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A bibliometric analysis of pro-environmental behavior research and social media based on WoS database

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Abstract:
Social media not only serves as a vital platform for information acquisition and social interaction but also acts as a significant driving force for research on pro-environmental behavior. It can shape users' values and behavioral intentions through incentives and advocacy. Consequently, investigating the link between social media use and pro-environmental behavior is significantly important. Based on this observation, this study conducts an econometric analysis of the literature in the domain of social media use and pro-environmental behavior using CiteSpace software. The findings indicate a substantial increase in the quantity of literature in this area in recent years, suggesting a growing research interest. The primary research concentrations are on sustainable fashion, sustainable transportation, and sustainable consumption. Ultimately, it is anticipated that this study will substantially assist researchers in understanding the latest developments in social media use and pro-environmental behavior research, offering valuable references and insights for future studies in related fields.

Keywords:
Pro-environmental behavior; Social media; CiteSpace

1. Introduction

Social media has become an important platform for information dissemination and communication in today's world. It has a close and far-reaching connection with sustainable behavior. Regarding information dissemination, social media offers a broad channel for promoting sustainable behavior, thereby increasing public attention to sustainable issues. In terms of communication and interaction, users can initiate discussions about sustainable behavior via social media, share their personal perspectives and experiences, and engage in conversations with other users. This interaction aids in raising awareness about environmental protection and encourages more active participation in sustainable behavior. Therefore, studying the relationship between social media use and sustainable behavior holds significant practical value. While academia has seen some research on the impact of social media on tourists' behavior (Michaelson & Stacks, 2011), there has been a lack of exploration into the link between social media and tourists' sustainable behavior. Furthermore, there are even fewer studies that have employed bibliometric methods to examine this relationship. To address this gap, this paper employs bibliometric methods to delve into the relationship between social media and sustain-

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able behavior within the context of sustainable development. The aim is to determine the volume of literature, leading research institutions, and key researchers in this area. The structure of the paper is as follows: first, the retrieved data are mapped and analyzed. Next, this study reviews the clustering of research and emerging trends in the field of social media and sustainable behavior. Finally, the study draws conclusions and highlights the limitations of the study.

2. Methodology

2.1. Data collection

In this study, the authoritative database, Web of Science, was used as the basic data source, and the Social Sciences Citation Index (SSCI) was selected as the citation database of the core collection. By searching with the keywords “online”, “social media” and “sustainable behavior”, we have collected a list of the most popular and most popular articles in the period from 1995 to 2024. A total of 1,789 articles published between 1995 and 2024 were collected. After carefully screening the literature with low relevance to the research topic, 1289 relevant papers were identified and exported in TXT format.

2.2. Bibliometric Approach

CiteSpace(Chen, 2004) is an open-source visualization software developed by Prof. Chaomei Chen and based on Java platform. The software is able to deeply mine and visualize a large amount of academic data to reveal information such as key authors, top research institutions, and popular keywords in the subject area. Among many literature analysis tools, CiteSpace is widely praised for its excellent visualization effect and wide applicability, especially in the field of econometrics research.

Bibliometric analysis is used to understand, organize, and synthesize the structure of knowledge within a field. It also allows for the visualization of cognitive structures through scientific mapping and provides a reference for subsequent research studies (Zhang, Wang, Sun, & Wei, 2020). Therefore, this study employs bibliometric analysis to examine the progress of research on pro-environmental behavior and social media. By combing the related literature, this study can clearly show the development history of the field. In this paper, this study firstly depict the current status of pro-environmental behavior research and social media from the dimensions of performance analysis, core authors, and collaboration network analysis; then, this study reveal the research hotspots in this field through the analysis of keyword co-occurrence mapping; then, with the help of clustering analysis, this study identify the core themes of the research; and finally, through the analysis of the emergent words, this study trace the cutting-edge dynamics in this field. After an in-depth discussion of the development trend and core topics in the field, this paper summarizes the overview, hot topics, and future research directions in the field of pro-environmental behavior research and social media.

