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Unlocking the Essence of Conservation Literacy: A Systematic Literature Review

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ABSTRACT

In the modern era, addressing the intricate challenges of natural resource conservation requires a deep societal understanding, often encapsulated in the evolving concept of "conservation literacy." This concept's definition and scope are still developing, necessitating a systematic literature review to unravel its true essence and global significance. Our objective was to compile a comprehensive understanding of conservation literacy using articles from Scopus-listed journals. Employing the keyword "conservation literacy," we identified 188 articles, of which 28 met our analysis criteria based on PRISMA guidelines. The publications exhibited a trend of growth from 2019 to 2022, followed by a decline. Various methodologies, including qualitative, quantitative, and mixed methods, addressed issues related to conservation literacy. Dirk Brounen emerged as a prominent author, and keywords such as literacy, developing country, energy literacy, and natural resource conservation were frequently used. Collaboration between universities within and across countries was common, with 33 institutions providing funding. Most publications adhered to ethical standards by disclosing funding sources. Our review yielded insights into the topics, aspects, and conceptualization of conservation literacy, providing a foundation for further research tailored to diverse backgrounds and objectives.

1. INTRODUCTION

The conservation of natural resources is becoming increasingly urgent due to various environmental issues that threaten the sustainability of our planet. Some of the most pressing challenges in natural resource conservation include climate change [1-3], ecosystem degradation [4-6], biodiversity loss [7-9], deforestation [10-12], pollution [13-15], unsustainable resource use [16-18]. Efforts to address these challenges not only require policies and technical actions but also a deep understanding and broad public engagement in conservation. Therefore, conservation literacy becomes an essential element in fostering awareness and sustainable actions.

Currently, the sustainability of ecosystems and the balance of nature are the key foundations for maintaining life on this planet [19, 20]. Natural elements such as water, air, soil, and biodiversity provide crucial ecosystem services that support human life and other organisms [21, 22]. Understanding the relationship between humans and the environment is crucial to avoid further ecosystem degradation [23, 24]. Consequently, sustainable actions, such as wise resource management and the application of environmentally friendly technologies, must be implemented to mobilize society in conservation efforts [25, 26]. Only through collective understanding and action can ecological balance be maintained and natural resources protected for future generations.

In this context, conservation literacy is not only important for increasing public understanding of conservation issues but also for facilitating behavioral changes that support sustainability. Conservation literacy encompasses the knowledge, skills, and attitudes needed to understand, appreciate, and contribute to the conservation of natural resources. This is becoming increasingly crucial in light of global sustainability challenges such as climate change, resource scarcity, and biodiversity loss [27].

Although conservation literacy plays a key role in promoting sustainable actions, this concept still requires further clarification. Existing research on conservation literacy tends to be fragmented, with varying focuses on specific aspects such as environmental education or biodiversity awareness. However, this literature often lacks consistency in its definitions and conceptual approaches, leading to a lack of comprehensive understanding of how conservation literacy can be measured, applied, and enhanced. Some studies have highlighted the importance of species literacy and biodiversity awareness in engaging the public in conservation, but other aspects of conservation literacy, such as practical skills and social responsibility, have received less attention [28, 29].

Thus, the gaps in this literature indicate the need for a systematic review to identify and analyze the various dimensions of conservation literacy holistically. This study aims to conduct a Systematic Literature Review (SLR) to uncover and clarify the concept of conservation literacy.

Through a comprehensive analysis of the literature, this research seeks to map the distribution of research, methods used, aspects studied, and international collaboration in conservation literacy research. It will also identify research gaps and provide a deeper understanding of how this concept can contribute to the design of effective policies and educational programs to increase public awareness and participation in conservation efforts [30, 31].

This research will include: distribution by year, types/methods of research, authors, keywords, authors' nationality and international collaboration, funding sponsors, topics in conservation literacy, aspects of conservation literacy, and the concept of conservation literacy. The findings of this study are expected not only to strengthen the theoretical foundation of conservation literacy but also to provide practical guidance for the development of public policies and educational initiatives that can advance efforts to preserve natural resources and biodiversity.

2. METHODOLOGY

This study employs a Systematic Literature Review (SLR), aiming to identify, evaluate, and analyze various articles found to address the research questions meticulously and seriously [32, 33]. SLR assists in providing a brief overview of the scholarly topic through systematically and transparently answering research questions [34].

The phrases "conservation" and "literacy" were used in the search menu of the Scopus Database. The obtained data were saved in CSV and RIS formats, which were then synchronized into Mendeley. The VOSviewer software was utilized to visualize the data, making the presented information more communicative, engaging, and clear. The search history of articles in Scopus, as we conducted, is as follows: KEY (conservation AND literacy) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT TO (SUBJAREA, "ENVI")) AND (LIMIT TO (DOCTYPE, "ar")) AND (LIMIT TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all")). With the search terms (conducted on February 20, 2024) and our pattern, we successfully found 185 articles within the period 2015-2024. We applied the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) model for inclusion and exclusion to find articles that truly fit. This model refers to previous studies [35, 36]. The following key points form the basis of inclusion criteria we used in this SLR:

a. Articles published within the last 10 years, from January 2015 to February 2024.
b. Only articles that are open access.
c. Publications include original research/articles.
d. The field of study of the articles is environmental science.
e. Articles published in English and are specifically related to "conservation literacy."

In summary, the research questions we explore in this review are as follows:

a. What specific topics and themes are common in the conservation literacy literature?
b. What are the main aspects of conservation literacy as identified in the literature?
c. How do academics conceptualize conservation literacy?

The sequence of inclusion and exclusion that we performed is presented in Figure 1.

