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Mapping Two Decades of Human-Elephant Conflict Research in Sri Lanka (1999–2023): A Scopus-Based Bibliometric Analysis

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ABSTRACT

Human-elephant conflict (HEC) remains a pressing concern in Sri Lanka, where human settlements and agricultural activities increasingly encroach upon the natural habitats of elephants. This bibliometric analysis aims to explore the existing research on HEC in Sri Lanka, identify major thematic areas in the literature, and analyze the trends and patterns in scholarly publications. A thorough literature retrieval was performed through Scopus database, resulting in a dataset of research articles, review papers, conference proceedings, book chapters, conference review, letter, and review. Visual mapping and bibliometric tools were applied to analyze articles on HEC published between 1999 and 2023 in the Scopus database. An assessment was carried out on 52 articles. Various bibliometric indicators were utilized to examine the trends in scholarly output, author contributions, institutional collaborations, and recurring research topics. The results reveal the heightened academic engagement with HEC research in Sri Lanka over the years, with a focus on topics such as elephant behavior, agricultural practices, mitigation strategies, and policy interventions. The analysis also highlights the collaboration networks among researchers and institutions involved in HEC research in Sri Lanka. Overall, this bibliometric analysis offers an in-depth overview of existing HEC research in Sri Lanka, highlights areas where further investigation is needed, and proposes directions for future research and policy actions aimed at mitigating HEC.

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1. Introduction

HECs in Sri Lanka are a pressing issue characterized by frequent and often destructive interactions between humans and elephants (Köpke et al., 2021; Prakash et al., 2020). Sri Lanka hosts around 10% of the Asian elephant population found in the natural habitat, accounting for nearly 2% of their global distribution (Fernando et al., 2011; Gunawansa et al., 2023a). As of the 2017 estimate, Sri Lanka is home to approximately 5,787 elephants, including 1,107 calves and 122 tuskers (Gunawansa et al., 2023a). Number of reported HEC incident are still increasing in Sri Lanka (Perera et al., 2022). Among countries worldwide, Sri Lanka records the highest number of elephant deaths each year and ranks second in terms of human fatalities resulting from HEC (Gunawansa et al., 2023a). In both elephants and humans, males experienced a higher mortality rate (Prakash et al., 2020). These conflicts primarily stem from the competition for limited resources, such as land and water, in a country where both human and elephant populations coexist in close proximity (Gunawansa et al., 2023a). Sri Lanka's HEC has been extensively documented and researched by scholars, environmentalists, and government agencies (Gunawansa et al., 2023a). According to a study published in the journal "Biological Conservation" these conflicts are mainly driven by the shrinking of elephant habitats, caused by the spread of agriculture, urban growth, and the expansion of human settlements into areas traditionally occupied by elephants (Köpke et al., 2021). Additionally, the fragmentation of elephant populations due to roads and railway networks further exacerbates the problem (Gunawansa et al., 2023a; Köpke et al., 2021). The consequences of HECs are multifaceted and include property damage, crop raids, and human injuries or fatalities (Prakash et al., 2020). These conflicts not only pose a threat to human livelihoods but also threaten the long-term sustainability of Sri Lanka's elephant population (Gunawansa et al., 2023a; Köpke et al., 2021; Perera et al., 2022; Prakash et al., 2020). Efforts to mitigate HECs in Sri Lanka have included various strategies, such as the establishment of elephant corridors and the use of deterrent methods like electric fences and noise-making devices (Gunawansa et al., 2023a; Köpke et al., 2021; Perera et al., 2022; Prakash et al., 2020; Thennakoon et al., 2017). Conservation organizations and government agencies are collaborating to develop sustainable solutions that balance the needs of both humans and elephants while preserving the rich biodiversity of the country. The escalating HEC has raised concerns among researchers, policymakers, and conservationists, prompting a growing body of research to understand the underlying causes, impacts, and possible mitigation strategies.

This bibliometric analysis seeks to explore the existing research on HEC in Sri Lanka over the past two decades (1999-2023), identify key research themes, and analyze the trends in scholarly publications. This analysis will help in understanding the key issues addressed by researchers and the gaps that exist in the current body of knowledge. The results of this study will enrich the current literature on HEC in Sri Lanka by offering a detailed overview of the research landscape. It will help researchers, policymakers, and practitioners to identify research gaps, prioritize areas for future investigation, and develop effective strategies for mitigating HEC. In the following sections of this research article, we will present the methodology used for data collection and analysis, discuss the results and findings in detail, and provide recommendations for future research and policy interventions to mitigate HEC in Sri Lanka.