3. Results

3.1. Annual analysis of publications

The annual distribution of the amount of research literature on pro-environmental behavior research and

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social media between 1995 and 2024 is shown in Figure 1, and it is worth noting that the data for 2024 is only incomplete. It can be clearly observed from Figure 1 that the number of relevant studies was relatively low from 1995 to 2013. However, since 2014, the number of related publications has shown a continuous upward trend, especially between 2019 and 2021, the research in this field has grown rapidly, and reached a peak in 2021 with a total of 244 publications. This trend indicates that pro-environmental behavior research and social media as a research topic is gradually gaining attention from academia and researchers in general. Nonetheless, there is a decreasing trend in the amount of literature published between 2022 and 2023.

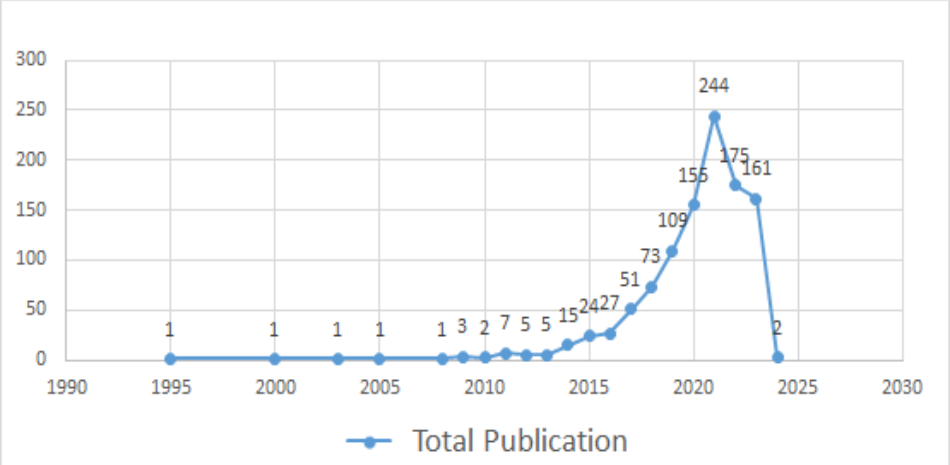


Fig. 1. Number of documents related to pro-environmental behavior research and social media per year.

3.2. Collaboration network analysis

3.2.1. Author collaboration network

Collaborative network analysis explores the collaborative relationships that exist between scholars during the knowledge production process, helping to understand the dissemination and diffusion of scholarly knowledge, and to identify influential research institutions and scholars. This study examines the collaborative networks of institutions and authors (La, Xu, & Buhalis, 2021). Taking the selected Web of Science as the research basis, CiteSpace software was used to obtain the co-occurrence knowledge map of authors (Figure 2). The larger font size in the map represents the higher number of authors' publications, and the higher density represents the stronger academic cooperation relationship among authors. As can be seen in Figure 2, the authors with the most publications are D. Acuti and A. Spiller (both with 3 publications), and other scholars are S. Kraus, C. M. J. Armstrong, R. L. Piligrimiene, C. M. Hall, etc., these scholars play a crucial role in the academic map and form important nodes with far-reaching influence. The collaborative links between research teams are relatively strong, and together they have constructed a broad academic consensus. In terms of the network of collaborative relationships S. F. Persada, A. P. Lertpratchya, A. Zwickle, etc. have relatively more academic collaborations with other scholars, whereas authors such as A. Spiller and A. Al. Mamun are relatively independent in their research and have not established a certain degree of collaborative relationships with other authors.

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Fig. 2. Visualization of the author collaboration network.