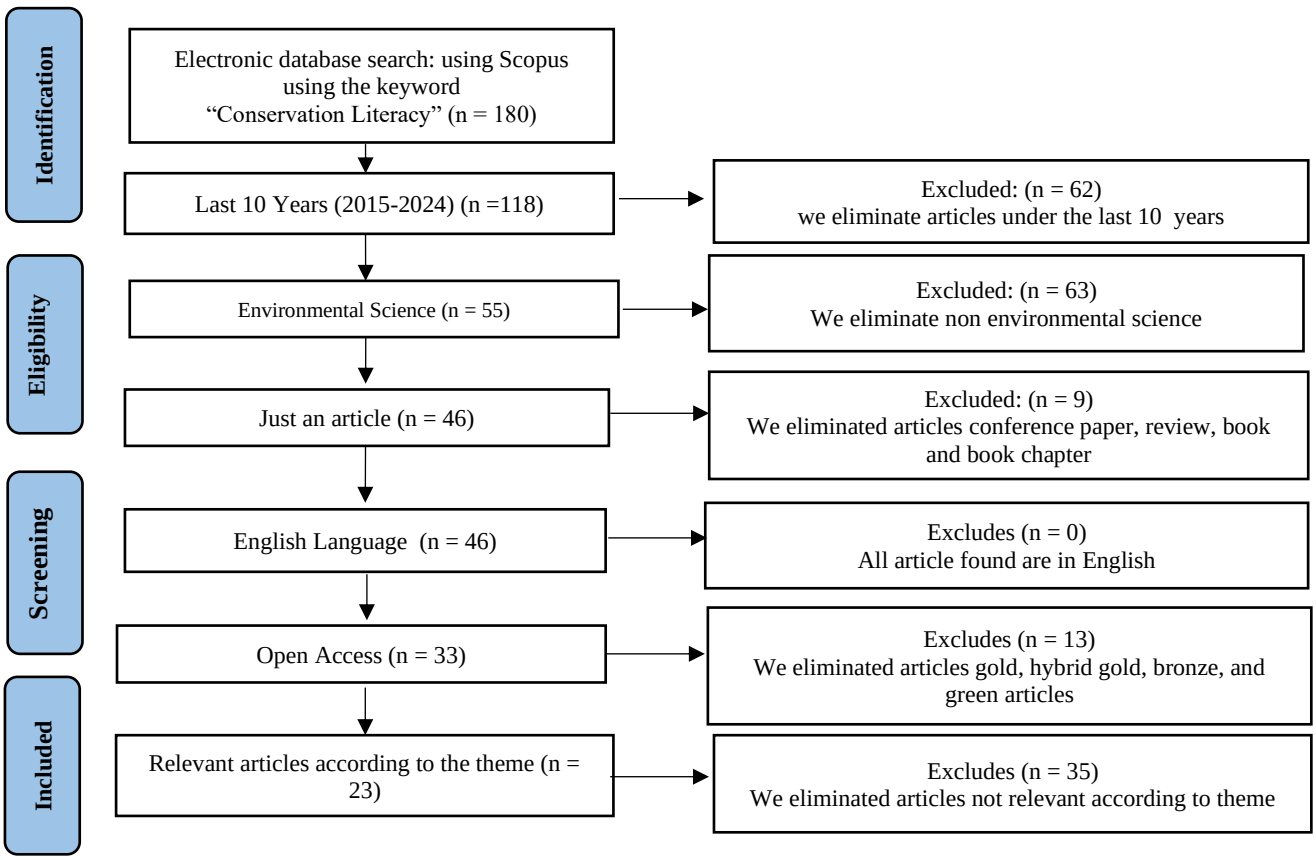

Figure 1. Systematic review of flow diagram using PRISMA model

Based on Figure 1, it can be observed that in the initial search using the keyword "conservation literacy," the author found 180 articles. Subsequently, the author applied the criterion of publication year within the last 10 years (2015-2024), resulting in 55 articles meeting the criteria and 62 articles being excluded. Further, the author applied the criterion of environmental science field, resulting in 55 articles meeting the criteria and 63 articles being excluded. We excluded fields other than environmental science, such as social sciences, engineering, computer science, economics, econometrics, business, management, accounting, arts, humanities, chemical engineering, mathematics, decision sciences, pharmacology, toxicology and pharmacy, psychology, materials science, immunology and microbiology, chemistry, health professions, veterinary medicine, physics, and astronomy.

The author only selected articles containing original research, leading to 46 articles meeting the criteria, and 9 articles being excluded. We excluded document types such as conference papers, reviews, books, and book chapters. Subsequently, the author applied the criterion of English language, resulting in 46 articles meeting the criteria and 0 being excluded. Then, the author applied the criterion of Open Access, resulting in 33 articles meeting the criteria and 13 being excluded. We excluded articles behind paywalls, hybrid gold, bronze, and green (requiring payment for access). Based on these criteria, the author found only 28 articles that met the criteria for analysis as a literature review.

3. RESULT

3.1 Year distribution

The distribution of years and the number of articles published per year from 2015 to 2024 are presented in Figure 2. Based on the Figure, it can be observed that the number of publications on conservation literacy fluctuates annually. In 2015, it gave an initial impression that conservation literacy did not receive significant attention at that time. This could also be due to articles published not being indexed in Scopus. However, 2016 marked a starting point with one recorded article. The year 2017 witnessed an increase in the number of registered articles, indicating a growing interest in conservation literacy initiated in the previous year. One article in 2018 indicates the continuation and sustainability of interest in conservation literacy.

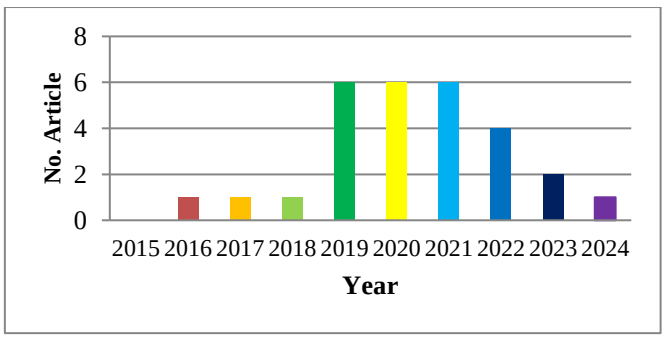

Figure 2. Distribution of published articles per year

In 2019, there was a significant spike with six articles listed. There may have been certain research trends or themes that gained popularity or were discovered during this timeframe. This trend continued into 2020 and 2021, where the number of articles remained steady at six. In 2022, a slight decrease was observed with four articles listed. This could reflect a shift in research focus or perhaps certain challenges limiting research during this period. In 2023, there was a further decrease to two articles. This may be due to various factors, such as changes in research trends or policy changes affecting research in specific fields. The year 2024 shows one article listed. This could signal that conservation literacy is still active, although not as high as the peaks in previous years.

