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A bibliometric review of global research on the human-wildlife conflicts

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Human-wildlife conflict (HWC) affects both wildlife sustainability and human wellbeing. Current strategies for human-wildlife conflict are often fragmented and predominantly conservation-focused, lacking the necessary coordination and support from other impacted sectors. This study aims to explore the global research landscape on HWC through bibliometric analysis, using the Scopus database as the primary source and VOSviewer software for data analysis. A total of 4,822 articles were found in the study of human-wildlife conflict. This study has been researched by a total of 4,065 authors widely distributed all over the world, with most of the studies from the United States of America. This study also analyzed four type of clusters which are: a) Human-wildlife management, b) Human-animal physiology, c) Human-carnivore conflict, and d) Conservation and policy. The interest in HWC research has notably increased, with publications covering 24 subject categories in the Scopus Database. Most of these publications are found in Environmental Science, followed by Agricultural and Biological Sciences, and Social Sciences. This study highlights several gaps such as the lack of study in the social dimensions on HWC, lacking in the strategies towards human-wildlife co-existence, and policy gap between regional. This research contributes to community awareness and conservation initiatives, providing essential data and insights for policy-making towards the human-wildlife co-existence. This study emphasizes the involvement of various stakeholders—from local communities to governments and NGOs—assists in crafting comprehensive and inclusive policies.

KEYWORDS

environmental analysis, environmental management, human-wildlife conflict, human-ecology, sustainable development

Introduction

The interplay between humans and wildlife is marked by intricate dynamics, where coexistence often gives way to conflict. Human-wildlife conflicts (HWC) arise from interactions that negatively impact both humans and wildlife, ranging from crop destruction and livestock predation to habitat degradation and human safety concerns (Waldhorn, 2019). According to IUCN (2020), Human-wildlife conflict occurs when the needs and behavior of wildlife impact negatively on human goals or when the goals of humans negatively impact the needs of wildlife. This often results in detrimental outcomes for both people and wildlife, and poses significant challenges for the coexistence of humans and wildlife. These conflicts are exacerbated by human encroachment into wildlife habitats,

a trend driven by population growth, urban expansion, and resource exploitation. Spanning rural and urban landscapes, HWC poses significant threats to sustainable development, biodiversity conservation, food security, and human health, undermining progress toward the Sustainable Development Goals (SDGs) and the Aichi Biodiversity Targets (IISD, 2021; FAO, 2020).

The consequences of HWC are multifaceted, encompassing economic, ecological, and social dimensions. Agricultural losses due to crop destruction, reduced farm productivity, competition for grazing lands, and livestock predation are common outcomes (Schell et al., 2021). Other impacts include infrastructure damage, human injuries or fatalities, and the spread of zoonotic diseases from wildlife to livestock. Additionally, conflicts often fuel negative attitudes toward conservation efforts, particularly when protected areas are expanded or established, creating friction between conservation initiatives and local communities (FAO and UNEP, 2020). For instance, high densities of large ungulates in forests can damage vegetation, hinder regeneration, and reduce forest productivity, with severe economic consequences (FAO, 2016; FAO and UNEP, 2020).

Research on HWC underscores its global scope, with studies spanning diverse ecosystems—from African savannas and the Amazon rainforests to Arctic tundra and the Australian Outback (Abas et al., 2022). This body of work highlights the importance of understanding ecological dynamics, socio-economic factors, and cultural perspectives to design effective mitigation strategies. Conflicts such as crop raiding by elephants, livestock predation by carnivores, urban wildlife encroachment, and zoonotic disease transmission demonstrate the pressing need for interdisciplinary approaches that integrate ecological, social, and economic frameworks (Mwangi et al., 2016; Mekonen, 2020).

As climate change and land-use pressures intensify, the frequency and severity of HWC are expected to rise, posing even greater challenges to both human and wildlife populations (Mahoney et al., 2015). Addressing these challenges requires collaboration among researchers, practitioners, policymakers, and local communities to develop adaptive, context-specific strategies. Innovative research and participatory approaches are essential for balancing human needs with wildlife conservation and promoting coexistence (Sharma et al., 2021).

Recognizing the shared responsibility to protect biodiversity while safeguarding human livelihoods, this article conducts a bibliometric review of global research on human-wildlife conflicts. By analyzing the spatial, temporal, and thematic trends in the field, it aims to illuminate current knowledge gaps and provide actionable insights for researchers, policymakers, and conservation practitioners. This review offer its integration of an extended dataset spanning 1990–2024, offering a more comprehensive temporal scope and its in-depth exploration of keyword co-occurrence clusters, providing nuanced insights into thematic evolution, compared to "Human-Wildlife Conflict: A Bibliometric Analysis during 1991–2023" by Ridwan et al. (2023), which focuses on trends without emphasizing cluster dynamics, and "Bibliometric Analysis of Human–Wildlife Conflict: From Conflict to Coexistence" by Su et al. (2022), which centers on the coexistence paradigm but lacks a granular breakdown of thematic clusters and emerging research directions. Offers critical recommendations to guide future research and inform sustainable solutions to mitigate conflicts and foster harmonious coexistence.

Research methodology

Data collection and screening

This research primarily utilized the Scopus database by Elsevier to gather data and significant samples. Scopus, a robust abstract and citation database, encompasses a wide array of academic fields such as science, technology, medicine, social sciences, and the arts. It indexes over 70 million entries from more than 23,000 peer-reviewed journals, conference proceedings, books, and patents. Scopus offers tools for citation analysis, author and affiliation profiling, and calculates metrics like the h-index, aiding researchers in monitoring the impact and reach of their work. Regular updates make it an essential resource for literature reviews, research evaluation, and academic assessments (Scopus, 2024). Using the Scopus database is sufficient for a bibliometric study due to its extensive coverage of high-quality, peer-reviewed literature across disciplines, including environmental science and ecology, which are critical for studying human-wildlife conflicts. Scopus provides robust bibliometric tools, standardized metadata, and global coverage, enabling the analysis of research trends, collaborations, and citation impacts from a global perspective. Its comprehensive and updated records from 1990 onward make it ideal for analyzing both historical and current research outputs. While Scopus may exclude some niche or regional journals, its structured data and citation metrics make it a reliable and efficient choice for bibliometric analysis (Pranckutė, 2021).

First, this study searched from 1990 until May of 2024 in the TS (Topic Search) = (human* AND wildlife* AND conflict*). The retrieved articles included these terms and their variants (with "*") in the titles, keywords, and abstracts. Which resulted in 5,115 articles.

In this study, only research articles published and appearing on the Scopus database have been selected. Other publications such as books, annual reports, short reviews, etc. were not selected. This study also generates a comprehensive review of those papers. Some articles were rejected due to their incompatibility with this study's aims, such as articles that studied public perception, and different kind conflict such as human vs. human or wildlife vs. wildlife. The final selection of the systematic review consisted of 4,973 papers concentrating solely on the human-wildlife conflict.

In ensuring the quality of the content of the articles, the remaining articles were presented to two experts for quality assessment. As suggested by Petticrew and Roberts (2006), the experts ranked the remaining articles into three quality categories, namely high, moderate, and low. Only articles categorized as high and moderate were reviewed. The experts focused on the methodology of the articles to determine the rank of the quality. Both authors had to mutually agree that the quality of the paper must at least be at a moderate level for it to be included in the study. Any disagreement was discussed between them before deciding on the inclusion or exclusion of the articles for the review. After this process, 2,445 articles were ranked as high, 2,377 as moderate and 151 articles as low. Thus, only 4,822 articles were