2. Materials and Methods

This study adopted a structured approach to carry out an extensive bibliometric assessment of Human-Elephant Conflict (HEC) research in Sri Lanka, drawing

primarily on data retrieved from the Scopus database, recognized as a prominent and a widely recognized resource for bibliometric analysis (Hasana et al., 2022; Hemati et al., 2021; Lima & Bonetti, 2020; Merigó et al., 2019). It is important to highlight that this investigation relied solely on data from the Scopus database, minimizing the likelihood of data duplication or errors (Rana, 2020).The keywords "*HEC in Sri Lanka*" selected as search parameters in the "search field". From the "All field" drop-down menu, "Article title, Abstract, Keywords" was selected. The search within the Scopus database was customized by filtering results to include only publications in English. This language constraint was applied to enhance precision in the data analyzed. The dataset for this study spans the years from 1999 to 2023, encompassing 52 documents retrieved on December 1st, 2023. VOSviewer (version 1.6.19) was used to generate visual representations of co-citation patterns, keyword distributions, and co-occurrence relationships. However, it is important to note that relying solely on the Scopus database may have excluded relevant studies available in other databases such as Web of Science, Google Scholar, and regional repositories. Future studies should expand to multiple databases to ensure comprehensive coverage. This reliance on English-only publications may have excluded valuable studies published in Sinhala and Tamil, which could provide crucial cultural and contextual insights into HEC.

Table 1. Key terminology used in VOS viewer (Su et al., 2022).

Term	Description
Items	Relevant elements including publications, authors, keywords, and researchers
Link	A link or association between two elements, for instance, the co-occurrence of keywords.
Number of links	The number of links an element shares with other elements.
Link strength	Every connection is represented by a positive numeric value, where a higher value in co-authorship links signifies more joint publications between the two authors.
Total link strength	The overall strength of an item's associations with other items.
Network	A collection of elements linked through their connections.
Cluster	A collection of elements is represented in a network map, where each element can belong to only one cluster.

The collected data were then subjected to a detailed analysis to extract meaningful understanding. The publication trends were investigated by evaluating the annual number of publications and determining the rate of growth over time. The distribution of publications by document type was also analyzed, along with the sources of publication, including journals and conference proceedings. To assess collaboration networks among researchers, co-authorship analysis was conducted to identify prolific authors and their contributions to the field. Collaborative partnerships among authors and institutions were identified to determine the level of knowledge sharing and cooperation in the research community. Bibliometric indicators, such as co-occurrence analysis and keyword analysis, were employed to identify research themes and clusters within the selected publications. This involved analyzing the frequency of keywords and their co-occurrence patterns to uncover prevalent topics and areas of research focus in the field of HEC in Sri Lanka. Recognizing the study's

limitations is crucial. In addition, this study focused primarily on quantitative bibliometric indicators. It did not conduct a qualitative content analysis of methodologies, findings, or practical implications in the reviewed works. Incorporating such qualitative approaches in future research would enrich understanding.

Potential limitations include the possibility of publication bias and the exclusion of non-English publications, which may have affected the representativeness of the dataset. Additionally, as with any bibliometric analysis, there is a risk of excluding unpublished research or gray literature, which could have provided valuable understanding. Ethical considerations were also taken into account throughout the study. The study was conducted in accordance with ethical standards, with all referenced materials appropriately credited and acknowledged. Intellectual property rights of the authors were respected, and no unauthorized use or reproduction of content occurred.

3. Results and Discussion

3.1 Publication Trends and Patterns

3.1.1 Publication Growth Over the Years

The analysis of publication growth provides understanding of the evolution of research on HEC in Sri Lanka. A chronological analysis of the publications reveals the changing trends and research interests over time. The dataset includes publications from a range of sources, including research articles, review papers, conference proceedings, book chapters, conference reviews, letter, and review.

