Understanding the State of Environmental Valuation Research: a Bibliometric Analysis of the Literature

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Abstract: This article proposes an extensive investigation of the prevailing methodologies of environmental valuation, offering a comprehensive synthesis and critical assessment of the literature. A bibliometric analysis of 531 articles revealed a higher prevalence of stated preference methods over revealed preference methods. However, a notable lack of consensus was identified regarding the valuation of ecosystem services, reflecting the varied individual preferences towards different types of benefits. The main contribution of the study lies in the critical evaluation of these valuation methodologies, exposing their discrepancies and areas for enhancement. This work sets a new benchmark for future research, promoting a comprehensive understanding of the benefits of ecosystems and fostering the integration of various valuation methods. Future research should explore the incorporation of machine learning techniques to more effectively analyze and utilize the large amounts of data being collected.

Keywords: Choice method; choice method experimentation; contingent valuation; environmental valuation; willingness to pay

1. INTRODUCTION

In neoclassical economics, nature's value is often equated with its utility to humans (Gómez-Baggethun *et al.*, 2010). Conventionally, nature's value is estimated by quantifying what people are willing to pay for environmental goods and services, minus the costs of their provision (De Groot *et al.*, 2002). However, this approach neglects important facets of nature, including its intrinsic value, which is independent of human desires. Given the growing consensus about the unsustainable nature of current economic practices, nature's valuation has gained increasing interest among reserchers (Scoones et al., 2020). Among the major global environmental concerns is climate change mitigation. Different methodologies, such as ecosystem services valuation, can quantify the external benefits of mitigating climate change, with these services encompassing the benefits humanity derives from nature like clean air and water, carbon sequestration, and biodiversity habitats. Yet, assessing climate change's external costs and the benefits of interventions is challenging due to the complexities in measuring climate change impacts, which involve factors like the severity and timing of future impacts, the socio-economic effects, and the efficacy and costs of mitigation measures. Further complicating this is the lack of consensus on valuing climate change mitigation benefits, hindering the determination of suitable investments in these actions (Streimikiene *et al.*, 2019).

To enable more informed decisions about resource management, there is a need for a holistic and refined approach that captures the full range of nature's benefits (Laraway *et al.*, 2019). This underpins the essence of environmental valuation, an economic field that examines the value people attribute to the environment and its constituent resources (Kostetska *et al.*, 2020). Despite this growing interest, there is no consensus on how to value ecosystem services (Zavaleta, 2000). One reason for this is the different ways that people can benefit from nature. Some benefits are direct, such as the food or water provided by an ecosystem, while others are indirect, such as the reduction in asthma rates from cleaner air (Shanahan et al., 2015). In addition, people may place different values on different types of benefits. For example, some people may place more value on the environmental regulation provided by wetlands than on the recreational opportunities they provide. There are several methods that have been used to estimate the value of ecosystem services: cost-benefit analysis (CBA), contingent valuation (CV), travel cost method (TCM), hedonic pricing, and replacement cost methods. Each of these methods has its own strengths and weaknesses, and there is no one "correct" way to value ecosystem services. In fact, it may be necessary to use multiple methods in order to get a complete picture of the benefits provided by an ecosystem.

The purpose of this study is to emphasize the main topics that have been the focus of research so far and to suggest some potential directions for future research. To achieve these objectives, the article aims to address the following research questions:

(1) What is the present state of research on environmental valuation, including the identification of the most influential authors, top journals, top publication countries, and topic areas of study?

(2) What is the conceptual framework of existing research on environmental valuation and what are the dominant method-

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ologies used in the field of environmental valuation as identified in the literature?

(3) Is there a consensus on the most appropriate method for valuing ecosystem services and what are the most prevalent topics in research on environmental valuation?

(4) What research gaps and prospective research paths exist in the field of environmental valuation?

The literature review will first provide an overview of the various methods that have been used to estimate the value of ecosystem services. These methods include cost-benefit analysis, contingent valuation, travel cost method, hedonic pricing, and replacement cost methods. The review will then assess the most prevalent topics in research on environmental valuation, including the valuation of ecosystem services, the use of choice methods and experimentation, and the importance of considering non-use values. The paper will also discuss the conceptual framework of existing research on environmental valuation, including the role of sustainability and the importance of interdisciplinary approaches. Finally, the paper will identify potential research gaps and future research paths in the field, including the need for more comprehensive and inclusive valuation assessment and the importance of integrating different valuation methods.