3.2.2. Institutions collaboration network

The analysis of institutional collaborative networks helps to illustrate the relationship between institutions focal in pro-environmental behavior research and social media, and can reveal the institutions' influence(Zhang, Wang, Sun, & Wei, 2020). In this study, Web of Science was selected as the data base for the research, and CiteSpace software was used to generate a knowledge map of the co-occurrence of publishing organizations (Figure 3). In a collaborative network, the size of the nodes indicates the number of articles published by the corresponding organization (Zhang, Wang, Sun, & Wei, 2020). According to Figure 3, it can be seen that academic institutions such as Hong Kong Polytech University (8 articles), Bucharest University Econ Studies (8 articles) and Aarhus University (7 articles) have published a significant number of articles in this field. Which reflects that these institutions have actively carried out academic exchanges and cooperation at home and abroad, and thus have obtained more academic resources and research opportunities. resources and research opportunities. Meanwhile, institutions such as Virginia Tech and UIm University are not linked in the map, which may mean that the research of these institutions focuses more on their internal teams, and there is relatively less communication and cooperation with other research institutions. Nonetheless, as a whole, the relatively dense inter-institutional connectivity shows that an extensive network of academic collaborations has been formed.

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Fig. 3. The collaboration network of institutions.

3.3. Keywords analysis

The analysis of keyword co-occurrence is highly significant as it assists researchers in uncovering trends and the underlying structure of a research field. Furthermore, this analytical method can aid in illustrating the architecture of knowledge within scientific literature (Giraldo et al., 2019). This study primarily uses keywords as the node type for data visualization and analysis, and accordingly constructs a keyword co-occurrence network mapping, as shown in Figure 4. This mapping clearly shows the associations and co-occurrence status between keywords, providing robust support for a deep understanding of the research topic. In Figure 4, this study selected keywords with a frequency greater than 60 out of the 467 extracted keywords and analyzed a total of 14 high-frequency keywords, as presented in Table 1.

These 14 high-frequency keywords related to ‘pro-environmental behavior research and social media’ reflect the research focus of this field. The research is multifaceted and includes the following aspects: first, from a psychological perspective, it addresses ‘perception’, ‘attitude’, ‘intention’ and ‘behavior’ aiming to delve into the psychological activity paths of individuals and groups and to comprehend the public’s psychological needs and behavioral patterns. This provides a scientific basis for environmental education and the motivation to engage in environmental behavior. Second, from the angle of green consumption, the text refers to ‘consumption’, ‘sustainability’ and ‘sustainable consumption’ suggesting that academic researchers view consumption behavior as a significant influence on the ecological environment and societal development, endeavoring to explore a greener, more sustainable lifestyle. Third, through factor analysis, the study focuses on ‘impact’ and ‘determinant’ aiming to reveal the extent of influence different factors have on sustainable behavior and their determinative roles, and to formulate effective intervention strategies accordingly to foster the development of sustainable behavior. Lastly, from the perspective of information technology, the text covers keywords like ‘information’ and ‘social media’ examining how to better utilize digital platforms, such as social media, to advance the dissemination and exchange of knowledge, with the goal of promoting the development of sustainable behaviors through technological innovation and application.

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Fig. 4. The network of keywords.

Table 1 Analysis of high-frequency keywords.

Number	Keyword	Freq	Centrality
1	behavior	210	0.16
2	impact	134	0.01
3	attitude	111	0.06
4	consumption	111	0.06
5	sustainability	107	0.04
6	model	107	0.01
7	intention	91	0.04
8	social media	91	0.01
9	consumer	84	0.03
10	planned behavior	80	0.03
11	perception	74	0.04
12	determinant	66	0.04
13	information	64	0.06
14	sustainable consumption	61	0.02

4. Research themes

Research clustering involves analyzing multiple research objects, categorizing research objects with similar characteristics, and then conducting in-depth refinement and summarization for each category, ultimately forming representative research themes. This method not only helps to clearly grasp the research focus of the field, but also reveals the vein and trend of the research field. Based on the core concept of green sustainable development, this study divided the 10 themes into 5 categories, as shown in Figure 5.