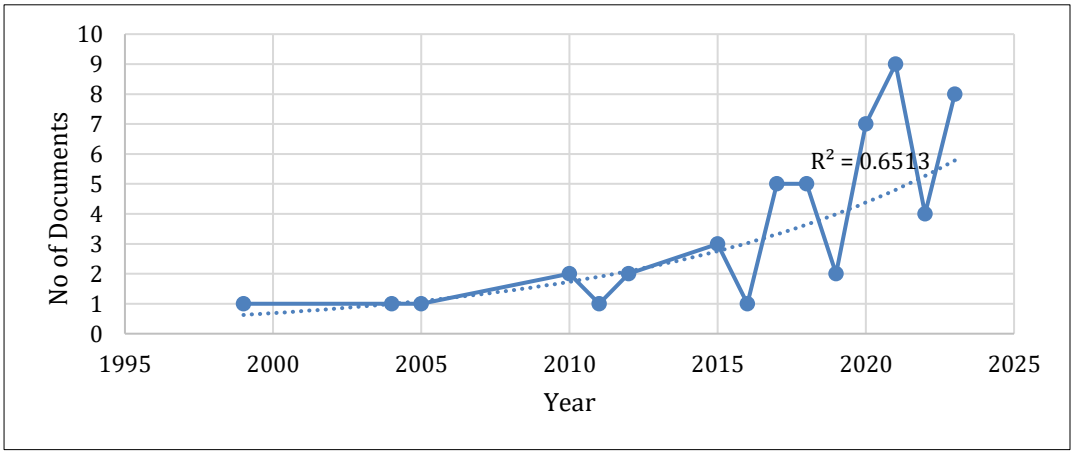

Figure 1. Publication on HEC in Sri Lanka between 1999 and 2023

The analysis shows an increasing trend in the number of publications on HEC in Sri Lanka. The initial research on HEC in the country can be traced back to the early 1990s, with a small number of publications. The Figure 1 indicates variations in publication activity over this period. Notably, there was a notable increase in publications from 2017 onwards, peaking in 2021 with 8 publications. However, over the years, the interest in HEC has grown significantly, leading to a substantial increase in the number of publications. This trend suggests a growing interest in and focus on the HEC issue in recent years.

3.1.2 Distribution of Publications by Document Type and Source

A clear understanding of HEC scholarship in Sri Lanka requires examining publication distribution by document type and source. This analysis provides understanding of the

preferred outlets for disseminating research findings related to HEC.

The dataset comprises various types of publications (Table 2). Research articles are found to be the most prevalent document type (52.1%), indicating the emphasis on empirical studies and scientific investigations related to HEC in Sri Lanka. In terms of sources, the analysis reveals that a significant portion of the publications originate from reputable peer-reviewed journals and conferences with a focus on wildlife conservation, ecology, environmental science, and information Technology (Table 3).

Table 2. The distribution of publications by document type (1999-2023)

Document types	No of Documents
Article	28
Conference Paper	19
Book Chapter	2
Conference Review	1
Letter	1
Review	1

This indicates the integration of HEC research within broader academic disciplines and the recognition of the importance of addressing HEC as a significant conservation challenge.

Table 3. The ten most popular Journals and Conferences with publication on HEC in Sri Lanka

Source title	No of Documents
ORYX	4
Sustainability	3
Biodiversity and Conservation	2
SAS 2015 - 2015 IEEE Sensors Applications Symposium, Proceedings	2
International Conference on Embedded Wireless Systems and Networks	2
Applied Acoustics	1
Applied Geography	1
Climatic Change	1
Communications biology	1
Crop Protection	1

3.1.3 Highly cited articles and leading authors in the field

The relevance of an article within a particular discipline is often assessed by the number of times it is cited over a given timeframe (Fang et al., 2018; Lima & Bonetti, 2020; Pathmanandakumar et al., 2021). Highly cited articles highlight their significance as key sources of information in the field. Older articles generally have more opportunities to be cited compared to newer ones, due to their longer presence in the literature (Chen et al., 2012; Pathmanandakumar et al., 2021). However, It is crucial to remember that the most often mentioned papers are not usually the most relevant ones (Mulet-Forteza et al., 2018; Pathmanandakumar et al., 2021). Table 4 displays the citation counts for the ten most frequently cited articles from 1977 to 2021. Among the 52 documents, the most cited article on HEC is "Perceptions and Patterns of Human–Elephant Conflict in Old and New Settlements in Sri Lanka: Insights for Mitigation and Management," authored by Fernando, Wikramanayake, Weerakoon, and Jayasinghe (Fernando et al., 2005). This article published in *Biodiversity and*

Conservation in 2005, has obtained a total of 109 citations. It investigated human–elephant conflict in two regions characterized by differing land use and conflict situations. The second most cited paper is titled "The net benefit of saving the Asian elephant: A policy and contingent valuation study". This article published in *Ecological Economics* in 2004, has received 78 citations. The study explores whether urban residents' willingness to pay (WTP) for elephant conservation is adequate to reimburse farmers for the damage inflicted by elephants (Bandara & Tisdell, 2004).

The third-most-cited publication is titled "Translocating the Problem and the Elephant?" This work was published in PLoS ONE in 2012 and received 67 citations. This paper discussed Translocating "problem-elephants" and elephant conservation strategy across elephant range (Prithiviraj et al., 2019) (Table 4).