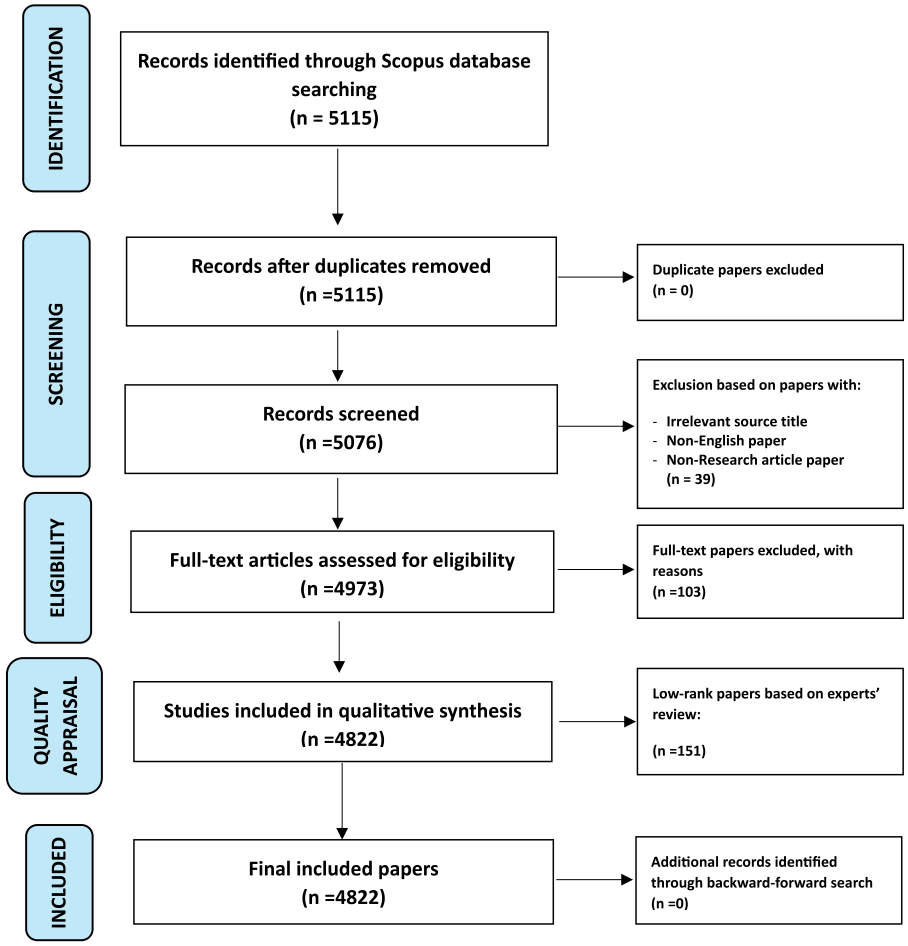


FIGURE 1
Flow diagram.

eligible for the review. The summary of the screening process can be seen in Figure 1.

Data analysis

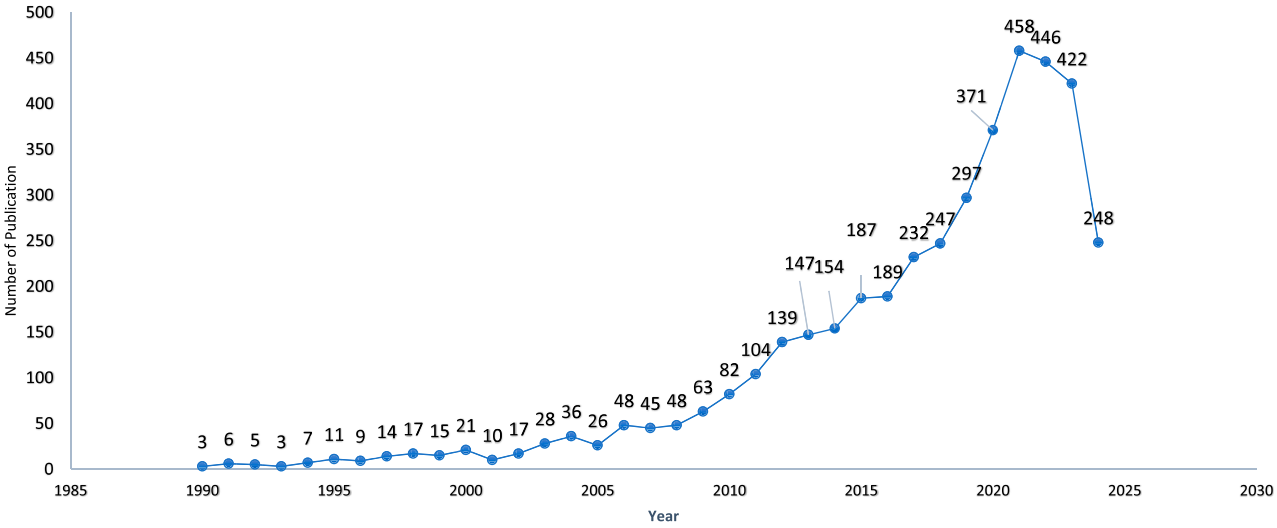
This study first examines the quantity of publications by analyzing research growth trends, subject area output, and journal types within the context of human-wildlife conflict, taking into account journal impact factors and H-index. The research assessment included: (1) publication output, (2) subject categories as indexed by the Scopus database from 1990 to 2024, and (3) the top 10 most influential journals. Publication performance and subject categories were analyzed using Microsoft Excel 2019. Second, co-authorship analysis was performed to identify relationships among the top authors and countries in the field. This analysis, commonly used to understand patterns of scientific collaboration (Ali et al., 2022), was conducted to highlight these interactions. Third, co-occurrence analysis was conducted to explore the relationships between publication keywords and track the evolution of research topics. This analysis utilized VOSviewer version 1.6.17, a software for creating and visualizing bibliometric networks based on citation, bibliographic coupling, co-citation, or co-authorship relations (VOSviewer, 2024). Author keyword frequency analysis provided insights into research focus areas within human-wildlife conflict studies. VOSviewer clusters items by analyzing the co-occurrence relationships within bibliometric data, such as keywords or terms. Using a modularity-based algorithm, the software positions related items closer together in a two-dimensional space while grouping them into clusters based on the density of connections. Each cluster is assigned a distinct color, reflecting thematic or conceptual relationships. Researchers can interpret and name clusters based on the terms they contain, enabling the identification of patterns and key topics within a research field (VOSviewer, 2024).

Results and discussion

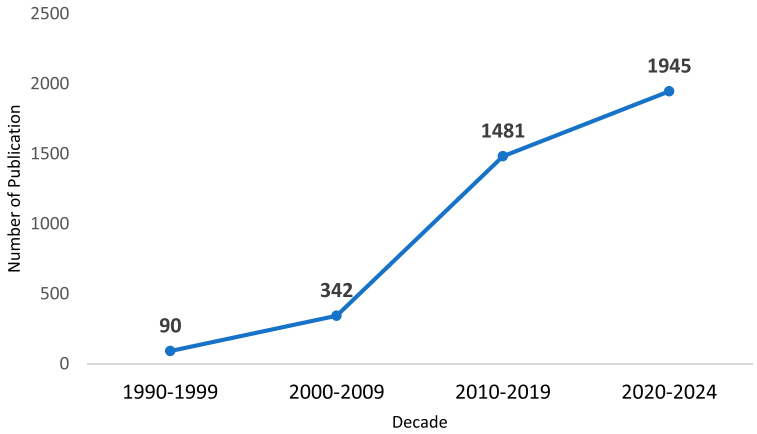
Characteristics of publication output and trends

The number of articles published by year

Figure 2A illustrates the publication trends related to 'human-wildlife conflict' from 1990 to 2024. Meanwhile, Figure 2B shows the publication trend by decade from 1990–2024. The peak of



(a) Trend of publication by year



(b) Trend of publication by decade

FIGURE 2
(A) Trend of publication by year. **(B)** Trend of publication by decade.

publications occurred in 2021, with 458 articles published in that year alone. The overall trend demonstrates a consistent increase in publications over the years. Distinct publication dynamics are evident across three periods: 1990–1999, 2000–2010, and 2011–2024. During 1990–1999, the maximum publication count was 17 in 1998. From 2000 to 2010, the highest was 82 in 2010, and from 2011 to 2024, it peaked at 458 in 2021. The rate of publication has shown a steady and significant rise over each decade, reflecting heightened interest among scientists and researchers in human-wildlife conflict studies. This study also conducted a Chi-Square Test to determine if there is a statistically significant trend. The X^2 = 2,468.02 where the p-value is = 0.00. The p-value is virtually zero, which means there is a highly significant trend in the publication counts across decades. The observed counts deviate dramatically from an equal distribution. This indicates that the issue continues to grow and requires extensive research worldwide. Woolaston et al. (2021) highlight that research on human-wildlife conflict remains vital as it addresses critical challenges in biodiversity conservation, human safety, and sustainable development. The growing human population encroaches on wildlife habitats, escalating conflicts and threatening both endangered species and human livelihoods (Ali et al., 2022). Climate change exacerbates these problems by altering habitats and wildlife behavior. Research in this domain informs policies and management practices, fostering coexistence and protecting ecosystems (Jamean and Abas, 2023). This understanding is crucial for balancing conservation efforts with human community needs, ensuring both ecological and socio-economic sustainability.