3.2 Type/method of research

In research articles on conservation literacy, several studies have been conducted to delve deeper into this concept. These studies can be grouped based on the type of methodology used, which can provide varying insights, the results of which are shown in Table 1 below.

Table 1. Types of research with the theme conservation literacy

No.	Research Type	n	Reference
1	Quantitative	13	[30, 37-48]
2	Qualitative	13	[49-61]
3	Mixed method	2	[62, 63]

Thirteen articles explore data quantitatively, presenting findings based on numbers and statistics, providing a strong foundation for understanding the extent to which conservation literacy is understood and implemented by various groups. Then an equal number, thirteen, employ qualitative methods, enriching our understanding of conservation literacy through in-depth interviews, narrative analysis, and other qualitative approaches. Furthermore, there are 2 articles with mixed methods, combining qualitative and quantitative methods to provide a more comprehensive and holistic view of conservation literacy.

3.3 Author

The author overview in the article is presented in Figure 3, showing the relationship between authors discussing the topic of conservation literacy. Based on the figure above, there are authors who are frequently cited in writing articles on conservation literacy, such as Dirk Brounen. He is often referenced by other authors such as Lee, Van Den Broek, and others, thus forming interconnected networks as depicted.

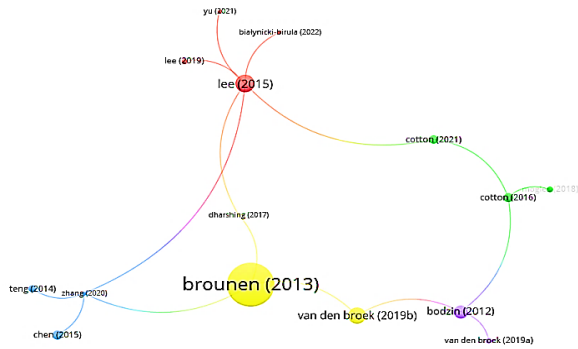

Figure 3. Authors who are dominant in the theme of conservation literacy

3.4 Keywords

The keyword trends are shown in Figure 4. The most frequently used keywords by the authors therein are literacy, developing country, energy literacy, energy conservation, human, and natural resource conservation. The top six ranks were published between 2015 and 2022. Several interesting keywords emerged in 2023, namely the direct relationship between literacy and humans and the indirect relationship between humans and health literacy.

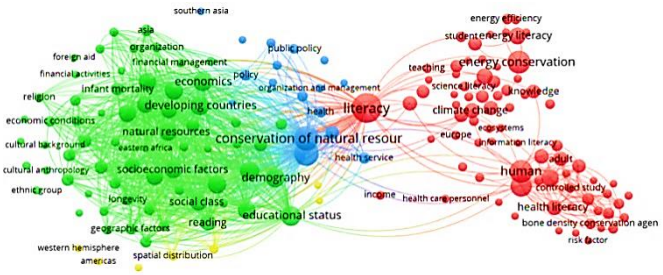

Figure 4. VOSviewer display for type of analysis "co-occurrence→keywords"

3.5 Author's nationality and international collaboration

Overall, the authors' citizenship is spread across 25 countries, all of whom have contributed articles on conservation literacy. The continent of origin can be clearly seen in Table 2.

Table 2. Author's nationality and continental on conservation literacy themes

No.	Country	Continent	n
1	United Kingdom	Europe	7
2	United States of America	America	4
3	Netherlands	Europe	3
4	China	Asia	3
5	Italy	Europe	3
6	Germany	Europe	3
7	Brazil	America	2
8	Ghana	Africa	2
9	Portugal	Europe	2
10	Switzerland	Europe	2
11	Taiwan	Asia	2
12	Greece	Europe	2
13	Australia	Australian-Oceania	1
14	Belgium	Europe	1
15	Chile	America	1
16	Ethiopia	Africa	1
17	Hawaii	America	1
18	Indonesia	Asia	1
19	Ireland	Europe	1
20	Israel	Asia	1
21	Canada	America	1
22	Colombia	America	1
23	New Zealand	Australian-Oceania	1
24	France	Europe	1
25	Sweden	Europe	1

The United Kingdom has the highest contribution with 7 authors. The United States of America follows in second place with 4 authors. The Netherlands, China, and Italy each have the same contribution, with 3 authors each. Germany, Brazil, Ghana, Portugal, Switzerland, Taiwan, and Greece each have 2 authors contributing. Australia, Belgium, Chile, Ethiopia, Hawaii, Indonesia, Ireland, Israel, Canada, Colombia, New Zealand, France, and Sweden each have 1 author contributing. Europe has the highest contribution with a total of 11 countries, including the UK, the Netherlands, Italy, Germany, Portugal, Switzerland, Greece, Belgium, Ireland, France, and Sweden. America follows with 6 countries, including the United States, Brazil, Chile, Hawaii, Canada, and Colombia. Asia is represented by China, Taiwan, Indonesia, and Israel, with a total of 4 countries. Africa is represented by Ghana and Ethiopia, and Australia-Oceania is represented by Australia and New Zealand, each with 2 countries respectively.

The author's continent of origin can be clearly seen in Figure 5.

