International Journal of Sustainable Development and Planning
Vol. 19, No. 6, June, 2024, pp. 2373-2379
Journal homepage: http://iieta.org/journals/ijsdp

Policy Design for Sustainable Development: A Bibliometric Study of Ecological Communications

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https://doi.org/10.18280/ijsdp.190635

Received: 8 June 2023
Revised: 8 September 2023
Accepted: 23 November 2023
Available online: 24 June 2024

Keywords:
ecology communication, sustainable development, development communication, ecological policy, environment

ABSTRACT

Ecological communication and sustainable development have become increasingly critical due to complex and urgent environmental challenges. This research aims to evaluate the development of ecological communication and sustainable development studies and consider adaptive policy plans based on available research documents. This research uses bibliometric analysis, whose data source comes from the Scopus database. Scopus is an academic database that collects various scientific publications. The selected documents were carried out in 2018-2022. The filtering results found 366 documents. The analysis tool used is Vosviewer. Vosviewer is a data analysis tool for visualizing and identifying patterns of relationships between keywords in large datasets such as those in the Scopus database. This study found several topics that could be followed up in policy formulation, especially topics currently becoming global trends, such as information and communication, economic and social impacts, conservation, and agriculture. Designing policies based on evolutionary ecology studies and sustainable development communications is critical in addressing environmental challenges and driving change toward a more sustainable society. The significance of these findings is crucial in the context of understanding and addressing global environmental challenges. This research has clear and significant implications for helping design more effective policies, driving further research, and encouraging cross-sector collaboration in addressing global environmental challenges.

1. INTRODUCTION

Ecological communication aims to convey information, knowledge, and awareness about environmental issues and encourage sustainable behaviour changes to protect and protect ecosystems and biodiversity [1]. Ecological communication involves various parties, including environmental organizations, governments, scientists, educators, media, and the general public [2]. Ecological communication is vital in providing education and accurate information about environmental issues. This involves providing knowledge about the state of the environment, climate change, biodiversity, natural resource conservation and sustainable practices.

This education and outreach can be carried out through various channels, such as seminars, workshops, public campaigns, websites and social media. Ecological communication aims to increase public awareness of environmental issues and their impact on human life [3]. Through clear information and persuasive communication, public awareness can be increased regarding the need for collective action to protect and preserve the environment. One of the main goals of ecological communication is to change human behaviour to make it more sustainable and environmentally friendly. It involves conveying strong messages about the importance of reducing energy consumption, adopting sustainable practices, minimizing waste and taking other positive actions to preserve the environment [4].

Ecological communication also involves active community involvement in decision-making regarding environmental issues. Ecological communication is not only concerned with

the exchange of information but also involves the active participation of society in decision-making processes that impact environmental issues. This makes it possible to build the awareness, support, and collective action needed to overcome environmental challenges and achieve sustainable development goals through open dialogue, community participation, and advocacy. Ecological communication enables society to contribute to developing environmental policy, managing natural resources, and protecting ecosystems. Ecological communication facilitates stakeholder collaboration, including environmental organizations, government, business, and civil society [5]. This collaboration is essential to achieve common goals in maintaining environmental sustainability [6].

Much research has been done on ecological communication. However, very few studies still specifically analyze this topic by relating it to a bibliometric analysis approach, especially for policy design. However, there is some relevant previous literature. *First,* ecological communication is essential in influencing how humans perceive and interact with the environment [7]. *Second,* through effective communication, information and awareness about ecological issues can be widely disseminated, and concrete actions can be taken to protect and preserve the earth for future generations [8]. *Third,* policy formulation in ecological communication is essential because it helps direct and coordinate practical communication efforts on environmental issues [9]. *Fourth,* bibliometric analysis can be valuable in designing policies based on literature studies [10].

The purpose of this study is to fill the gaps in previous research by analyzing the evolution of the study of ecological communication and sustainable development. This research question is formulated as follows: (a) How is the evolution of the study of global ecological communication? (b) How is the design of policies needed to support sustainable development based on the evolution of ecological communication studies? The answers to these two questions make it possible to know trends in the development of studies and designs needed to support the idea of ecological communication in the future.