Category 1: Sustainability Insights from a Multi-Dimensional Perspective involves Clusters 2, 3, 5 and 8.

Cluster 2 focuses on sustainable fashion, exploring how to realize environmentally sustainable fashion in-

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dustry practices while meeting the needs of consumers and producers. The cluster advocates the integration of the concepts of ‘low carbon, green, healthy and smart’ into all aspects of the fashion industry chain, including production, design, consumption and recycling. Currently, the development of sustainable fashion has benefited from the joint efforts of many parties. Brands have been adhering to the concept of sustainable development from the very beginning of their founding and have been conveying relevant information to consumers (Turunen & Halme，2021); designers are also trying to find ways to realize ‘zero pollution’ and ‘zero waste’ of their products; in addition, with the rapid progress of information technology and the wide dissemination of social media, consumers have become more aware of environmental protection and the importance of environmental protection. In addition, with the rapid progress of information technology and the wide dissemination of social media, consumers' awareness of environmental protection and responsibility has gradually increased, and they have begun to pay attention to and participate in sustainable fashion consumption.

Cluster 3 focuses on sustainable diets and explores how to ensure that human nutritional and health needs are met while minimizing negative impacts on the environment and ecosystems. According to the 2010 definition, a sustainable diet is one that has a low environmental impact, contributes to food and nutrition security, and is conducive to a healthy life for current and future generations. It is also concerned with the conservation of biodiversity and ecosystems, as well as balancing cultural, economic, nutritional and health aspects (Burlingame & Dernini，2010). This clustering focuses on the sustainability of the food system, including aspects of food safety, food waste, organic farming, and nutritional health.

Cluster 5 explores sustainable transportation, discussing how to use modern technology to achieve ‘green mobility’ in order to build a developed and sustainable transportation network. Conventional transportation systems are inadequate in terms of safety, comfort and energy, and do not meet the requirements of sustainable development or the needs of the times. Therefore, in order to ensure efficient transit of goods and high-quality transportation services (Ogryzek，Adamska-Kmieć，& Klimach，2020), it has become inevitable to develop a green transportation network with the goal of sustainable development, which plays an important role in the sustainable development of space and provides access to economic and social opportunities for all communities (Richardson, 2005). The cluster includes topics such as bike sharing, public transportation, and walking, and aims to promote the development of a green transportation sector for a low-carbon transition.

Cluster 8 emphasizes the importance of consumer behavior in sustainable food consumption practices. Sustainable food consumption includes reducing food waste, shifting to a ‘climate-friendly’ diet (Alfredsson, 2004), changes in the way food is purchased such as biking or walking instead of driving to distant supermarkets (Hesselgren, & Hasselqvist, 2016，Hasselqvist, Hesselgren, & Bogdan, 2016) , changes in the use of refrigerants (retail or home), and changes in the way energy is used for food preparation (Shrinivasan et al., 2013). The clustering explores consumer behaviors in terms of environmentally friendly purchasing, healthy food choices, and sustainable food handling to achieve sustainable food consumption.

Category 2，The importance of policy support is particularly emphasized, as represented by the findings of clustering 23.

Cluster 23 focuses on the study of national parks, which mainly focuses on the protection of the ecological

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environment and aims to realize the sustainable development of the natural environment. Its development path focuses on recreation management and community participation. However, the construction of the national park system is a complex project, which not only requires the joint efforts of the general public, but also the strong support of the government. Since the ecological protection of national parks restricts the development of rural areas to a certain extent (Xue & Gao, 2020), a new compensation mechanism should be introduced into the ecological environmental protection work of national parks. Jiang Yuanxun, a deputy to the National People's Congress, suggested that the Ecological Compensation Mechanism of National Parks should be introduced at the national level, exploring the establishment of an innovative ecological protection compensation mechanism based on financial compensation, supplemented by diversified compensation such as technology, in-kind compensation and employment, and realizing the standardization and systematization of ecological compensation (Armitage et al., 2020). In addition, by publishing and implementing a series of tourism management policies online, the government can raise tourists' awareness of ecological protection and ensure that their behavior is in line with ecological ethical standards. In terms of community participation, the government's policy support can promote the participation of community residents, for example, through ecological compensation, improve the management system and other ways to mitigate the impact of the construction of national parks on the local residents, thus increasing the willingness of residents to participate in the community (Jia, Wei, & Wang, 2022).