The number of articles published by subject category

Figure 3 presents the distribution of publications across various subject categories in the Scopus Database. The analysis indicates that research on human-wildlife conflicts spans 24 Scopus categories,

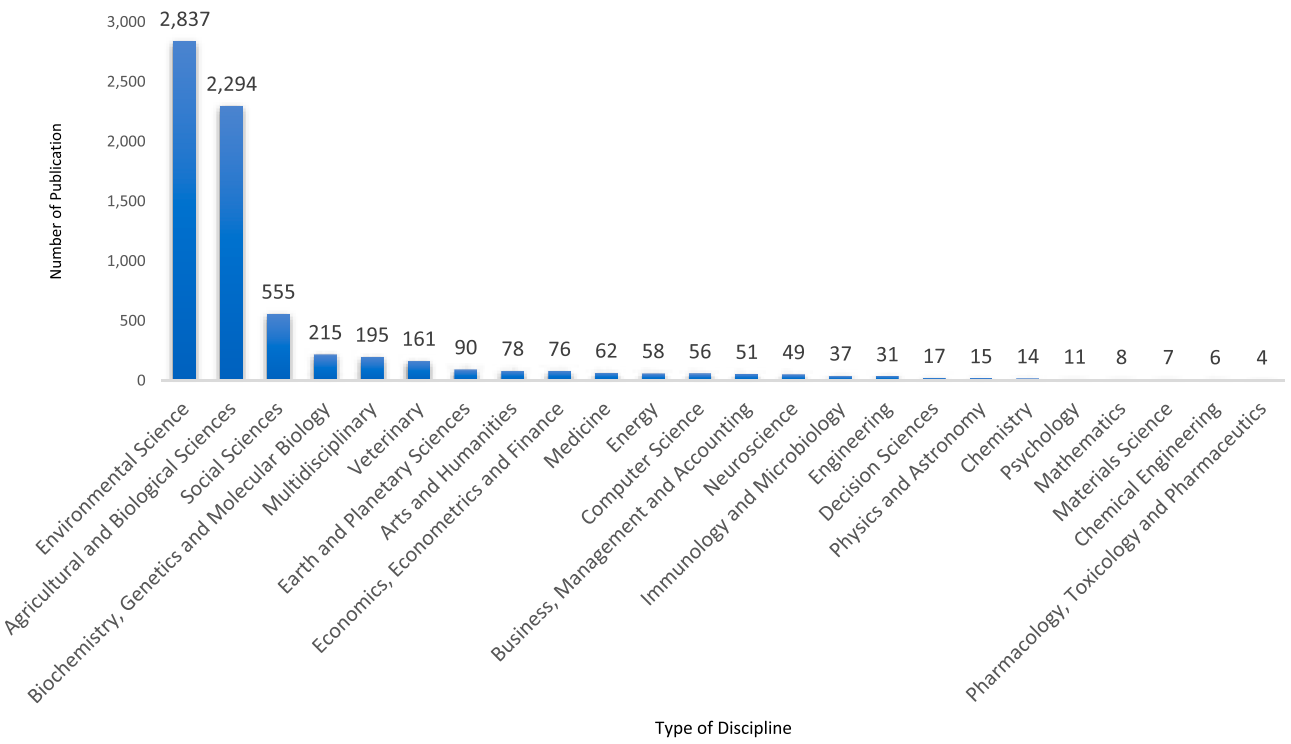


FIGURE 3
Trend of publication by discipline.

TABLE 1 Number of publications by journal.

Journal	N	P	TC	TC/N	CS 2023	H-index
Biological Conservation	200	4.7	8,227	41.135	10.2	224
Human Wildlife Interactions	193	4.6	2,148	11.12	2.8	22
Human Dimensions of Wildlife	155	3.7	4,212	27.17	4.4	59
Plos One	124	2.9	4,631	37.34	4.2	404
ORYX	123	2.9	4,689	38.12	5.3	80
Journal Of Wildlife Management	112	2.6	2,663	23.77	4.0	120
Global Ecology and Conservation	82	1.9	1,317	16.06	8.1	57
Animals	82	1.9	541	6.59	4.9	60
Wildlife Society Bulletin	80	1.9	1,879	23.48	2.1	89
European Journal of Wildlife Research	80	1.9	1,379	17.23	3.4	75

N, number of article; P, percentage; TC, total citation; CS, CiteScore.

with Environmental Science leading at 2,837 articles. This is followed by Agricultural and Biological Sciences (2,294 articles), Social Sciences (555), Biochemistry, Genetics, and Molecular Biology (215), Multidisciplinary Science (195), and Veterinary Science (161). Other categories each contain fewer than 100 articles. Notably, 89% of the articles are published in science and technology, highlighting the dominance of scientific research in this field. Historically, human-wildlife conflict studies have focused on wildlife aspects such as behavior, diet, genetics, and ecology (Nyhus, 2016). However, incorporating social sciences is crucial for a comprehensive understanding (Su et al., 2022), as effective conflict resolution requires insights into both human and wildlife perspectives. Abas (2023) emphasizes that the human element in these conflicts is complex due to varying community behaviors, cultures, beliefs, and climates, necessitating tailored approaches.

Number of articles published by journal

Table 1 presents the ten leading journals in publishing articles on "Human-Wildlife Conflicts" from 1990 to 2024. These top journals account for at least 26% of total publications, with Biological