Understanding the evolution of ecological communication studies is important because it helps us identify trends, changes, and recent discoveries in increasingly complex ways of communicating and understanding environmental issues. With a deeper understanding of these developments, policy design can be more responsive to contemporary developments, enabling more effective policy development in supporting sustainable development. By leveraging recent findings in ecological communication studies, policies can be designed to raise public awareness, motivate sustained action, and facilitate the inter-stakeholder collaboration needed to address global environmental challenges and create a more ecologically sustainable society.

2. METHOD

This research uses bibliometric analysis using data from the Scopus database, which was chosen because of its reputation as a global indexer that recognizes high standards in accepting scientific publications. Data was collected by filtering the keywords "ecological communication" and "sustainable development" in 2018-2022 without limiting the document type. The filtering results included 366 documents, then analyzed using Vosviewer, an analysis tool to optimize this data. Co-occurrence type analysis with the All Keywords analysis unit identifies pairs of words that appear together in documents. Using Vosviewer, a network model is formed with nodes representing words and edges connecting nodes based on the co-occurrence of words in the same document. The type of Co-occurrence analysis with the All Keywords analysis unit used in this study contributes significantly to the research objectives by allowing the identification of close relationships between the keywords "ecological communication" and "sustainable development," as well as visualizing the patterns of these relationships in a model network. The data obtained is then visualized to provide deep insight into trends and relationships in the study of ecological communication and sustainable development—graphical representation, namely through tables and figures. Overall, validity and reliability in this research are maintained by selecting appropriate data sources, a well-documented analysis process, and a clear graphical representation, thus ensuring that the findings are reliable and follow the study's objectives.

3. RESULTS AND DISCUSSION

3.1 Evolutionary development of the study of ecological communication and sustainable development

Knowing the evolution of the development of the study of ecological communication and sustainable development has a critical urgency. Studying ecological communication and sustainable development helps raise public awareness about pressing environmental issues. Through effective communication, information about the negative impacts caused by human activities on the environment can be conveyed to a broader audience [11]. This helps drive individual and collective behaviour change towards more sustainable actions.

This section examines the trends in research development based on the number of documents, the year of publication, and the number of author citations. When analyzing the trend of published documents based on the year of publication, the following observations were made:

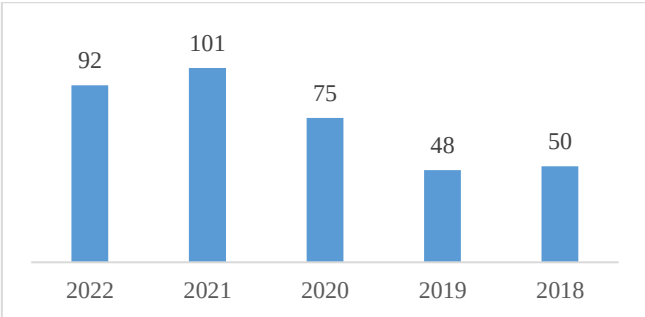

Figure 1. Trends in the number of published documents

Figure 1 shows that publications on ecological communication and sustainable development have experienced a significant trend in the number of published documents. Since 2018, there have been 50 published documents, but the number decreased in 2019, namely 48 documents. After that, 2020 experienced a positive publication trend, marked by 75 published documents. This will continue in 2021, namely the addition of publication documents to 101

documents. In 2022 the number of documents found was 92 publications documents.

The development of study of ecological communication and sustainable development has experienced a trend of significant publication growth in recent years. This reflects the increasing global awareness and attention to environmental issues and the need to achieve sustainable development. More and more people are realizing the importance of protecting the environment and adopting sustainable practices. This drives increased interest in research and publication in ecological communication and sustainable development.

Advances in information and communication technology, especially social media, have facilitated the rapid dissemination of information and research on environmental issues [12]. This has also encouraged many researchers and academics to publish their research results in ecological communication and sustainable development. Many institutions, including universities, research institutes, and non-profit organizations, have provided more significant support for research and publication in this field. They recognize the importance of effective communication to achieve sustainable development goals and provide financial support.

The study of ecological communication and sustainable development involves collaboration between various disciplines, including communication, ecology, environmental science, and social science. Increased understanding of the complexities of environmental and sustainable development issues has stimulated growth in interdisciplinary publications. The significant development of publications in the study of ecology communication and sustainable development is an essential indicator of the increasing focus and efforts to understand and address the world's environmental challenges today. In addition to increasing the number of published documents based on the year of publication, there is another trend, namely frequently cited published documents.