Table 4. Top ten most frequently cited articles on HEC in Sri Lanka between 1999 to 2023

Authors	Title	Publication Year	Total Citations
Fernando et al. (2005)	Perceptions and Patterns of Human–elephant Conflict in Old and New Settlements in Sri Lanka: Insights for Mitigation and Management	2005	109
Bandara & Tisdell (2004)	The net benefit of saving the Asian elephant: A policy and contingent valuation study	2004	78
Fernando et al. (2012a)	Problem-Elephant Translocation: Translocating the Problem and the Elephant?	2012	67
Prithiviraj et al. (2019)	First country-wide survey of the Endangered Asian elephant: Towards better conservation and management in Sri Lanka	2019	32
De Silva & Srinivasan (2019)	Revisiting social natures: People-elephant conflict and coexistence in Sri Lanka	2019	32
Galappaththi et al. (2020)	An overview of the HEC in an overview of the Human – Elephant Conflict in Tissamaharamaya , Hambantota District , Sri Lanka	2020	25
Horgan & Kudavidanage (2020)	Farming on the edge: Farmer training to mitigate human-wildlife conflict at an agricultural frontier in south Sri Lanka	2020	22
Anuradha et al. (2019)	The Role of Agricultural Land Use Pattern Dynamics on Elephant Habitat Depletion and HEC in Sri Lanka	2019	17
Santiapillai & Read (2010)	Would masking the smell of ripening paddy-fields help mitigate human–elephant conflict in Sri Lanka?	2010	17
King et al. (2018)	Wild Sri Lankan elephants retreat from the sound of disturbed Asian honey bees	2018	14

3.1.4 Analysis of Publication Output by Authors and Institutions

To gain an understanding of the key contributors to HEC research in Sri Lanka, the analysis examines the publication output by authors and institutions. This analysis explored the productivity and involvement of individual researchers and the collaboration

patterns among institutions. The results indicate a diverse range of authors who have contributed to HEC research in Sri Lanka. Several prominent researchers have emerged as key contributors (Table 5), demonstrating their expertise and commitment to addressing the issue of HEC. Furthermore, collaboration among researchers and institutions is prevalent, with co-authored publications being a common occurrence. This highlights the importance of collaborative efforts in tackling the complex challenges associated with HEC.

In terms of institutions, the analysis reveals a wide range of organizations involved in HEC research in Sri Lanka. These include universities, research institutes, conservation organizations, and governmental bodies (Table 6).

The collaboration between academia, government agencies, and non-governmental organizations signifies the multidisciplinary and interdisciplinary nature of HEC research, as well as the recognition of the need for comprehensive approaches to mitigate HECs.

Table 5. The ten most prominent authors on HEC in Sri Lanka, ranked by their number of publications

Author name	No of Documents
De Zoysa, K.	8
Keppitiyagama, C.	8
Hewage, K.	7
Voigt, T.	7
Suduwella, C.	5
Jayasuriya, N.	4
Sayakkara, A.	4
Fernando, P.	3
Perera, K.	3
Ranathunga, T.	3

Table 6. Information of the ten most influential Institutions on HEC in Sri Lanka

Institutions	No of Documents
University of Colombo	14
University of Peradeniya	8
Uppsala Universitet	7
RISE, Swedish Institute of Computer Science	6
Sri Lanka Institute of Information Technology	5
Uva Wellassa University	5
Rajarata University of Sri Lanka	4
Centre for Conservation and Research	3
RMIT University	3
George Mason University	3
University of Southern Queensland	3

Table 7. The number of authors per publication on HEC in Sri Lanka

No of Authors	No of Doc	Source
Single Author	2	Benadusi (2015) and Nuwer (2019)
Two Authors	10	Bandara and Tisdell (2004), De Silva and Srinivasan (2019), Gamage and Wijesundara (2017), Horgan and Kudavidanage (2020), Kitratporn and Takeuchi (2018), Oriel and Frohoff (2020), Pemasinghe and Abeygunawardhana (2023), Perera and Tateishi (2012), and Santiapillai and Read (2010)
Three Authors	3	Galappaththi et al. (2020a); Galappaththi et al. (2020b); and Rathnayake et al. (2011)
Four Authors	10	Adam et al. (2018), Anuradha et al. (2019), Dharmarathne et al. (2020), Dissanayake et al. (2018), Fernando et al. (2012b), Gunawansa et al. (2023a), LaDue et al. (2021a), Ladue et al. (2021c), and Rathnayake et al. (2022a)
Five Authors	8	Fernando et al. (2023), Fernando et al. (2021), Gunasekara et al. (2021), Gunawansa et al. (2023b), Ladue et al. (2021b), Perera et al. (2018), Thilakarathne et al. (2022), and Wijesekera et al. (2021)
More than five Authors	19	Dabare et al. (2015), Dissanayake et al. (2019), Elvitigala et al. (2015), Fernando et al. (2020), Fernando et al. (2005), Janssen et al. (2010), Jayasuriya et al. (2017a), Jayasuriya et al. (2017b), King et al. (2018), Köpke et al. (2023, 2021), Santiapillai et al. (1999), Sayakkara et al. (2017), Sayakkara et al. (2018), Tennakoon et al. (2015), Weerasinghe et al. (2022), and Wijayagunawardane et al. (2016)