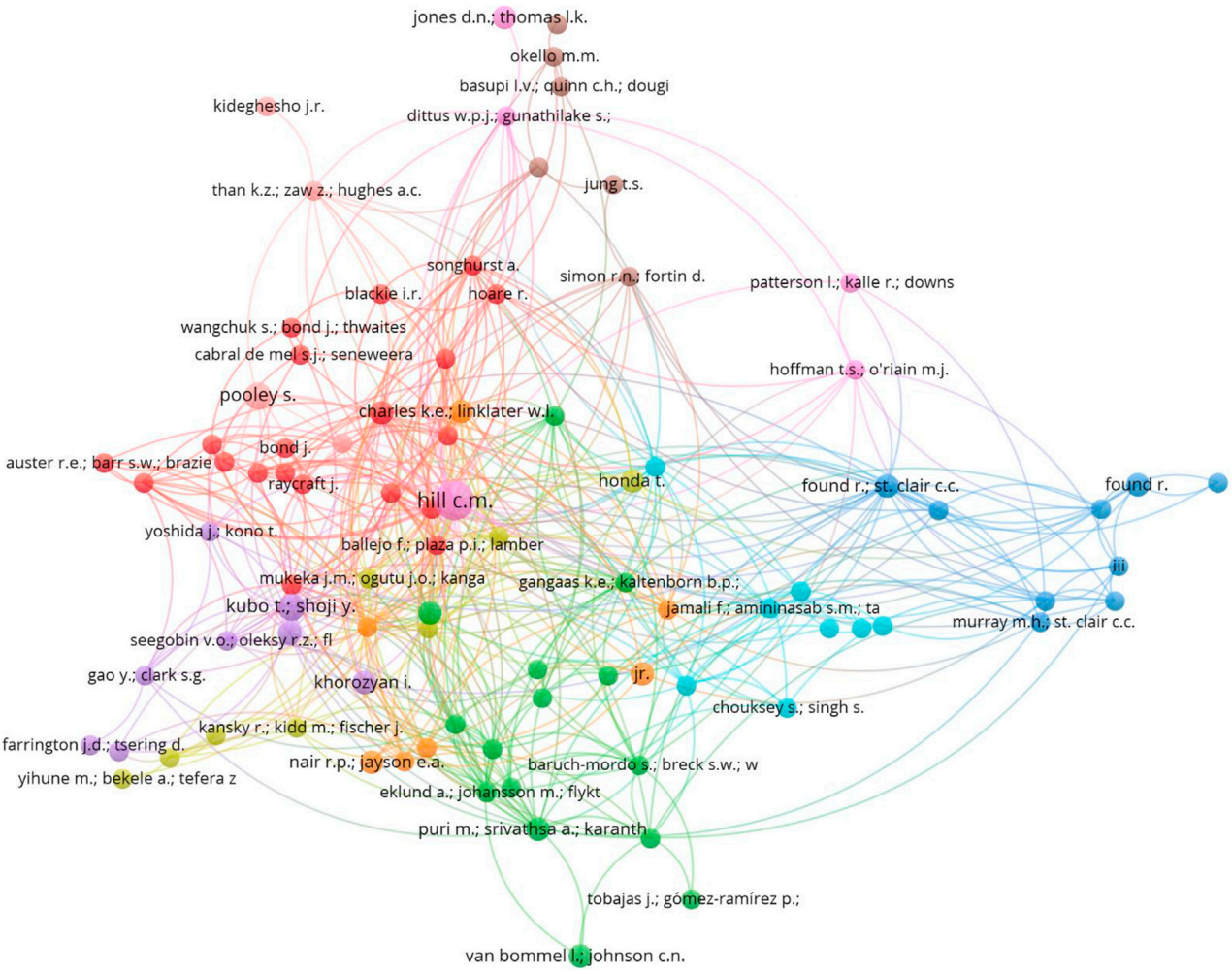


FIGURE 4
Analysis of Co-authorship.

Conservation leading with 200 articles (TC = 8,227). This is followed by Human Wildlife Interactions with 193 articles (TC = 2,148), Human Dimensions of Wildlife with 155 articles (TC = 4,212), PLOS ONE with 124 articles (TC = 4,631), ORYX with 123 articles (TC = 4,689), and Journal of Wildlife Management with 112 articles (TC = 2,663). The remaining journals in the top ten each published fewer than 100 articles, all with a TC of less than 2000. Notably, all top ten journals have a CiteScore exceeding 2.0, indicating that each article is cited at least twice over the past 2 years. According to Basumatary et al. (2023), journals with high CiteScores or Impact Factors tend to have greater visibility and a wider audience due to their high accessibility and open access policies.

Analysis of co-authorship

Co-authorship among the authors

The co-authorship analysis started with an initial pool of 4,065 authors of publications focused on "Human-Wildlife Conflicts" research. By setting a minimum threshold of two publications per author, the analysis revealed 104 authors meeting this criterion. This is indicating a relatively small group of consistently active contributors in this research area. The resulting authorship networks, depicted graphically, illustrate the interconnections among these researchers. Node sizes in the visual representation correlate with link strength, indicating robust connections among researchers from diverse countries and disciplines. Figure 4 displays the relationships between authors, organized into 10 primary clusters. Notably, Hill C.M. from Oxford Brookes University leads with eight publications, suggesting their prominent role in advancing HWC research, particularly in the social sciences. Other active contributors include Pooley, S. and Kubo, T., with four publications each, indicating moderate but focused contributions in their respective fields.

Cluster 1 (Red), comprising 20 authors, includes Anand, S., Auster, R.E., Blackie, I.R., Hoare, R., Rust, N.A., and Songhurst, A., and is closely linked with Cluster 4 (Dark Yellow), which includes 8 authors like Dickman, A.J., Honda, T., and Gubbi, S. This indicates strong thematic or regional overlaps. Cluster 2 (Green) contains 15 authors such as Puri, M., Tobajas, J., Gore, M.L., and Amit, R., and is strongly connected with Cluster 7 (Orange), consisting of

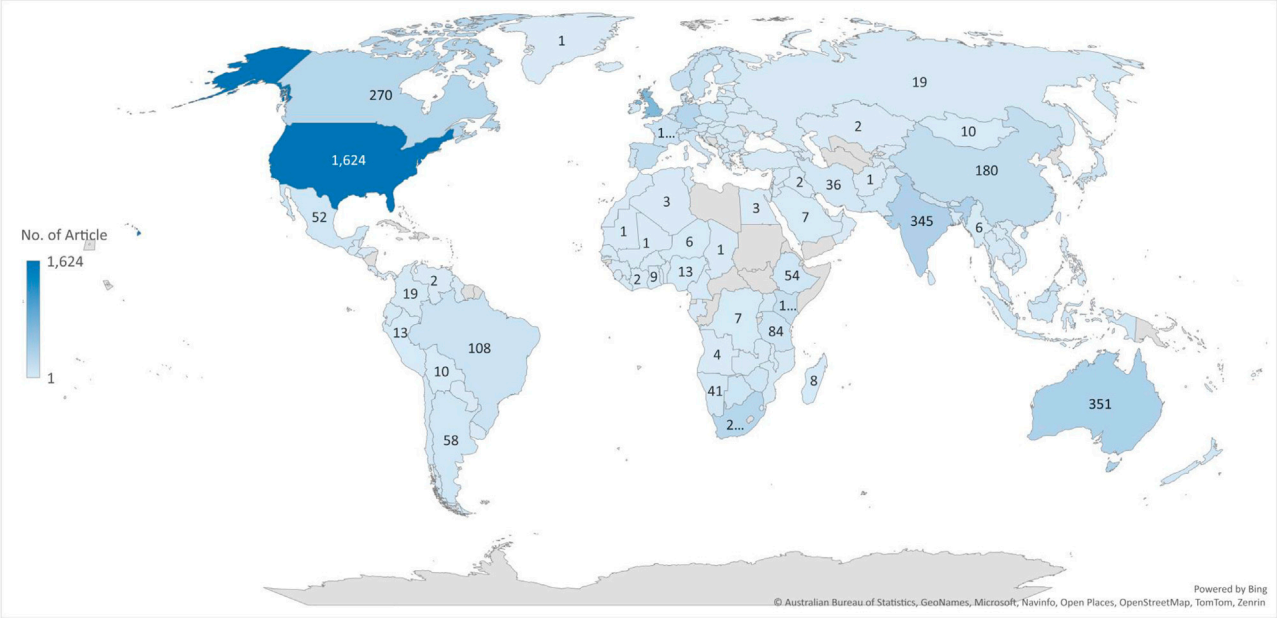


FIGURE 5
Number of publication by country.

7 authors including Nair, R.P., Bhatia, S., and Charles, K.E. This shows the connectivity between Cluster 2 (Green) and Cluster 7 (Orange) suggests shared research interests or cooperative efforts across institutions. Cluster 3 (Dark Blue) with 9 authors, including Found, R., and Murray, M.H., is closely associated with Cluster 9 (Pink), which includes 5 authors like Hoffman, T.S. The association between Cluster 3 (Dark Blue) and Cluster 9 (Pink) highlights collaborations on specialized topics within HWC.

The analysis of author regions

Number of articles by region

Figure 5 illustrates the global distribution of articles across 150 countries contributing to the study of "Human-Wildlife Conflict." Meanwhile, Figure 6 focuses on the top 15 most prolific countries in this field, led by the United States with 1,624 articles, followed by the United Kingdom (691), Australia (351), India (345), Germany (284), South Africa (280), and Canada (270). Other countries have contributed fewer than 200 articles. In contrast, Figure 7 categorizes article distribution by continent, with Europe leading at 2,438 articles, followed by North America (1898), Asia (1,131), Africa (924), Oceania (406), and South America (324).

The United States' substantial publication output on human-wildlife conflicts stems from its rich biodiversity, urban expansion, and the imperative for effective conservation strategies. For example, studies frequently examine interactions between suburban communities and coyotes to mitigate property damage and ensure public safety (Wieczorek et al., 2008). This research addresses public health concerns, agricultural losses, and policy development while promoting human-wildlife coexistence (Nyhus, 2016).

In Europe, high population density, diverse wildlife, and rewilding initiatives drive extensive research on human-wildlife conflicts. The reintroduction of wolves in Germany, for instance, has sparked research on livestock predation and effective management strategies. Comprehensive wildlife protection laws and a robust academic infrastructure further bolster Europe's contribution to this field (Henle et al., 2008; McKinley et al., 2017).