Category 3: Focuses on the collection and analysis of informational material and includes clustering 6.

Overview of Cluster 6: This cluster focuses on systematically categorizing, dissecting and aggregating research in the field of sustainability, covering a wide range of dimensions such as sustainable innovation, economy, society and environment. Through in-depth exploration and precise refinement of these dimensions, this study aims to develop a comprehensive grasp of the current state of research on the topic. This approach helps to evaluate the development history and effectiveness of specific research areas, thereby revealing under-explored research areas and planning future research directions.

Category 4: Focuses on the specifics of the implementation process and includes clusters 0 and 1.

Cluster 0 Consumer Engagement: This cluster focuses on consumers' attitudes, willingness and behaviors to engage in sustainable practices. In promoting sustainable consumption, the key lies in stimulating consumers' active participation (Piligrimien et al., 2020), because consumers' attitudes can be transformed into behavioral intentions, which in turn guide actual behaviors. Therefore, policy guidance and online publicity and education can be used to enhance consumers' awareness of environmental protection, raise their environmental awareness and sense of responsibility, and cultivate green consumption concepts.

Cluster 1 Ethical Consumption: emphasizes the consideration of social responsibility, ethics and environmental protection in the consumption process. Research has shown that ethical considerations guide decision-making, influence policy and practice, and promote behavioral accountability (Wang, Chen, & Tawiah, 2023). This cluster focuses on consumer behavior and promotes the concept of ‘healthy, environmentally friendly’ consumption, encouraging consumers to take environmental responsibility into account when making purchasing decisions, in addition to product quality and safety.

Category 5: focuses on ways and means of implementation and includes clusters 7 and 32.

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Cluster 7 and 32 focus on ways and means of implementing sustainable practices. The keywords extracted under this category are 'social media marketing', 'digital marketing' ,'eco-marketing' ,'green marketing' ,'eco-marketing' ,'green marketing' and 'sustainable marketing'. This indicates that these two clusters mainly explore how to improve marketing effectiveness through innovation, while also considering the fulfillment of social responsibility and environmental protection. With the development of society and the rapid progress of the Internet, 'social media marketing' and 'digital marketing' have become the core of marketing activities of enterprises. They mainly emphasize expanding brand influence through online platforms, rapidly increasing market share, and effectively connecting with customers. On the other hand, 'eco-marketing', 'green marketing' and 'sustainable marketing' advocate the integration of green concepts into marketing activities in order to realize the common development of self and society, and achieve win-win goals. The goal of 'Eco-marketing', 'Green Marketing' and 'Sustainable Marketing.'