Overall, analyzing publication trends and patterns offers important understanding of the expansion of research on HEC in Sri Lanka, the preferred outlets for dissemination, and the involvement of authors and institutions.

This understanding of the publication landscape helps identify the key players and their contributions, facilitating collaboration and knowledge sharing among researchers and stakeholders working towards effective HEC management strategies in Sri Lanka.

3.2 Collaboration Networks

3.2.1 Authorship Patterns and Collaboration Trends

In this section, we investigate the patterns of authorship alongside the collaboration trends of investigators around the HEC research in Sri Lanka. Per publication, we review how many authors there are, whether there are more single-authored papers or multi-authored papers, and what extent individual researchers collaborate. As shown by our analysis (Table 7), collaboration is the main feature of HEC research in SL. Another point to note is that most work is done by teams, so this area boasts good research team dynamics. It is important that we work together when it comes to addressing HEC because it involves wildlife ecology, conservation biology, and sociology among others.

This is because collaborative research combines different fields like wildlife ecology, conservation biology, sociology, and policy development which results in a more comprehensive result.

We have therefore identified top prolific authors as well as research groups who have been very important in Sri Lanka's HEC researches. They have always provided high quality work reflecting their knowledge and commitment towards HEC issues. Additionally, we explore their publication records to identify their modes of collaboration with other authors as well as institutions researched together with organizations.

3.2.2 Identification of Key Collaborating Institutions and Countries

In the following section, we look at how researchers in Sri Lanka work together with institutions and countries within the HEC research. By studying the patterns of co-authorship, we try to find out how much and in what manner they collaborate among themselves.

It is evident from our findings that there is a wide range of collaborations among different institutions within Sri Lanka and between them and other countries across the world (Table 8).

This shows that Sri Lanka has strong local research capacity as it is evident that local universities as well as research institutes including some conservation organizations are actively participating in this study area.

Table 8. Key Collaborating Institutions

Institutions	Documents	Citations	Total Link Strength
Department of Engineering Technology, Uva Wellassa university Gunawansa et al. (2023a) and Gunawansa et al. (2023b)	2	1	2
Department of export agriculture, Uva Wellassa university Gunawansa et al. (2023a) and Gunawansa et al. (2023b)	2	6	4
Department of mechanical and Manufacturing Engineering, University of Ruhuna Gunawansa et al. (2023a) and Gunawansa et al. (2023b)	2	1	2
Department of zoology, University of Peradeniya Santiapilla and Read (2010) and Santiapillai et al. (1999)	2	30	0
Eco-Collective Research Association, Colombo, Sri Lanka Köpke et al. (2021, 2023)	2	9	4
Faculty of organic agricultural sciences, university of Kassel, Germany Köpke et al. (2021, 2023)	2	9	4
Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka Köpke et al. (2021, 2023)	2	9	4

School of geography, planning and spatial science, University of Tasmania, Australia Rathnayake et al. (2022a) and Rathnayake et al. (2022b)	2	6	4
School of science, RMIT university, Australia Rathnayake et al. (2022a) and Rathnayake et al. (2022b)	2	6	4
SICS Swedish ICT, Sweden Sayakkara et al. (2017) and Elvitigala et al. (2015)	3	14	6
University of Colombo school of computing Sayakkara et al. (2017), Elvitigala et al. (2015), Gamage and Wijesundara (2017),Jayasuriya et al. (2017a), and Jayasuriya et al. (2017b)	7	22	9
Uppsala university, Sweden Sayakkara et al. (2017), Elvitigala et al. (2015), Gamage and Wijesundara (2017) Jayasuriya et al. (2017a), and Jayasuriya et al. (2017b)	7	26	9