Conversely, South America faces challenges in researching human-wildlife conflicts due to limited funding prioritized for economic development over environmental concerns, notably in Brazil and Venezuela. Institutional support is sparse compared to Europe, with research efforts often focused on biodiversity conservation rather than conflict mitigation. Geographic barriers in remote regions like the Pantanal further hinder extensive research efforts (de Lima et al., 2020; Marchini et al., 2024).

The higher publication output on Human-Wildlife Conflicts (HWC) from the UK and USA compared to African countries can be attributed to several factors, including greater access to research funding, advanced technologies, and established academic institutions that support large-scale studies (Gross et al., 2022). Researchers in the UK and USA are often part of global networks, enabling collaboration on studies conducted in biodiversity-rich regions like Africa, leading to more publications under Western institutions. In contrast, African countries face limited research budgets, infrastructural constraints, and language barriers, which hinder the production and international dissemination of HWC studies (Bailey et al., 2020). Additionally, the focus in African countries often revolves around localized conservation issues, which may not always align with global academic trends that favor theoretical and large-scale studies (Stephenson et al., 2021).

Number of citations by region

Table 2 presents the citation counts attributed to countries contributing to the study of Human-Wildlife Conflict. The United States of America (USA) leads with 436,777 citations

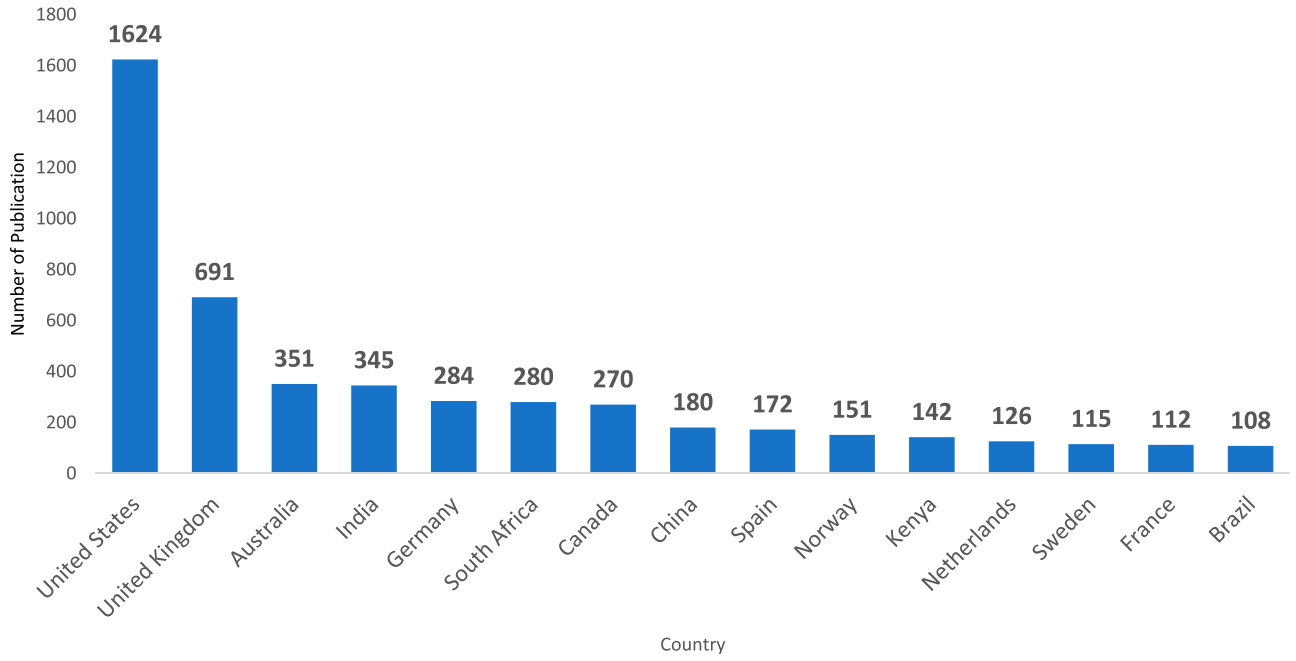


FIGURE 6
The Top 15 Countries with most publication.

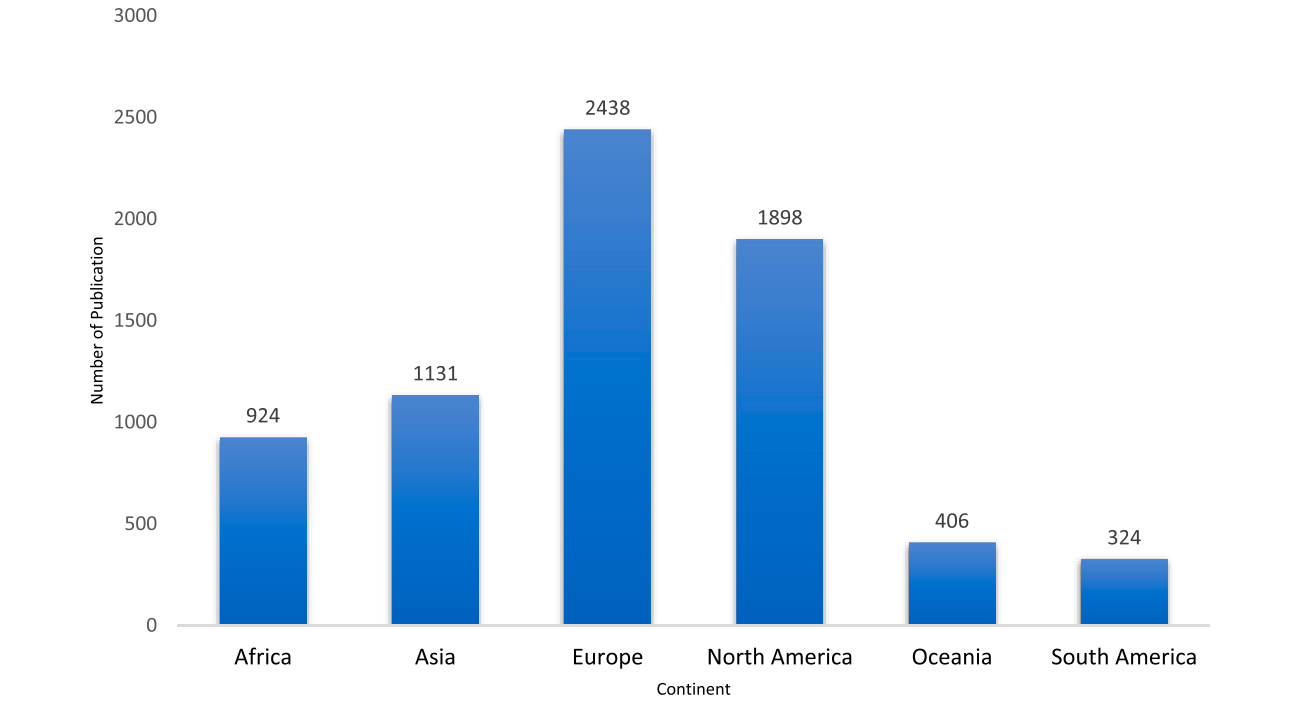


FIGURE 7
Number of publications by continent.

from 1,624 articles, followed by the United Kingdom with 23,811 citations (from 691 articles), Australia with 7,968 citations (from 351 articles), India with 7,270 citations, South Africa with 6,125 citations, Canada with 5,902 citations, and Germany with 5,892 citations. Other countries each have fewer than 5,000 citations. The number of citations generally reflects the quality and impact of the respective articles, as well-crafted studies tend to receive more citations from subsequent research.

TABLE 2 Number of publication and citation based on Top 15 Countries.