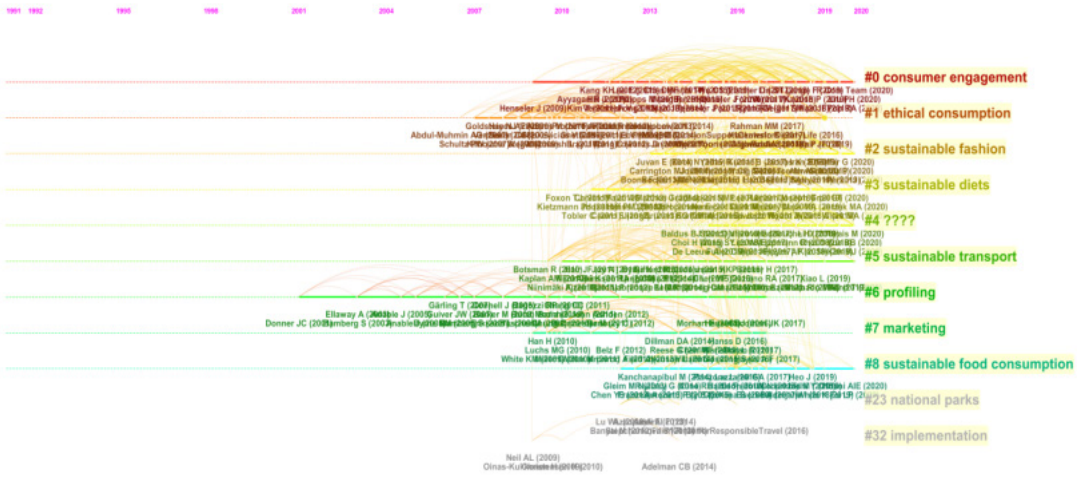


Fig. 5. Keyword clusters network.

5. Analysis of emergent words

In this paper, this study use CiteSpace software to map the knowledge map of the network of emergent words in the field of pro-environmental behavior research and social media, thus visualizing the frontiers and trends in the field. By analyzing the top six emergent keywords (shown in Fig. 6), this study reveals the research dynamics in the field.

First, the keyword 'internet' emerged in 2011 with an intensity of 5.3782, indicating the growing importance of the internet in sustainable development research. Research shows that about 85% of IoT deployments are expected to address the SDGs (López-Vargas, Fuentes, & Vivar, 2020).

Second, the emergence of the keyword 'attitude' in 2014 emphasizes the impact of individual attitudes on sustainable development. Attitude not only influences individual behavior, but also has a profound impact on society and the environment. Therefore, fostering positive attitudes through education and changing or developing attitudes that support sustainable development are important elements of ESD. For example, UNESCO promotes the concept of education centered on promoting the SDGs (Rieckmann, 2017).

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Third, the emergence of the keyword 'conservation' in 2015 highlights the strong link between conservation and sustainable development. Conservation is the foundation of sustainable development, while sustainable development provides the impetus for conservation. Community-centered conservation requires more inclusive and just governance principles to guide future development (Armitage et al., 2020).

Fourth, the keyword ‘sustainable tourism’ emerged in 2017 with an intensity of 4.6203, reflecting the growing interest of scholars in sustainable tourism development. The study concludes that the impact of sustainable tourism on economic growth is noteworthy and needs to be expanded to include related terms such as trade openness, pollution, energy consumption, and globalization (León-Gómez et al., 2021).

Finally, the keywords ‘purchase intention’ and ‘COVID-19’ emerged in 2021 with an intensity of 3.6724 and 4.9888, respectively. This year, the global outbreak of COVID-19 had a profound impact on the global economy, society and personal life. The epidemic and government measures led to changes in consumer purchase intentions and behavior. Studies have shown that due to the closure of malls, restaurants and markets due to the outbreak, people turned to online purchases, thus increasing the number of consumers on online shopping sites (Ait Youssef, Jaafari, & Belhcen, 2020).

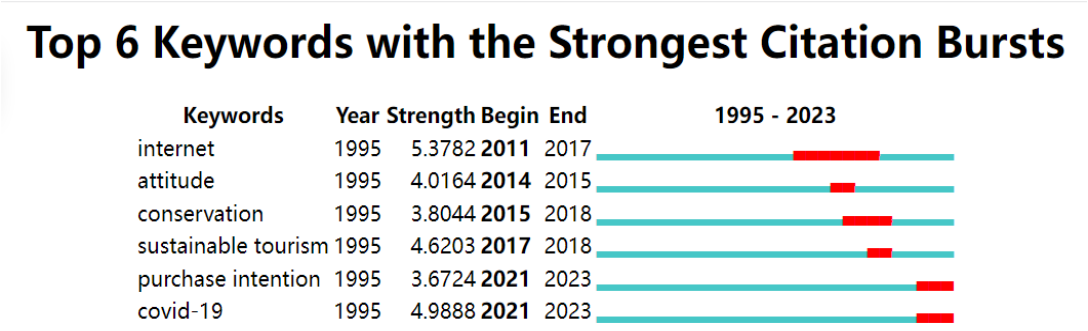


Fig. 6. Results of research fronts analysis.