Table 9. Key Collaborating Countries

Country	Documents	Citations	Total link strength
Sri Lanka	41	469	29
Australia	10	111	9
united states	9	225	10
Sweden	7	26	7
United Kingdom	5	76	4
Germany	3	9	3
Japan	2	18	2

Table 10. Key Collaborating Countries

Country	Documents	Citations	Total link strength
Sri Lanka	41	469	29
Australia	10	111	9
united states	9	225	10
Sweden	7	26	7
United Kingdom	5	76	4
Germany	3	9	3
Japan	2	18	2

We have picked out some of the main places that have been highly involved in researching on this topic concerning human elephant conflict and these are characterized by great numbers of linkages to other research institutions. In addition, we explore international collaborations and identify countries that have actively engaged in HEC research in Sri Lanka (Table 9 and Figure 2). Collaborations with international researchers and organizations bring global perspectives, expertise, and resources to

address the complex challenges of HEC. These collaborations contribute to the sharing of knowledge, best practices, and innovative approaches to mitigate the HEC. The collaboration networks identified in this study highlight the importance of interdisciplinary and cross-sectoral collaborations in addressing the HEC effectively. By fostering collaborations among researchers, institutions, and countries, valuable understanding and solutions can be shared, leading to more informed decision-making and effective policy interventions.

Overall, the collaboration networks in HEC research demonstrate the collective efforts of researchers, institutions, and countries in addressing this pressing issue. Collaboration plays a vital role in generating knowledge, promoting information exchange, and fostering partnerships for sustainable HEC management strategies.

3.3 Analysis of intellectual structure

3.3.1 Thematic Analysis

Thematic analysis is a useful method applied in the research process to examine the frequency of a given topic or pattern in the selected literature. When applied to the context of the research article on HEC in Sri Lanka, the thematic analysis assists in identifying the main research themes and groups formed by the analysed publications. In this section, the researcher presents a brief discussion on the methods used for thematic analysis in the study (Table 10). Bibliometric analysis included tasks such as a systematic review of the identified publications concerning HEC in Sri Lanka. In this section, the primary themes or topics were derived from the content and the specific objectives and findings of the reviewed articles. The purpose was to better appreciate the various aspects of HEC in Sri Lanka by sorting out the articles based on relevant themes.