Country	No. of articles (N)	Total citation (TC)	TC/N
United States	1,624	436,777	268.95
United Kingdom	691	23,821	34.47
Australia	351	7,968	22.70
India	345	7,270	21.07
South Africa	280	6,125	21.87
Canada	270	5,902	21.86
Germany	284	5,892	20.74
Kenya	142	4,429	31.19
Norway	151	3,806	25.20
Spain	172	3,367	19.57
China	180	3,321	18.45
Netherlands	126	3,204	25.43
Sweden	115	2,550	22.17
Brazil	108	2,310	21.39
France	112	2,240	20.00

Table 2 also reveals notable TC/N values, particularly in Kenya and the Netherlands, where despite a similar number of articles, Kenya achieves a TC/N value of 31.19 with 142 articles, and the Netherlands 25.43 with 126 articles. This underscores the study's significant contributions and wide applicability within the scientific community, indicating robust collaborative networks and substantial research investments. Moreover, it underscores global acknowledgment of these contributions, highlighting each country's pivotal role in advancing knowledge within this field (Atkinson, 1995; Awang et al., 2021).

USA has the highest citation reflects the country's robust academic infrastructure, access to funding, and collaborative networks (Bozeman et al., 2013). Meanwhile, The United Kingdom follows at the second place, maintaining a strong presence in HWC research, likely driven by its historical ties to biodiversity-rich regions and advanced conservation policies (Fiasco and Massarella, 2022).

Other notable contributors include Australia, India, South Africa, Canada, and Germany, which collectively represent diverse geographical and ecological contexts (Baughn et al., 2007). Their contributions highlight the importance of addressing region-specific HWC challenges. However, countries such as Kenya and the Netherlands, with fewer articles, achieve high Total Citation per Number of Articles (TC/N) values (31.19 and 25.43, respectively). This indicates that their research outputs are particularly impactful, likely due to strong focus areas, collaboration, or innovative methodologies (Pohl et al., 2010). Kenya's high TC/N may also reflect the global relevance of its research, given its rich biodiversity and ongoing HWC issues.

Co-authorship among the regions

Research publications originating from various nations provide insights into their significance and influence in climate change and paddy field research. Figure 8 illustrates the structural framework of author cooperation networks across different regions. Circle sizes denote publication frequencies, while connecting lines between countries represent collaboration statuses, with line thickness indicating the intensity of cooperation.

According to Figure 8, collaboration among 150 nations, particularly the United States of America, United Kingdom, South Africa, Australia, and India, has notably expanded in the context of human-wildlife conflict studies. The United States of America leads with 319,935 link strengths, 436,777 citations, and 1,624 articles, followed by the United Kingdom with 209,713 link strengths, 23,821 citations, and 690 articles, Germany with 103,401 link strengths, 5,892 citations, and 282 articles, South Africa with 98,582 link strengths, 6,125 citations, and 280 articles, and Australia with 79,208 link strengths, 7,968 citations, and 280 articles.

In terms of clustering, the United States of America forms a group with several American continent nations like Mexico, Chile, Brazil, and Argentina, due to similar economic development levels, biodiversity hotspots, and robust conservation frameworks (Marchese, 2015). Similarly, the United Kingdom clusters with African nations such as Kenya, Congo, Senegal, and Cameroon, owing to historical ties and shared conservation challenges like poaching and habitat loss in savanna ecosystems with diverse wildlife populations.

European nations with advanced economies and cohesive environmental policies cluster together, addressing issues such as habitat preservation and wildlife corridors. South Africa aligns with nations like Uganda, Mozambique, Tanzania, and Namibia, while Germany collaborates with European counterparts like Norway, Poland, Denmark, and Italy. Meanwhile, Australia collaborates with India, Sri Lanka, Nepal, and Pakistan, sharing challenges related to dense human populations, biodiversity conservation, and specific

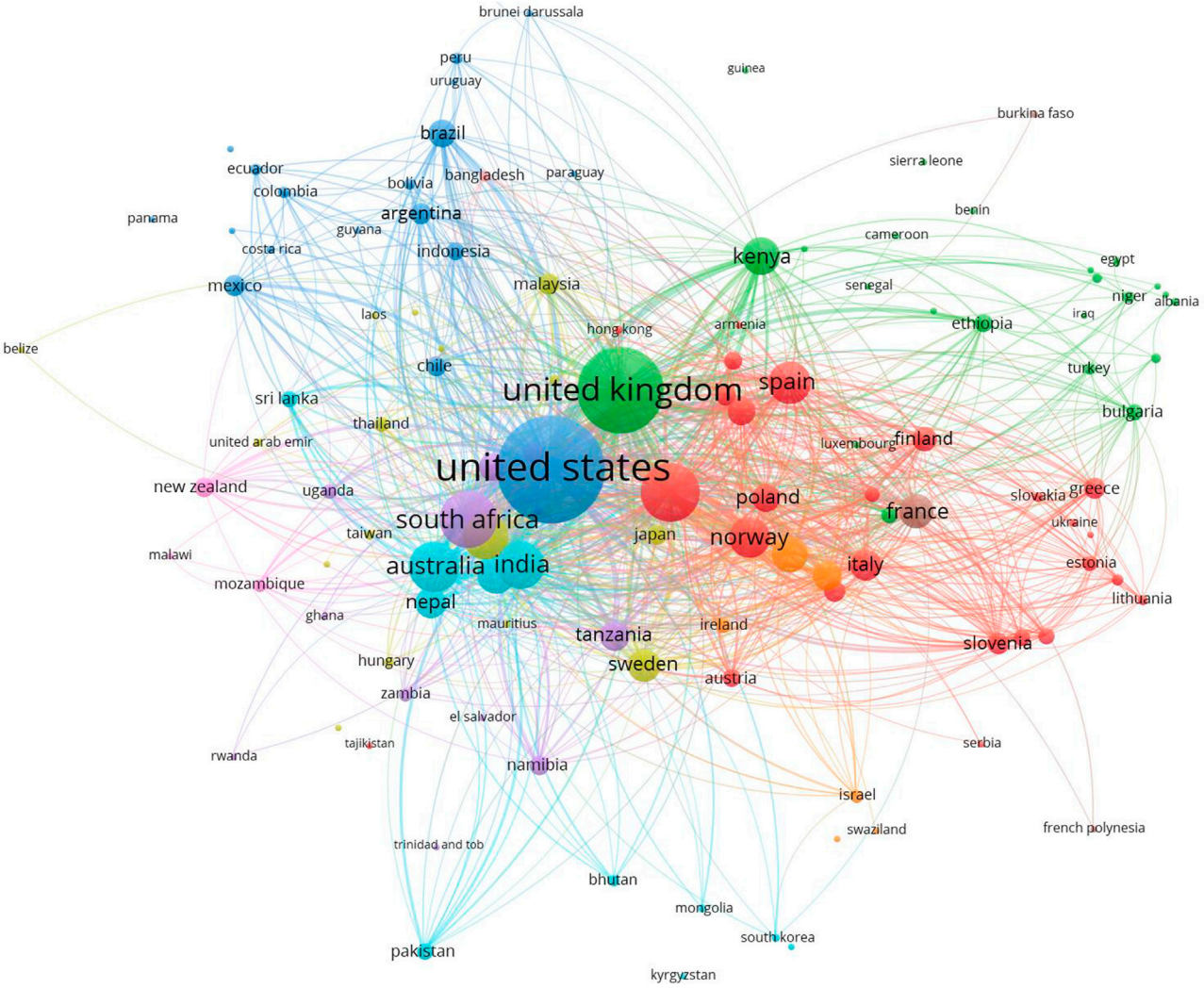


FIGURE 8
Analysis of publication based on countries.

human-wildlife conflicts involving large mammals. These collaborations reflect shared environmental concerns and collaborative efforts across diverse geographical regions (Hoffmann, 2022; Holechek and Valdez, 2018; Nunny, 2020).

Analysis of co-occurrence

The field of Human-Wildlife Conflict (HWC) has seen rapid growth, with a diverse range of studies exploring its ecological, socio-economic, and policy dimensions. To uncover prevailing themes and track research trajectories, this study conducted a keyword co-occurrence analysis of publications from 1990 to 2024. Keywords are valuable indicators of theoretical frameworks, research priorities, and knowledge gaps in HWC. Through this analysis, 197 frequently occurring keywords were identified and grouped into four primary clusters. These clusters reflect the thematic diversity of HWC research, as visualized in Figure 9. Node sizes in the co-occurrence network represent keyword frequency, line thickness denotes co-occurrence strength, and clustering highlights distinct research areas. Each cluster reveals essential insights into the complexities of HWC and its associated challenges.