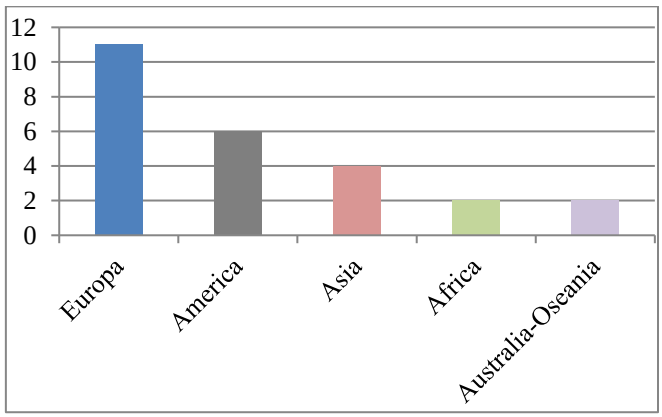

Figure 5. Number of authors from each continent

Based on international collaboration, it is divided into 3 categories (Figure 6).

Firstly, collaboration within one country. There are 11 articles involving collaboration among authors from a single country.

Secondly, international collaboration, where a total of 10 articles involve international collaboration, with authors from various countries working together in writing articles.

Thirdly, without collaboration, 7 articles were found in which authors worked independently without collaborating with other authors, either domestically or internationally.

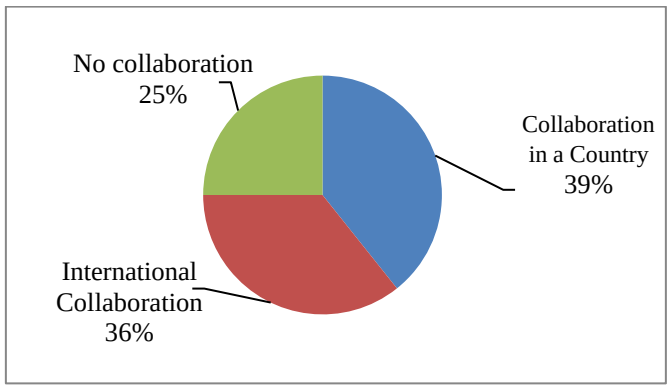

Figure 6. Author collaboration in writing articles

3.6 Funding sponsor

This data shows the distribution of funding amounts for research divided into several categories (Figure 7).

A total of thirteen studies in this data received no funding at all. There are four studies that received single funding. Six studies received support from two funding sources.

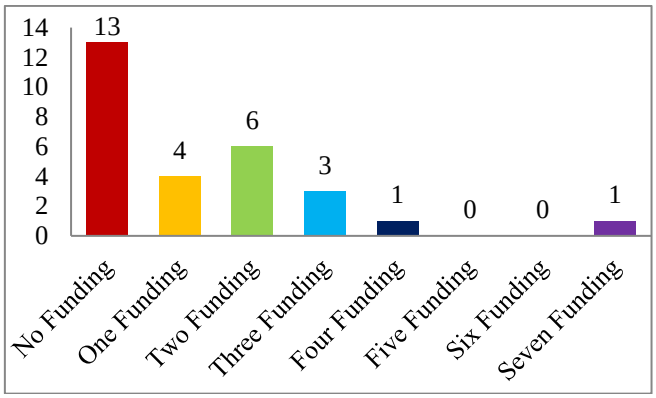

Figure 7. Funding sponsors of conservation literacy-themed articles

Three studies received funding from three different sources. One study received support from four different funding sources. One study received support from seven funding sources, but only for journal publication costs and not research funding. Based on the country of funding sponsors, it can be seen in Table 3.

Table 3. Funding sponsors for conservation literacy themes

No.	Funding Sponsor	Country	n
1	Hawai'i Community Foundation	United States of America	7
2	National Oceanic and Atmospheric Administration		
3	National Science Foundation Coastal SEES Program		
4	United States Environmental Protection Agency (EPA)		
5	University of Wisconsin		
6	Food Integrity' grant		
7	Nonprofit organization, Healthy Oceans, Healthy People,		
8	Universidad Católica de la Santísima Concepción	Chile	7
9	Universidad Autónoma de Chile		
10	Universidad Andres Bello		
11	Universidad de Las Americas		
12	Universidad Gabriela Mistral		
13	Universidad de Santiago de Chile		
14	Universidad Tecnológica Metropolitana		
15	13th Five-Year Plan for the Development of Philosophy and Social Sciences Fund of Guangzhou	China	5
16	National Social Science Fund of China		
17	Humanities and Social Sciences Research and Planning Fund of the Ministry of Education of China		
18	Humanities and Social Sciences Foundation of Ministry of Education of China		
19	Natural Science Foundation of Shandong Province		
20	European Union's Horizon 2020 research and innovation programme	Germany	5
21	Qualitätsoffensive Lehrerbildung		
22	Green Awareness in Action: grant agreement		
23	German Research Foundation (DFG)		
24	University of Bayreuth		
25	Portuguese Foundation for Science and Technology (FCT)	Portugal	4
26	AgriFood XXI		
27	Portuguese Foundation for Science and Technology (FCT)		
28	EU Interreg Atlantic Area Program grant		
29	Ministry of Science and Technology, grants	Taiwan	2
30	Environmental Protection Administration		
31	Australian Research Council Future Fellowship	Australia	1
32	CAPES Foundation grant, Ministry of Education of Brazil.	Brazil	1
33	Colombian Administrative Department of Science, Technology, and Innovation	Colombia	1

United States of America (USA) and Chile, these countries are the largest contributors by supporting 7 research projects. Then China provides support for 5 research projects. Germany, this country also supports 5 studies, Portugal supports 4 research projects, Taiwan supports 2 studies. Australia, Brazil, and Colombia provide support for 1 research project.

3.7 Topics in conservation literacy

The data covers topics in conservation literacy from various aspects focused on various topics such as oceans, energy, water, education and research, focusing on species, conservation areas, and agriculture. Here is a brief description of each category (Table 4).