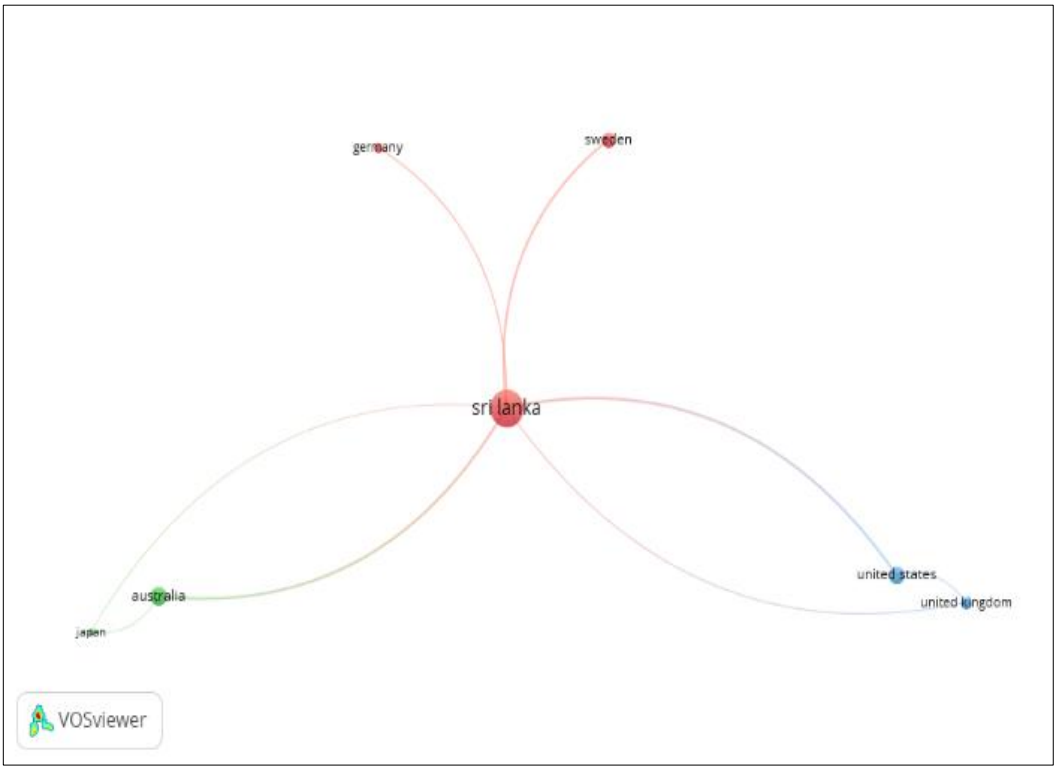

Figure 1. Key Collaborating Countries

Table 11. The major research themes and groups

Key Themes	Source
Elephant behavior	Benadusi (2015), Fernando et al. (2023), Fernando et al. (2012b), Galappaththi et al. (2020), King et al. (2018), Ladue, Vandercone, et al. (2021), Oriel and Frohoff (2020), Perera et al. (2018), Rathnayake et al. (2011), and Wu et al. (2021)
Agricultural practices	Anuradha et al. (2019), Fernando et al. (2005), Gunawansa et al. (2023), Kitratporn and Takeuchi (2018), Köpke et al. (2023), Köpke et al. (2021), LaDue et al. (2021), LaDue, Farinelli, et al. (2021), Nuwer (2019), and Rathnayake et al. (2022)
Mitigation strategies	Adam et al. (2018), Bandara and Tisdell (2004), Dabare et al. (2015), De Silva and Srinivasan (2019), Elvitigala et al. (2015), Fernando et al. (2020), Gamage and Wijesundara (2017), Gunasekara et al. (2021), Horgan and Kudavidanage (2020), Jayasuriya, Ranathunga, et al. (2017), Jayasuriya, Sayakkara, et al. (2017), Pemasinghe and Abeygunawardhana (2023), Perera and Tateishi (2012), Rathnayake et al. (2022), Santiapillai and Read (2010), Sayakkara et al. (2018), Sayakkara et al. (2017), Tennakoon et al. (2015), Thilakarathne et al. (2022), Weerasinghe et al. (2022), Wijayagunawardane et al. (2016), and Wijesekera et al. (2021)
Policy interventions	Fernando et al. (2021), Gunawansa et al. (2023), Janssen et al. (2010), and Perera et al. (2022)