Table 1. Top 10 frequently cited publication documents

Document Title (Year)	Authors	Cited
A systematic literature review on machine learning applications for sustainable agriculture supply chain performance (2020)	Sharma, R., Kamble, S.S., Gunasekaran, A., Kumar, V., Kumar, A.	222
Advanced UAV–WSN system for intelligent monitoring in precision agriculture (2020)	Popescu, D., Stoican, F., Stamatescu, G., Ichim, L., Dragana, C.	109
Environmental cost of non-renewable energy and economic progress: Do ICT and financial development mitigate some burden? (2022)	Ramzan, M., Raza, S.A., Usman, M., Sharma, G.D., Iqbal, H.A.	86
Microbe-induced plant volatiles (2018)	Sharifi, R., Lee, S.-M., Ryu, C.-M.	82
Experience versus expectation: farmers' perceptions of smart farming technologies for cropping systems across Europe (2020)	Kernecker, M., Knierim, A., Wurbs, A., Kraus, T., Borges, F.	79
Integrated ecological–economic fisheries models—Evaluation, review and challenges for implementation (2018)	Nielsen, J.R., Thunberg, E., Holland, D.S., et al.	75
Stretching "smart": Advancing health and well-being through the smart city agenda (2019)	Trencher, G., Karvonen, A.	74
A synthesis: What is the future for coasts, estuaries, deltas and other Transitional habitats in 2050 and beyond? (2019)	Elliott, M., Day, J.W., Ramachandran, R., et al.	62
A novel ICT framework for sustainable development goals (2019)	Kostoska, O., Kocarev, L.	58
Ecological intensification for sustainable development (2021)	Raj, A., Jhariya, M.K., Khan, N., Banerjee, A., Meena, R.S.	55

According to Table 1, there are several publications from the years 2018 through 2022 that are commonly mentioned in research on ecological communication and sustainable development. The value of citing publications on ecological communication and sustainable development in other texts must be considered. In-depth research and analysis documents are crucial for citation because they offer a robust framework for comprehending and debating pertinent subjects. Because they support and validate the arguments and assertions made in other texts, credible and correct references are crucial to cite.

Document citations are often crucial for supporting claims, offering academic backing, and influencing research and policy direction [13]. An essential factor in the growth and influence of this topic is the high citation rate of published articles dealing with issues of ecological and sustainable development communication. Citations of publications show how research has influenced and contributed to our understanding of ecological communication and sustainable development. The citations demonstrate how such research advances our understanding of environmental and sustainability concerns, bridges knowledge gaps, and adds to the body of knowledge.

Publication documents on ecology communication and sustainable development often provide in-depth research and analysis. The document contains research results that can form the basis for further research and policy development. Quality published documents have a strict peer review process so that they can be used as reliable references in research and policy development [14]. Therefore, the citation of relevant published documents can provide trust and credibility to the research and policies developed.

The more frequently other documents cite a published document, the higher the visibility and recognition it will get for the author and related institutions [15]. This can enhance the authors' and institutions' academic and professional reputations [16]. Widely cited published documents can help strengthen the support and influence of policies proposed by governments. Citation by relevant published documents can provide a solid basis for formulating and implementing effective policies on ecological communication and sustainable development.

Some of the highest-cited research in ecological communication and sustainable development has revealed important findings that strengthen the development of more sustainable policies and practices. Regarding the first document, the application of machine learning in agricultural supply chains shows improvements in productivity and soil health [17]. The second document discusses UAV–WSN systems for precision agriculture that enable efficient crop monitoring [18]. The third document highlights the

environmental costs of non-renewable energy and an ICT framework for sustainable development [19]. The fourth document discusses microbial-induced volatiles to improve plant health [20]. The fifth document discusses European farmers' perceptions of smart agriculture [21].

The sixth document highlights future evaluations of transitional habitats and ecological-economic models for fisheries [22]. The seventh document discusses the potential of technology in improving the quality of life through the smart city agenda [23]. The eighth document synthesizes the results of numerous case studies from experts around the world on the environmental state, sustainability and likely future of river estuaries, lagoons, semi-enclosed seas and coastal ecosystems, highlighting the importance of better management to maintain the ecological structure of natural and sustainable ecosystem services [24]. The ninth document presents a new ICT framework for achieving sustainable development goals, which integrates local and global aspects and enables citizen involvement in the governance of sustainable development goals [25]. Finally, the tenth document outlines the concept and prospects of ecological intensification in various natural resources, such as agriculture and forestry, to achieve sustainable production systems at the global level [26].