Table 4. Content in conservation literacy

No.	Content in Conservation Literacy	n	Reference
1	Ocean	6	[49, 54-56, 59, 64]
2	Energy	6	[37, 38, 40, 50, 65, 66]
3	Water	4	[45-47, 61]
4	Education and Research	4	[30, 43, 60, 63]
5	Species Focus	3	[42, 51, 62]
6	Conservation area	3	[52, 53, 58]
7	Agriculture	2	[48, 57]

3.8 Aspects of conservation literacy

Data from articles on the aspects of conservation literacy can be grouped into four key aspects: Knowledge, Awareness, Attitude, and Behavior (Table 5). The aspect of conservation literacy encompasses the knowledge, awareness, attitudes, and behaviors of individuals or communities regarding environmental conservation efforts.

Table 5. Aspects of conservation literacy

No.	Aspects of Conservation Literacy	Reference
1	Knowledge	[28, 35, 39, 41, 45, 47, 52, 54, 56-61, 63, 65]
2	Awareness	[37, 39, 45, 47, 49, 53, 54, 65, 68]
3	Attitude	[38, 40, 45, 48, 50, 52-54, 60-63]
4	Behavior	[38, 40, 46, 48, 53, 54, 60, 62, 67]

Knowledge entails individuals' or communities'

understanding of basic conservation principles, ecology, and the importance of preserving natural resources. Conservation awareness involves understanding and recognizing environmental issues and their impacts on human life and ecosystems. Attitudes reflect individuals' feelings, evaluations, and reactions to conservation issues. Conservation behavior includes the actual actions taken by individuals or communities to engage in practices that support environmental sustainability.

3.9 Concept of conservation literacy

Conservation literacy encompasses a broad spectrum of knowledge, awareness, attitudes, and behaviors for addressing environmental challenges and promoting sustainability. Viewed from various perspectives, conservation literacy can be aligned with specific domains such as energy, water, marine, and species conservation, each emphasizing the importance of individual and collective actions in preserving natural resources. The results of a review of the concept of conservation literacy can be seen in Table 6.

For instance, energy literacy focuses on knowledge of energy consumption, efficiency, and sustainable practices that influence better decision-making in energy use. Similarly, water conservation literacy highlights understanding water usage, threats to water resources, and responsible behaviors, often encouraged through citizen science initiatives.

Marine conservation literacy involves public understanding of marine ecosystems, policies, and the role of informed decision-making in promoting ocean sustainability. This also extends to the concept of oceanic citizenship, which fosters personal responsibility and pro-environmental behaviors to enhance marine conservation efforts.

Species conservation literacy, on the other hand, emphasizes the importance of knowledge and identification skills related to biodiversity preservation. This is crucial in promoting awareness and protective actions toward endangered species.

Additionally, conservation literacy is essential in promoting sustainable agricultural practices, such as supporting farmers in adopting water harvesting technologies. Visual communication tools are vital in engaging communities with low literacy levels, ensuring they understand and adopt conservation technologies.

Conservation literacy is thus a multidimensional concept, integrating knowledge exchange, behavioral change, and community involvement across various environmental sectors to support sustainability efforts globally. By enhancing public understanding and participation, conservation literacy serves as a cornerstone in addressing environmental challenges and preserving natural resources for future generations.

Table 6. Information on conservation literacy definition from articles analyzed in this study

No.	Information	Reference
1	Conservation literacy can be viewed from the perspective of energy literacy, which includes knowledge, attitudes, and behaviors related to sustainability and energy conservation. It emphasizes individual actions in practicing sustainability concepts.	[50]
2	Conservation literacy is essential in supporting farmers to adopt water harvesting technologies. This article highlights the importance of visual communication for farmers with low literacy levels to help them understand conservation technologies.	[46]
3	Marine conservation literacy involves public understanding of marine resources, marine policies, and informed decision-making participation for marine conservation.	[55]
4	Species conservation literacy involves in-depth knowledge of species and identification skills, which are crucial for biodiversity preservation.	[39]
5	Water conservation literacy includes understanding direct and indirect water use, as well as threats to water resources. Citizen participation through "citizen science" promotes responsible behavior.	[61]
6	Conservation literacy consists of enhancing knowledge, attitudes, and behavioral intentions related to environmental issues, focusing on species protection, such as land crabs.	[34]
7	Marine conservation literacy includes understanding the value of the oceans and the importance of involving communities in conservation through an interdisciplinary approach.	[62]
8	Marine conservation literacy also encompasses the development of oceanic citizenship, personal role understanding, and pro-environmental behaviors to raise awareness about marine conservation.	[56]
9	Energy conservation literacy involves knowledge about energy consumption and efficiency, as well as energy-saving behaviors that are crucial for better decision-making.	[38]
10	Conservation literacy covers awareness of protected areas, threats to biodiversity, and public behavior supporting environmental conservation.	[58]
11	Conservation literacy is linked to STEM education for teachers, which includes understanding freshwater ecosystems and developing pro-conservation citizenship and behaviors.	[42]
12	Water conservation literacy involves knowledge about water sources and usage, communication skills, and sustainable actions to protect water resources.	[45]
13	Conservation literacy includes four pillars: knowledge, attitudes, behaviors, and skills needed to understand and effectively respond to environmental issues.	[40]
14	Conservation literacy involves knowledge exchange between farmers and scientists for sustainable natural resource management through social learning.	[57]
15	Conservation literacy is integrated with individual and environmental well-being in a positive education and sustainability approach, focusing on sustainable well-being.	[60]
16	Conservation literacy in linguistic ecology includes five main factors: knowledge, awareness, ethics, emotions, and ecological behavior, supporting sustainable behavior.	[53]
17	Energy literacy includes understanding energy usage, its impact on the environment, and appropriate behaviors in energy management.	[37]
18	Seafood literacy includes consumer knowledge in identifying fish species consumed, which is essential for more ethical and sustainable consumption choices.	[51]