Cluster 1 (red): human-wildlife management

This cluster examines strategies and practices aimed at managing interactions between humans and wildlife to mitigate conflicts and promote coexistence. A significant portion of research in this cluster addresses the consequences of human activities, such as urbanization, habitat fragmentation, and agricultural expansion, which disrupt wildlife populations and ecosystems. Key topics include habitat connectivity, wildlife population dynamics, and biodiversity conservation in urban and rural contexts.

Notably, studies highlight the role of urban green spaces and wildlife corridors in mitigating the effects of habitat fragmentation and facilitating wildlife movement. Research also emphasizes the importance of sustainable land-use planning and habitat restoration

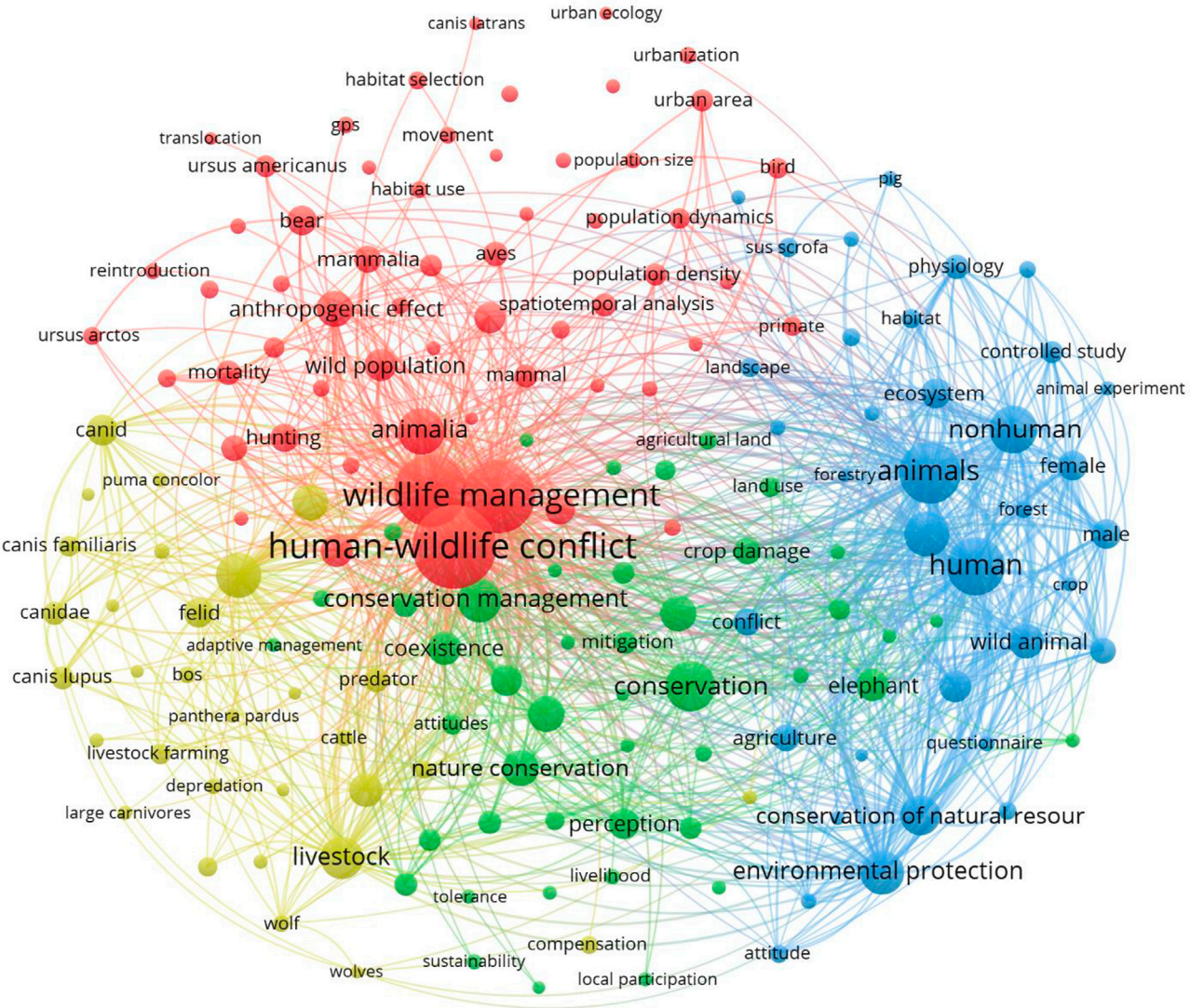


FIGURE 9
Analysis of Co-occurrence within publication.

to address human-induced pressures on ecosystems (Jamean and Abas, 2023). Furthermore, this cluster explores community-based conservation initiatives that engage local populations in wildlife management, fostering stewardship and reducing human-wildlife conflicts.

Another key theme involves the integration of technology in wildlife management, such as the use of GPS tracking, camera traps, and drone surveillance to monitor wildlife movements and mitigate potential conflicts. These technological advancements have enhanced the ability to predict and prevent human-wildlife encounters, particularly in areas where urban expansion encroaches on natural habitats (Soulsbury and White, 2015).

Cluster 2 (blue): human-animal physiology

This cluster focuses on the physiological and behavioral adaptations of wildlife in response to human activities and environmental changes. Studies within this cluster highlight the interconnectedness of wildlife health, ecosystem dynamics, and human influence. For example, agricultural practices, deforestation, and pollution significantly impact wildlife behavior and physiology, altering reproductive rates, stress responses, and movement patterns.

Research in this cluster underscores the importance of sex-specific studies, which reveal critical differences in how male and female animals respond to environmental stressors and human disturbances. These insights are crucial for understanding population dynamics and for designing targeted conservation interventions (Burger et al., 2007).

Moreover, this cluster highlights the role of education in raising public awareness about the ecological consequences of human actions. Public engagement campaigns focusing on wildlife health and its links to ecosystem services have been shown to foster greater support for conservation initiatives. Additionally, there is growing recognition of the need to integrate traditional ecological knowledge

with modern scientific approaches to better understand the long-term impacts of human activities on wildlife physiology and behavior (Foster et al., 2022).

Cluster 3 (yellow): human-carnivore conflict

This cluster delves into one of the most contentious aspects of HWC: conflicts involving carnivorous species such as lions, tigers, wolves, leopards, and jaguars. These conflicts often stem from livestock predation and competition for resources, posing significant challenges to human livelihoods and carnivore conservation efforts.

Studies in this cluster explore the behavioral ecology of carnivores, including hunting patterns, territoriality, and interactions with human settlements. The research highlights the critical ecological roles that carnivores play, such as regulating prey populations and maintaining ecosystem balance, while also addressing the socio-economic impacts of their predatory behavior on local communities.

Mitigation strategies are a central focus, with studies advocating for measures such as improved livestock enclosures, predator deterrents, and community-based compensation schemes to reduce retaliatory killings of carnivores. Additionally, habitat management practices, including reforestation and the creation of buffer zones, have been proposed to minimize human-carnivore interactions (Tshewang et al., 2021).

Another important area of inquiry involves understanding the cultural attitudes and perceptions of local communities toward carnivores. Research shows that traditional beliefs and cultural values can influence tolerance levels and support for conservation initiatives. As a result, integrating social and ecological perspectives is essential for designing effective coexistence strategies (Lozano et al., 2019).

Cluster 4 (green): conservation and policy

This cluster examines the policy frameworks and governance mechanisms necessary to address HWC and promote sustainable human-wildlife coexistence. Central to this cluster is the recognition that conservation challenges are inherently socio-political and require interdisciplinary approaches to balance ecological and socio-economic priorities.

A significant focus is placed on the role of protected areas, including national parks, wildlife reserves, and community conservancies. Studies highlight the importance of adaptive management strategies that account for climate change, land-use changes, and shifting species distributions. Policy interventions that incorporate local knowledge and stakeholder engagement are emphasized as key to the success of conservation initiatives.