Highly cited research in ecological communication and sustainable development has led to a deep understanding of how technology, awareness and model integration can play a key role in achieving sustainable development. From machine learning applications in agricultural supply chains to UAV–WSN systems for precision agriculture, as well as new ICT frameworks for achieving sustainable development goals, this research illustrates a variety of approaches aimed at increasing productivity, maintaining natural ecological structures, and promoting sustainable practices. By emphasising better management in maintaining sustainable ecosystem services and integrating local and global aspects within an information and communications technology (ICT) framework, this research confirms the importance of ecological communication in guiding policies and practices that support future sustainable development.

The importance of the research cited in the context of ecological communication and sustainable development lies in its direct contribution to our understanding of environmental and sustainability issues and its ability to shape more sustainable policies and practices. The high citations of these publications demonstrate their great influence in guiding research direction, shaping opinion, and influencing decision-making, both at the academic and policy levels. Thus, the emphasis on better management, integration of local and global aspects, and the application of sophisticated information and communication technology carries clear implications for future efforts towards more sustainable development.

3.2 The relationship between the different research topics and how future research gaps

Each research topic is related and can influence the development of further research [27]. Several trending research topics related to ecological communication and sustainable development are described as following Figure 2.

Figure 2 shows that among interrelated research topics, some topics are still relatively new. Research topics continue to experience development trends. Some topics have often been studied in other cases. However, when it comes to ecological communication and sustainable development, it is considered that they have yet to be widely explored by global researchers. It became a gap for future research. Some research topics that are still newly researched have been identified, including Information and communication, economic and social effects, conservation, and agriculture. It shows that the communication of ecology and sustainable development has links with several topics, which include Information and Communication Technology (ICT), economic and social impacts, conservation, and agriculture.

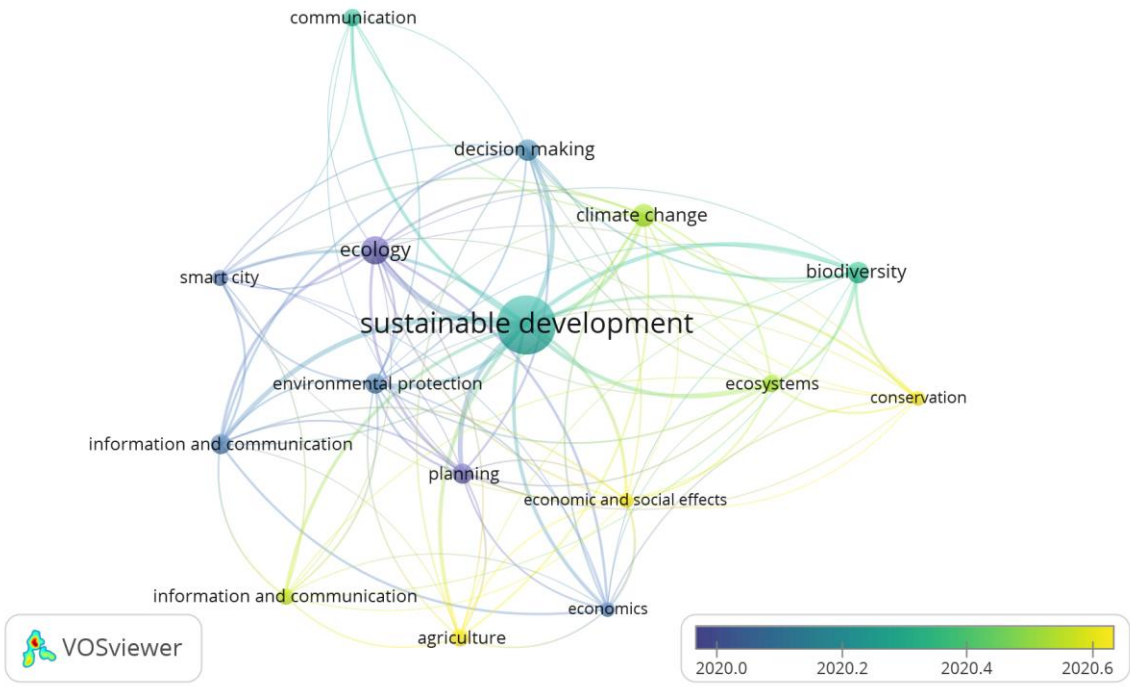

Figure 2. Research topics related to ecological communication and sustainable development