19	Water conservation literacy encompasses cognition, attitudes, and behaviors related to wise water use, which is important in facing the global water crisis.	[47]
20	Marine conservation literacy involves sharing scientific and local knowledge to support ecosystem-based management and adaptive marine conservation.	[59]
21	Conservation literacy is measured through scientific publications related to conservation as an indicator of research capacity in Sub-Saharan African countries.	[43]
22	Conservation literacy focuses on sustainable land use practices, including knowledge and skills in soil and water conservation.	[48]
23	Spatial landscape literacy involves the ability to identify and understand landscape processes in a digital context, crucial for conservation efforts.	[52]
24	Marine conservation literacy includes understanding basic ocean principles, the relationship between oceans and humans, and behaviors supporting ocean sustainability.	[54]
25	Eco-conservation literacy includes students' understanding of environmental values, art, culture, and natural resources through digital applications.	[63]
26	Energy conservation literacy involves knowledge and energy efficiency practices in households, focusing on education and awareness campaigns.	[41]
27	Ocean literacy includes knowledge, behaviors, awareness, attitudes, and emotional connections to the oceans to promote conservation and sustainability.	[44]
28	Energy conservation literacy involves awareness and energy efficiency practices in households, as well as the influence of socio-economic factors on energy-saving behaviors.	[30]

4. DISCUSSION

4.1 Year distribution

The number of articles on the theme of conservation literacy from 2015 to 2024 follows a fluctuating pattern. In 2015, no articles discussing conservation literacy were found, then from 2016 to 2018, there was only one article each year. This may be due to the limited interest of researchers in discussin conservation literacy and related topics. Interestingly, from 2019 to 2021, there were six articles indexed in Scopus each year related to conservation literacy. As we know, during this period, the COVID-19 pandemic occurred. However, upon further investigation of the articles published during these years, most of them used online research methods (questionnaires and interviews).

The advantages of online research include global accessibility, especially internet-based, as online-based research can reach respondents from various countries as needed [54]. Another advantage is related to time flexibility, where respondents can participate in research according to their own schedules [57]. It also saves energy and costs because online-based research does not require significant energy and costs [47]. Then, from 2022 to 2024, there was a decline in the graph. This could be due to new research emerging or certain research themes continuing to attract interest.

4.2 Method of research

The research methods often used in articles on conservation literacy are quantitative methods, qualitative methods, and mixed methods (Table 1). Articles using quantitative methods were found in 13 articles. Quantitative methods are research approaches that focus on collecting numerical or statistical data [42, 44]. In the context of conservation literacy, this method involves surveys and statistical analysis of quantitative data related to conservation literacy. Examples of analyses performed include measuring the level of understanding of conservation concepts, the level of participation in conservation activities, or changes in behavior related to conservation literacy.

Next, articles using qualitative methods were found in 13 articles. Qualitative methods focus on in-depth understanding of phenomena through the collection and analysis of non-numeric data, such as interviews, observations, or text analysis [60, 61]. In the context of conservation literacy, qualitative methods may be used to gain insights into individuals' perceptions, values, and experiences related to conservation literacy. The results of this method can help researchers understand the social and cultural contexts that influence conservation literacy.

Lastly, articles using mixed methods, combining quantitative and qualitative methods, were found in 2 articles. Mixed methods combine elements of quantitative and qualitative methods to provide a more comprehensive understanding of a phenomenon [44, 54]. In the context of conservation literacy, the use of mixed methods may involve a combination of statistical analysis and in-depth explanations through interviews or text analysis. The choice of mixed methods can provide a more complete perspective and allow researchers to leverage the strengths of both approaches.

The use of methods in conservation literacy research can be tailored to the needs and goals of the research. All methods have their own advantages and disadvantages. However, based on the articles reviewed, the use of mixed methods is still rare. This could be an opportunity for further research, especially related to conservation literacy. One of the advantages of mixed methods is comprehensiveness. Mixed methods allow researchers to gain a more comprehensive understanding of a phenomenon or research question. By combining quantitative and qualitative data, researchers can view the phenomenon from various perspectives and obtain a more complete picture [39].

4.3 Author

Dirk Brounen is a lecturer at Tilburg University, Netherlands. According to Google Scholar, his research focus is on Real Estate Investment Trusts (REITs), sustainability, and household finance. Dirk Brounen's referenced article was written in 2013 with Nils Kok (Maastricht University Netherlands) and John M. Quigley (University of California, Berkeley, United States). The title of the article is "Energy literacy, awareness, and conservation behavior of residential households," which has been cited 403 times to date [41]. In general, the article examines the awareness, literacy, and behavior of households regarding energy expenditure at home.

This article serves as the basis for other researchers to develop topics related to energy literacy, which later evolved into conservation literacy. Energy literacy plays a key role in shaping individuals' understanding, attitudes, and actions related to energy conservation, which in turn contributes to efforts to create a more sustainable energy society [58].

4.4 Keywords

Between 2015-2022, six frequently used keywords emerged: literacy, developing country, energy literacy, energy conservation, humans, and natural resource conservation. The increase in article numbers is attributed to the development of environmental issues and global awareness of the importance of conservation literacy [57, 64]. The keyword "literacy" is the main focus of these articles. Most likely, these articles discuss literacy in the context of conservation, whether it's energy literacy or literacy related to other natural resources. Increasing literacy is deemed essential for understanding and addressing conservation challenges [65].

In 2023, particularly regarding the direct and indirect relationships between literacy and human health, there was a shift in research focus. Increased awareness of the impact of conservation on human health can serve as a catalyst for better understanding this complex relationship [66, 67]. Emphasizing the direct relationship between literacy and humans as well as the indirect relationship between humans and health literacy highlights the importance of understanding ecosystem balance and its impact on human health [68, 69]. Pollution and environmental degradation can have significant health implications [70, 71]. The focus on the interconnection between literacy, human health, and conservation of natural resources reflects an understanding that these issues cannot be separated. This creates awareness of the complexity of global challenges involving human health and environmental sustainability.