Furthermore, this cluster explores the economic dimensions of conservation, such as the use of incentives, subsidies, and eco-tourism to support biodiversity preservation. Research also highlights the importance of transboundary conservation efforts, particularly in regions where wildlife populations migrate across political borders. Collaborative approaches between countries are essential to address shared conservation challenges and mitigate conflicts in these areas (Selier et al., 2016).

Another emerging theme is the integration of conservation goals into broader development agendas. By aligning conservation policies with objectives such as poverty reduction, food security, and climate resilience, policymakers can create synergies that benefit both human communities and wildlife. This cluster underscores the need for robust policy frameworks that are flexible, inclusive, and responsive to changing environmental conditions (Fehlmann et al., 2021).

Holistic perspectives and implications

The expanded insights from these clusters reflect the interdisciplinary and dynamic nature of HWC research. By synthesizing knowledge across ecological, physiological, socio-economic, and policy domains, researchers and practitioners can develop comprehensive strategies to address the root causes of conflicts and foster sustainable coexistence.

The findings also emphasize the importance of collaboration among diverse stakeholders, including governments, non-governmental organizations, local communities, and the private sector. Integrating technological innovations, traditional knowledge, and adaptive management practices can enhance the effectiveness of conservation efforts in increasingly complex landscapes.

Ultimately, the co-occurrence analysis provides a roadmap for future research and policy development, offering valuable insights into the interconnected challenges of HWC. As human populations grow and environmental pressures intensify, addressing HWC will require sustained commitment and innovative solutions to balance the needs of people and wildlife in a shared world.

Future research directions

Interdisciplinary approaches

Future research on human-wildlife conflicts must adopt interdisciplinary approaches to address the complex interplay between ecological and social dimensions. Integrating social sciences with natural sciences allows for a more comprehensive understanding of the factors driving these conflicts. While social sciences provide critical insights into human behavior, cultural dynamics, and societal impacts, natural sciences focus on wildlife behavior and ecological patterns. This combination fosters the development of holistic solutions that are scientifically robust, socially acceptable, and practically implementable (Volski et al., 2021). For example, coupling ecological data on wildlife movements with data on community attitudes can lead to tailored strategies that balance conservation goals with human livelihoods.

Human dimensions of wildlife conflict

The human dimensions of wildlife conflict remain underexplored, yet they are integral to effective conflict management. Research should focus on understanding human perceptions, attitudes, and behaviors toward wildlife, recognizing

that these can vary significantly across cultural, economic, and social contexts (Bhatia et al., 2020). Community-based approaches that engage local stakeholders in conservation efforts have shown promise in fostering acceptance and sustainability. For instance, culturally sensitive education and intervention programs can address misconceptions about wildlife and encourage coexistence. By prioritizing community engagement, conflict management strategies are more likely to gain local support and achieve lasting impact.

Wildlife management and conservation strategies

The rapid pace of urbanization necessitates focused research on urban wildlife management. Urban and peri-urban areas face unique challenges, including habitat fragmentation, pollution, and increased human-wildlife interactions. Leveraging technological innovations such as drones, GPS tracking, and camera traps can significantly enhance wildlife monitoring and conflict prediction (Chisom et al., 2024). These tools allow for real-time data collection, enabling adaptive and responsive management practices. Additionally, urban conservation strategies should address habitat connectivity and the creation of green corridors to reduce the likelihood of conflict.

Climate change and wildlife

Climate change is a significant driver of shifts in wildlife behavior, habitat use, and distribution, increasing the frequency of human-wildlife interactions. Research must explore the effects of climate change on resource availability, migration patterns, and species adaptability (Abrahms et al., 2023). Adaptive management practices that account for these changes are crucial to mitigating future conflicts. For example, flexible conservation strategies, such as dynamic land-use planning and climate-resilient habitats, can help wildlife and human communities adapt to evolving environmental conditions.

Policy and governance

Effective human-wildlife conflict management requires strong policies and governance frameworks. Identifying gaps in existing policies and proposing improvements is essential to enhancing their effectiveness. Inclusive governance that involves local communities, governments, NGOs, and other stakeholders is critical for fostering coexistence (Marino et al., 2021). Policies should prioritize stakeholder engagement, ensuring that the voices and needs of affected communities are integrated into decision-making processes. Such inclusive approaches promote equitable solutions and reduce resistance to conservation initiatives.

Addressing spesies-specific wildlife conflicts

Targeted research on species-specific conflicts is vital for developing effective mitigation strategies. Conflicts involving large carnivores, crop-raiding herbivores, and other high-impact species often require tailored approaches. For instance, understanding the ecology of crop-raiding elephants or predatory behaviors of large felids can inform the design of sustainable deterrents (Wilkinson et al., 2020). Non-lethal methods, such as habitat management and compensation schemes, can help balance conservation priorities with the protection of human livelihoods.

Education and public awareness

Public education and awareness are fundamental to building a supportive foundation for wildlife conservation. Research should explore innovative approaches to communication, including storytelling, social media campaigns, and community outreach, to shift public perceptions and foster coexistence (Kansky, 2020). Educational programs must be evaluated to ensure they effectively convey the importance of conservation and the mutual benefits of human-wildlife harmony. Engaging younger generations through school programs and interactive learning initiatives can create long-term attitudinal shifts toward wildlife conservation.

Global comparative studies

Conducting global comparative studies offers valuable insights into the shared challenges and solutions in managing human-wildlife conflicts. Such studies facilitate knowledge exchange across regions, highlighting best practices and adaptable strategies. For example, the robust conservation frameworks in biodiversity-rich regions of the Americas may provide lessons for African countries dealing with habitat encroachment and poaching (Facchini et al., 2023). Tailoring strategies to specific ecological and socio-cultural contexts ensures their effectiveness. Comparative studies also help identify scalable solutions that address the unique needs of diverse communities and ecosystems (Abas et al., 2023).

Conclusion

A total of 4,822 articles were found in the study of human-wildlife conflict. This study has been researched by a total of 4,065 authors widely all over the world, which most studies came from United States of America. This study also analyzed 4 type of clusters which are: a) Human-wildlife management, b) Human-animal physiology, c) Human-carnivore conflict, and d) Conservation and policy. The study of human-wildlife conflicts (HWC) has garnered significant research interest, reflected in publications spanning 24 subject categories in the Scopus Database. Most publications fall within Environmental Science, followed by Agricultural and Biological Sciences, and Social Sciences, among others. The predominant focus on science and technology (89% of publications) underscores a strong emphasis on wildlife aspects such as behavior, diet, genetics, and ecology. However, the increasing recognition of the need for social sciences research highlights the importance of understanding the human dimensions of these conflicts. The rise in publications,

particularly from 1990 to 2024, with a peak in 2021, reflects the growing importance of studying HWC due to ongoing challenges posed by human encroachment on wildlife habitats and climate change.

This research significantly contributes to community awareness and conservation efforts. By elucidating the multifaceted nature of HWC, the study underscores the necessity of educational initiatives to inform communities about the impacts of their actions on wildlife and the importance of coexistence. Tailoring conflict resolution strategies to specific local contexts, considering unique community behaviors, cultures, and beliefs, promotes more effective and sustainable outcomes. Insights from the study aid in developing improved wildlife management practices, particularly in urban areas and fragmented habitats, and in protecting endangered species and their habitats, thereby preserving biodiversity.

The findings also provide valuable data and insights for policy-making, leading to more effective conservation management and conflict resolution strategies. Emphasizing the involvement of various stakeholders—from local communities to governments and NGOs—assists in crafting comprehensive and inclusive policies. Integrating interdisciplinary approaches, which combine science and social sciences, enhances the understanding of HWC. Analyzing keywords and clustering topics provides a clear depiction of the primary focus areas in HWC research, guiding future studies and knowledge development. Overall, this study underscores the increasing complexity and importance of addressing human-wildlife conflicts through a multidisciplinary approach, significantly contributing to community literacy, conservation efforts, sustainable practices, policy formulation, and the advancement of knowledge in this critical field. This study also has several limitations such as only use one database which is Scopus, limited keywords and focus on the bibliometric analysis.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

AA: Conceptualization, Funding acquisition, Methodology, Supervision, Writing–original draft, Writing–review and editing. AR: Writing–original draft. TM: Conceptualization, Project administration, Software, Writing–review and editing. AY: Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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