Vol. 29, Issue 1). El Profesional de la Informacion. https://doi.org/10.3145/epi.2020.ene.03

13. Naatu, F., & Alon, I. (2019). Social franchising: A bibliometric and theoretical review. Journal of Promotion Management, 25(5), 738–764. https://doi.org/10.1080/10496491.2019.1584 777

14. Sakr, G. E., Elhajj, I. H., Mitri, G., & Wejinya, U. C. (2010). Artificial intelligence for forest fire prediction. IEEE/ASME International Conference on Advanced Intelligent Mechatronics, AIM, 1311–1316. https://doi.org/10.1109/AIM.2010.5695809

15. Secinaro, S., Brescia, V., Calandra, D., & Biancone, P. (2020). Employing bibliometric analysis to identify suitable business models for electric cars. In Journal of Cleaner Production (Vol. 264). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2020.12150 3

16. Seidl, R., Schelhaas, M. J., Rammer, W., & Verkerk, P. J. (2014). Increasing forest disturbances in Europe and their impact on carbon storage. Nature Climate Change, 4(9), 806–810. https://doi.org/10.1038/nclimate2318

17. Tounekti, O., Ruiz-Martínez, A., & Skarmeta Gomez, A. F. (2022). Research in Electronic and Mobile Payment Systems: A Bibliometric Analysis. Sustainability (Switzerland), 14(13). https://doi.org/10.3390/su14137661

18. Xie, H., Zhang, Y., Wu, Z., & Lv, T. (2020). A bibliometric analysis on land degradation: Current status, development, and future directions. In Land (Vol. 9, Issue 1). MDPI AG. https://doi.org/10.3390/LAND9010028

19. Yoshioka, H., Himoto, K., & Kagiya, K. (2020). Large Urban Fires in Japan: History and Management. Fire Technology, 56(5), 1885–1901. https://doi.org/10.1007/s10694-020-00960-8