4.5 Author's nationality and international collaboration

The United Kingdom and the United States of America dominate the contributions to conservation literacy articles in the Scopus database, which could be due to several factors (Table 2 and Figure 5). These countries have strong research institutions and academics, adequate resource access, and sufficient financial support [72]. Meanwhile, other countries are rarely found in writing conservation literacy articles. This could be due to research policies, national resources, and conservation challenges that may vary by region [73].

Europe and America have the highest contributions with 17 countries involved in research projects. Europe and America (Figure 6) have advanced and mature research infrastructures. Universities, research institutions, and research centers in both regions are often equipped with modern facilities and equipment, supporting high-quality research [74, 75]. Meanwhile, the rest, comprising 11 countries, are spread across Asia, Africa, and Australia-Oceania. Countries in Asia, Africa, and some of Australia-Oceania might be more focused on economic development and everyday issues [76, 77], thus resource allocation for research might not be as extensive as in Europe and America.

Based on collaboration status, most articles are written and published using a collaborative system. Articles published by a single author are very rare. Many articles are the result of international collaboration. Furthermore, although there are some articles written by authors from only one country or even one university, it is evident that authors still collaborate across disciplines. This aligns with [78], stating that conservation research requires broad scientific collaboration. This pattern supports efforts to develop programs and document ideas, as well as further opportunities for productive research implementation [79].

Based on these findings, international collaboration in conservation research needs to be encouraged. According to [80], in the context of Asia, international collaborative research certainly faces several challenges. Several issues could arise, such as language barriers, funding, limited face-to-face meeting times, and some political issues. If these challenges can be effectively addressed, it would enable the formation of new solidarity in environmental education that cannot be achieved through limited cooperation within one country alone.

4.6 Funding sponsor

Overall, there are fifteen articles that received research funding, with varying amounts, from one funding to seven fundings (Figure 7). However, for articles that received seven fundings, it was solely for article publication. The provision of funding sponsorship can reflect the complexity, scale, or focus of research conducted by researchers. Research of different scales may require various levels of funding, and this can reflect the diversity of research topics within the conservation literacy domain [81, 82]. Meanwhile, thirteen articles did not receive any funding or sponsorship. This could be done without financial support from external parties and carried out independently. This shows a level of independence and the ability of researchers or institutions to carry out small to medium-sized projects without relying on external funds. Other reasons could also be due to limited resources, smaller research scales, or potential impacts on the quality and relevance of research results [83, 84].

The United States and Chile are among the countries with the largest economies in the world [85]. Their large financial capacities enable them to provide financial support for various research fundings. Not only in the field of conservation but almost in all fields of science. Meanwhile, other countries such as China, Germany, Portugal, Taiwan, Australia, Brazil, and Colombia are still limited in providing funding for research. These countries may have limited funds and national or strategic interests in certain research projects that support conservation literacy.

4.7 Topics in conservation literacy

Topics in conservation literacy regarding the sea involves a deep understanding of marine ecosystems, threats to sustainability, and actions that can be taken to preserve and protect the oceans [86, 87]. The ocean plays a crucial role in the global ecosystem and supports life on Earth [88, 89]. Topics in conservation literacy concerning energy involves a profound understanding by society of energy sources, the environmental impacts of energy use, and concrete actions to reduce consumption and transition to renewable energy sources. Information on energy conservation highlights the need to reduce carbon footprint [90, 91] and support renewable energy sources [92, 93].

Topics in conservation literacy regarding water explains the importance of understanding water resources and how humans

can contribute to water conservation and sustainability. Water conservation encompasses efforts to protect and preserve water quality, reduce water consumption, and manage water sustainably [40, 41, 48, 53]. These initiatives can involve communities, industries, and the agricultural sector [94], and may even involve the education sector. Topics in conservation literacy in the Education and Research field indicate a focus on the role of education and research in shaping societal conservation understanding and behavior. This may include community education programs, biodiversity research, and the development of innovative conservation methods [30, 46, 52, 63].

Topics in conservation literacy focusing on species highlight the emphasis and specific attention to the protection, understanding, and preservation of particular species. In the analysis of this review article, specific species under study include land crabs [62], aquatic invertebrates [45], and fish [54]. The focus on species indicates efforts to conserve biodiversity and avoid the extinction of certain species. These efforts include habitat conservation [95], population recovery [96], and wildlife protection [97]. Conservation Area as a focus of Topics in conservation literacy indicates the need for a deep understanding of the management and preservation of conservation areas, such as national parks, nature reserves, or other natural habitats. In the analysis of this review article, specific conservation areas under study include Natura 2000 [58], Sabana de Bogotá [55], and Guiyang City [56]. Information about conservation areas highlights the sustainability of specific regions. This involves the establishment of national parks, nature reserves, or initiatives to preserve specific natural areas.

Topics in conservation literacy in the context of agriculture aims to understand knowledge, awareness, attitudes, and behaviors related to conservation efforts in this sector. The inclusion of agriculture categories indicates awareness of the environmental impacts of agriculture [40, 58]. Conservation literacy in the context of agriculture may focus on sustainable pesticide use, organic farming practices, and sustainable land management. To achieve comprehensive conservation literacy, it is important to integrate all identified aspects in the data. The interconnection of these aspects creates a holistic approach to engaging communities and stakeholders in conservation efforts.

4.8 Conservation literacy aspects

Conservation literacy encompasses a deep understanding of environmental aspects, biodiversity, and efforts to preserve natural resources. The reviewed articles demonstrate a consensus that increasing conservation knowledge positively impacts people's attitudes and behaviors toward the environment [50, 55]. In this context, education plays a vital role in enhancing public understanding of conservation [38]. However, there is debate regarding the effectiveness of educational approaches applied to different generations. Some literature suggests the need for strategies tailored to demographic characteristics [98]. While others emphasize the importance of universal and inclusive educational content [38]. This indicates that conservation literacy requires a flexible approach, adaptable to generational and educational differences.