Ecological communications utilize ICT to disseminate information on environmental and sustainability issues. ICT can collect, store, process, and disseminate environmental data and information to the broader community [28], to increase awareness and participation in efforts to preserve the environment and sustainable development [29]. In addition, the communication of ecology and sustainable development also involves understanding the economic and social impacts of environmental practices and policies. Effective communication can help inform and influence consumer behaviour, business practices, and government policies that impact sustainable development's economic and social aspects [29].

Ecological communication is essential in conserving natural resources and biodiversity [30]. Through campaigns, education, and public awareness, ecological communication helps increase understanding of the importance of protecting ecosystems, promoting conservation actions, and sustainably managing natural resources. Ecological communication in the agricultural context involves disseminating knowledge about sustainable agricultural practices, efficient use of resources, and environmental protection [31]. Thus, effective communication can influence farmers, food producers, and other stakeholders to adopt environmentally friendly agricultural practices and contribute to sustainable development.

The link between ecology and sustainable development communication and topics such as Information and Communication Technology, economic and social impacts, conservation, and agriculture highlights the importance of effective communication in promoting awareness, action, and behaviour change that supports sustainable development.

3.3 Policy design based on the study of ecological communication and sustainable development

Policy design based on the evolution of studies on the communication of ecology and sustainable development plays a vital role in addressing environmental challenges and driving the transition towards a more sustainable society. Conduct a review of the latest literature and research in the field of ecological communication and sustainable development. It helps understand the latest developments, trends and important discoveries that can provide a scientific basis for policy design.

Identify key issues in ecological communication and sustainable development that require policy interventions. This could cover aspects such as natural resource management, climate change mitigation and adaptation, biodiversity conservation, environmental education and awareness, and sustainable development in agriculture, energy, and transport sectors. In addition, it involves experts, researchers and practitioners experienced in ecological communication and sustainable development. They can provide valuable insights and input to help design policies based on current knowledge and experience.

Incorporating a practical communication approach in policy design includes using the right communication strategy to convey messages about environmental issues to various stakeholders, including the general public, the business sector, and the government can make a positive contribution. A better understanding of the audience and using relevant communication channels can increase acceptance and support for the proposed policy. These things encourage cross-sectoral collaboration between the government, the business sector, civil society organizations, and the general public. Ecological communication and sustainable development policies require close cooperation and coordination between various stakeholders to achieve sustainable results.

4. CONCLUSIONS

Designing policies based on evolutionary studies on ecology and sustainable development communication is essential in addressing environmental challenges and promoting change towards a more sustainable society. By integrating the latest knowledge, involving experts, using a practical communication approach, and conducting cross-sectoral collaboration, policies can be better designed to achieve sustainable development goals. Evaluation of the impact of policies and the active involvement of stakeholders is also vital in ensuring that the implemented policies achieve the desired changes. With a comprehensive and collaborative approach, policy can be essential in driving the transition towards a more sustainable future.

This study also found several topics that could be followed up in policy formulation, especially on topics currently becoming global trends, such as information and communication, economic and social impacts, conservation, and agriculture. The topics identified in this study have strong relevance to policy formulation in ecological communication and sustainable development. Information and communication are the main foundations for disseminating knowledge about environmental issues and changing behavior towards sustainable practices. Understanding how society delivers and receives these messages is essential in building public awareness and support for sustainable action. Sustainable practices' economic and social impacts require in-depth analysis to measure their effectiveness and identify potential improvements. This includes an understanding of how sustainable practices can provide long-term economic benefits and positive social impacts.

In addition, conservation and agriculture are essential to preserving ecosystems and maintaining a balance between human and environmental needs. Future research can contribute by investigating effective communication methods in supporting conservation and sustainable agricultural practices and investigating innovative solutions to overcome challenges associated with these topics. By focusing on these topics, future research in ecological communication and sustainable development can provide valuable guidance for policymakers in designing more effective strategies to address global environmental challenges and move society toward sustainability.

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