6. Conclusion

An analysis of data on annual postings shows that research on pro-environmental behavior research and social media has been growing overall, but has seen some decline over the past two years. This phenomenon may indicate that research in this area is maturing and that scholars have explored the topic in depth. As research deepens, some of the early hot topics may have been well researched, and the academic focus on pro-environmental behavior research and social media may have changed, which in turn has affected the number of publications. In terms of lead authors, D. Acuti and A. Spiller contributed the most with three articles each. However, in terms of collaborative networks, S. F. Persada, A. P. Lertpratchya and A. Zwickle have collaborated more frequently with other scholars. Additionally, Hong Kong Polytechnic University (8 articles), Bucharest University of Economic Studies (8 articles), and Aarhus University (7 articles) have published the largest number of articles, indicating that these institutions are at the forefront of research in this field.

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Keyword co-occurrence and cluster analysis reveal key topics in pro-environmental behavior research and social media. By analyzing the keyword co-occurrence network mapping, this study found that academic research in the field of pro-environmental behavior research and social media mainly focuses on the core concepts of 'consumption', 'behavior', 'attitude' and 'sustainability.' These high-frequency keywords not only highlight the research hotspots in the field but also point to cutting-edge issues. However, the role of social media and online platforms in academic research is not significant, which may indicate that these areas still need to be explored in depth. In the keyword clustering analysis, the research foci can be categorized into five main categories: core themes, policy support, information preparation, concrete operations, and implementation methods. This suggests that in studies on the areas of fashion, diet, transportation, and food consumption, scholars generally agree that achieving the SDGs requires the concerted efforts of all three parties: government, business, and the public. This finding emphasizes the importance of multi-stakeholder collaboration in advancing sustainable behaviors.

By analyzing the distribution of emergent words, this study finds that there is a close connection between the hot words in two consecutive years. This reflects the continuity and coherence of the research content. In the early stages of the sustainability research field, the research hotspots primarily focused on the influence of the Internet on sustainable behavior. Subsequently, scholars noticed that through interaction and sharing, consumers' knowledge of tourism products becomes deeper, forming a more rational consumer attitude and tending to adopt behaviors that protect the environment. With the increase in environmental awareness, 'sustainable tourism' has gradually become a new research hotspot, and the focus of research has begun to shift to how to provide tourists with a greener and more environmentally friendly tourism experience. However, the outbreak of COVID-19 in 2021 brought an unprecedented impact to the global tourism industry. In this context, scholars have begun to focus on health and safety issues and explore how these factors affect consumer purchase intentions and behavior. Due to factors such as the risk of infection and financial crisis, consumers' purchase intentions and behaviors have changed significantly. In order to better meet consumers' needs and increase their confidence in purchasing, scholars have begun to delve deeper into the underlying drivers of the 'willingness to buy' and provide companies with targeted strategies for sustainable development.

7. Limitations and future research

In this study, a knowledge graph construction method was used to analyze the frontiers and trends of pro-environmental behavior research and social media. However, there are some potential problems in the process of data grooming and summarization. First, as the data screening process relies on manual work, this may lead to incomplete data or mistakenly selecting data that do not match the research topic; second, when selecting keywords related to pro-environmental behavior research and social media, it may not adequately cover all the relevant semantics, which limits the breadth of the study; and lastly, due to the limited ability of individuals to analyze and summarize the data, in-depth digging into the online

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