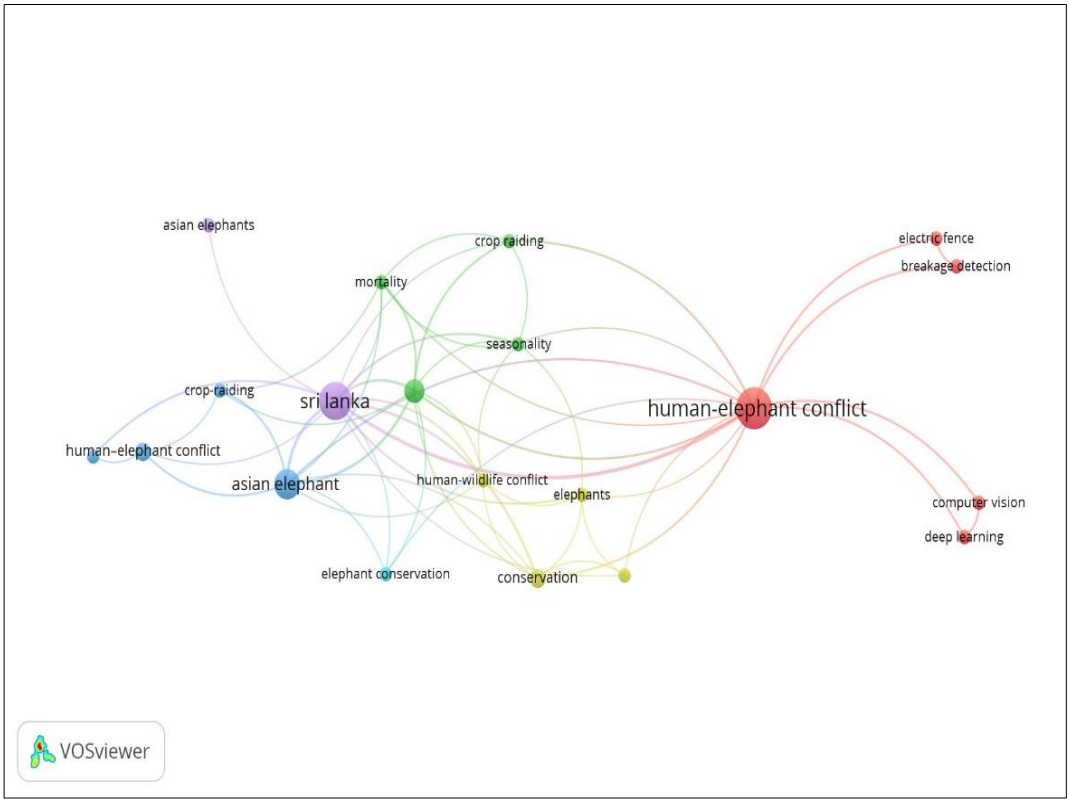

Figure 3. Co-occurrence author keywords network

Table 12. Top ten keywords, co-occurrence frequency, and total link strength

Keyword	Occurrences	Total link strength
Human Elephant Conflict	16	26
Sri Lanka	13	29
Asian elephant	8	17
Elephas maximus	5	17
Elephant Conservation	3	10
Asian elephant (Elephas maximus)	2	3
Electric fence	2	4
crop raiding	2	7
Seasonality	2	8
Wildlife management	2	4

3.3.2 Analysis of Keywords and Co-Occurrence Patterns

Content analysis of the identified publications was also followed by a keyword analysis to determine terms most frequently used and their co-occurrence patterns. This analysis offered deeper understanding about the major themes and subjects depicting the field of HEC in Sri Lanka (Table 11 and Figure 3). They make it possible to identify connections between the concepts and themes in question and highlight potential areas of focus and research gaps.

4. Conclusion and Recommendations

This bibliometric analysis synthesizes the literature on HEC in Sri Lanka, outlines the emerging trends, research topics, and communities. These findings help in improving the future understanding of HEC in its present state and potential future developments and provide a conceptual lens for researchers and policy makers to better understand the topic. Bibliometric analysis also depicted an increasing trend in the number of HEC research publications in recent years, which reflects the escalating interest and concern towards this aspect. Several researchers from various institutions and countries have published studies on HEC in Sri Lanka and have formed collaboration networks which are important in synthesizing diverse disciplines in order to tackle the multifaceted issues of human-elephant interactions. It is worth noting that HEC research themes include the behaviour of elephants, agriculture, management measures, and policy approaches. That is associated with multifaceted character of the problem, which is environmental, social, and policy in its nature. The identification of these themes offers worthwhile guidance for researchers and policymakers to pay attention to the specific elements of HEC and to work towards designing relevant solutions. However, as highlighted by the above-researched ideas, there are still research gaps that need to be filled in undertaking HEC research. For instance, the effects of HEC on socio-economic lives of host communities, as well as the assessment of efficacy of different mitigation measures have been identified as key areas that require further research efforts. Also, to bring into perspective in HEC research, remote sensing technology can offer spatial and temporal data on elephants and their preferred habitats. Effectively managing HEC in Sri Lanka requires active collaboration among diverse stakeholders, such as academic researchers, government bodies, local populations, and wildlife conservation groups. Through this partnership, there are benefits in the sharing of information, skills, and assets in the formulation of policies and interventions that can effectively address HEC. As a result, this bibliometric analysis seeks to populate the

research landscape of HEC in Sri Lanka by identifying research trends and thematic clusters as well as collaboration networks. It is therefore important that the work of this study adds to the existing literature on HEC and can be useful for researchers and policymakers in subsequent research activities or policy interventions to enhance positive interactions between people and elephants for the direct benefit of conservation and improvement of the quality of life of communities living nearby habitats.

4.1 Research Gaps and Future Directions

Researchers have conducted many empiric studies on HEC in Sri Lanka in the past but, future research should assess the efficiency and the feasibility of the contemporary HEC activities such as electric fences, barriers and early warning systems. Future research should also consider community level involvement from farmers, villagers, and wildlife officials to address the long-standing problems of HEC through approaches to community policing, crop choice diversification, and compensation. Previous studies mainly examine HEC's ecological and conservation effects and rarely incorporate socio-economic effects on the end-users. Future research should evaluate the financial costs, psychological and social impacts of HEC and elaborate on economic activities that can prevent conflict. Furthermore, studies should investigate new methods such as the use of natural repellents, sonic devices, and space management instruments for human-elephant conflict resolution. As climate change impacts HEC, future studies should investigate how it affects elephant behavior, migration, and resource availability. Focus should be placed on how policies affected HEC management and the involvement of the government and non-governmental organizations. Additionally, future studies should consider incorporating qualitative content analysis to critically evaluate research methodologies, findings, and contextual relevance, offering deeper understanding beyond bibliometric indicators. Moreover, the analysis could be enhanced by assessing the representation of various stakeholder perspectives—such as those of farmers, conservationists, policymakers, and local communities—within the HEC literature. Filling these gaps will improve the knowledge on HEC in Sri Lanka and help in establishing proper solutions to minimize the conflicts and increase positive interactions between humans and elephants.

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