Environmental awareness and the urgency of conservation actions are essential elements of conservation literacy. Most literature agrees that conservation campaigns and adequate access to information can increase public awareness of environmental issues [49, 53, 58]. Nevertheless, there is disagreement regarding other factors influencing awareness. Some articles highlight education as the primary factor [99], while others stress that culture and access to information also play crucial roles [100, 101]. These differing views suggest that conservation awareness cannot be built solely through education but also requires contextual understanding of culture and available media.

Attitudes toward conservation reflect an individual's perspective on environmental preservation and natural resource protection. Conservation literacy measures not only knowledge but also how this knowledge is translated into positive or negative attitudes toward conservation. Research indicates a strong correlation between knowledge and attitudes toward conservation [61]. However, some articles argue that conservation attitudes are also influenced by an individual's direct experience with the environment [60, 62], not just theoretical knowledge. This debate underscores the importance of practical experience in shaping conservation attitudes, alongside formal education.

Conservation behavior is the tangible outcome of conservation literacy, reflected in daily actions that support or undermine environmental preservation efforts. The majority of literature agrees that conservation behavior is strongly influenced by awareness, attitudes, and knowledge [50]. However, there is debate over the factors that drive or hinder conservation behavior. While some articles highlight the importance of intrinsic motivation, such as awareness [46], others emphasize external factors like government policies and economic incentives [54]. This suggests that conservation behavior is multifactorial, requiring a comprehensive approach that integrates both internal and external factors.

The synthesis of literature shows that conservation literacy is a multidimensional concept encompassing knowledge, awareness, attitudes, and behavior, all of which are interconnected. These findings lead to the conclusion that conservation education should not only aim to increase knowledge but also focus on fostering awareness and positive attitudes toward conservation. Furthermore, an important implication of this research is the need to tailor conservation literacy programs to the social, cultural, and demographic contexts of communities to ensure their effectiveness.

In practice, conservation literacy is closely linked to sustainable development. By equipping society with a strong understanding of the importance of environmental preservation, conservation literacy can serve as a foundation for broader actions toward sustainability.

4.9 Concept of conservation literacy

There are several differences in the concept of conservation literacy proposed by the experts you mentioned. Each expert views conservation literacy from a specific perspective related to a particular conservation topic or context. Each expert presents the concept of conservation literacy with a different approach, according to their field of specialization or the environmental issue they focus on, such as energy, water, biodiversity, oceans, or individual behavior.

The concept of ecological literacy and sustainable relationships emphasizes the transformation of education to be more environmentally and sustainability-oriented [102, 103]. Quality education, as mandated by SDG 4, not only emphasizes academic achievement but also strengthens

learners' understanding of environmental responsibility and sustainability [104, 105]. Literature findings highlighting the importance of increasing conservation awareness through knowledge and education [96], enhancing environmental concern [106], and integrating local community wisdom in environmental preservation [107], directly support SDG 4 by ensuring that conservation literacy becomes an integral part of a more holistic education curriculum. Concrete recommendations include implementing curricula that integrate concepts of conservation, ecosystems, and sustainability, so that learners not only gain knowledge but also acquire the skills to actively participate in environmental preservation.

Conservation awareness, particularly concerning climate change, is one of the key aspects that need to be further developed through education and community engagement. SDG 13 focuses on urgent climate action, and insights gained from the literature on conservation awareness [30], the integration of local policies [108], as well as ecotourism efforts that consider environmental preservation [109, 110], can form an important foundation for supporting more concrete climate actions. Environmental education programs that emphasize climate change and ecosystem solutions can be designed to build a generation that is more aware and responsive to climate challenges.

SDG 15 emphasizes the importance of protecting, restoring, and promoting the sustainable use of terrestrial ecosystems, including sustainable forest management and halting biodiversity loss. The concept of species literacy, which deepens the understanding of the ecological role and conservation of biodiversity [53, 111], directly supports SDG 15. Understanding endangered species and the impact of human activities on them is a crucial step in preserving ecosystems [52, 59]. Concrete recommendations for SDG 15 include developing species literacy programs within education systems and broader society to encourage the protection of species and critical ecosystems.

Recommendations for Integrating Conservation Literacy into Sustainable Development Policies:

1. Development of Environment-Based Curricula: Integrating conservation literacy into formal and non-formal curricula in alignment with SDG 4, 13, and 15. These education programs should strengthen the understanding of the relationship between humans and nature and promote sustainable responsibility.
2. Community Participation and Citizen Science: Findings that highlight the importance of community participation in conservation projects and environmental monitoring [37, 38, 41], indicate the need to develop focused community engagement initiatives. By expanding community participation in citizen science projects, we can enhance their knowledge and involvement in conservation actions, supporting the goals of SDG 13 and SDG 15.
3. Application of Technology and Innovation in Conservation: Adopting a STEM approach in environmental literacy education, as mentioned in the literature [40, 42, 60], will help accelerate the achievement of SDGs through technology-based solutions. The utilization of scientific innovations, such as data-driven environmental monitoring technologies, can strengthen ecosystem conservation efforts.

By integrating the concept of conservation literacy into education, policy, and community participation, this literacy can become one of the pillars in achieving the SDGs, particularly SDG 4, SDG 13, and SDG 15. The awareness, knowledge, and behaviors fostered through this comprehensive approach will reinforce global efforts to protect biodiversity, mitigate the impacts of climate change, and support more inclusive and sustainable development.

5. CONCLUSION

Conservation literacy is an evolving concept in response to the complexity of conservation challenges in the modern era. Although still a growing field of study, this systematic literature review provides a comprehensive understanding of the true meaning and relevance of conservation literacy in a global context. The research highlights publication trends, conservation issues accessible through various approaches, and the role of international collaboration in developing this understanding. The authors emphasize the significant contribution of Dirk Brounen in the context of conservation literacy. These findings can serve as a vital foundation for researchers to delve into the theme of conservation literacy according to their respective backgrounds and objectives, while highlighting key aspects and concepts in conservation literature.

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