2. LITERATURE REVIEW

Environmental valuation is a subfield of non-market economics that focuses on the assessment of the welfare effects of environmental interventions or degradation on people and social groups, in terms of the monetary value of the benefits or costs they generate (Bruvoll & Nyborg, 2004). This type of valuation is relevant for policy-making, as it provides decision-makers with the necessary information to design and implement effective policy measures for resource allocation, taxation, and compensation schemes that address environmental externalities and align economic incentives with environmental objectives (Haab & McConnell, 2002). To this end, environmental valuation relies on various techniques that aim to quantify the costs and benefits of utilizing environmental goods, enhancing their conditions, or addressing environmental issues (Nyborg, 2000). These techniques take into account the diversity and complexity of the environmental assets present in a given region, as well as the values and preferences of the stakeholders affected by the environmental changes (Remoundou & Koundouri, 2009). Some of the most commonly used environmental valuation techniques include stated preference methods, which involve asking individuals directly about their preferences and values, and revealed preference methods, which involve observing people's actual choices and behaviors (Niemeyer & Spash, 2001). Examples of stated preference methods include contingent valuation and choice experiments, while examples of revealed preference methods include hedonic pricing and travel cost analysis. These techniques are commonly used in the assessment of the welfare effects of environmental interventions or degradation, in order to provide policymakers with information for resource allocation, taxation, and compensation schemes that address environmental externalities and align economic incentives with environmental objectives (Christie *et al.*, 2012).

Environmental valuation can also help to assess the economic impacts of environmental changes on different stakeholders, beyond the direct beneficiaries or users of environmental goods or services. For example, protected natural areas, such as national parks, can provide economic benefits that go beyond the travel and leisure sector, including attracting and retaining residents, skilled workers, investors, and other professionals, as well as enhancing regional development and competitiveness. These benefits may be derived from the diverse range of environmental goods and services that protected natural areas offer, such as recreational opportunities, ecosystem functions, cultural values, and aesthetic appeal, as well as their contribution to the conservation of biodiversity, the improvement of air and water quality, the provision of natural resources, and the adaptation to and mitigation of climate change (Lindberg & Lindberg, 1991). On the other hand, some studies have demonstrated the negative impact that deteriorating environmental conditions can have on stakeholders' values, such as reduced property values, decreased quality of life, and reduced health outcomes. To take an example, research has shown that noise and air pollution from road traffic can decrease real estate prices and affect the attractiveness of a neighborhood or a city as a place to live, work, or invest (Baranzini & Ramirez, 2005). Economists have traditionally used tools such as individuals' willingness to pay for environmental amenities and the associated costs to evaluate the environmental value of a particular site or policy option. These tools are based on the assumption that people's preferences and behaviors are influenced by the quality of the environment, and that the value of environmental improvements or deterioration can be measured in terms of the changes in their willingness to pay or the changes in their behavior. The degradation of the environment is often assessed by determining the loss incurred by those who benefited from it and the appropriate compensation for that loss in terms of willingness to pay (Hanemann, 1991).

Environmental valuation methods can be classified according to their focus on use or non- use values, and their specific techniques and assumptions (Adamowicz *et al.*, 1993). Use values refer to the benefits obtained from the actual use or consumption of an environmental resource. These values can be further divided into direct use values, which are the values that individuals or groups derive from the immediate use of an environmental resource, and indirect use values, which are the values that individuals or groups derive from the use of goods or services that are produced using an environmental resource as an input (Gürlük & Rehber, 2008). Non-use values, on the other hand, are the benefits that individuals derive from the existence, bequest, or preservation of an environmental resource, even if they do not use it themselves (Remoundou *et al.*, 2009). Non-use values can be further divided into existence values, which are the values that people place on environmental goods simply for their existence, and inheritance values, which reflect the value people associate with the potential future utilization of an environmental resource. Existence values can be motivated by ethical, spiritual, or cultural reasons, and may be influenced by the intrinsic value of nature, the intrinsic value of biodiversity, or the intrinsic value of natural capital. Inheritance values can be motivated by altruistic, bequest, or precautionary reasons, and may be influenced by the potential future benefits or

risks associated with the environmental resource. Non-use values can be difficult to quantify, as they depend on individuals' subjective preferences, beliefs, and attitudes, and may vary across different cultures, generations, and contexts. However, non-use values can be significant drivers of environmental policy, as they reflect the social norms, values, and preferences that shape society's relationship with the environment.

Environmental valuation methods typically include a range of techniques and assumptions that are specifically designed to assess the economic value of natural resources and ecosystems. These methods can be categorized into several groups based on their specific approaches, which typically include:

- Stated preference methods. These methods are a type of environmental valuation technique that rely on the use of surveys to elicit individuals' preferences for environmental goods and services. They are based on the assumption that individuals' choices reveal their underlying values and can be used to estimate the willingness to pay for environmental improvements or the willingness to accept compensation for environmental losses. These methods include contingent valuation, which asks individuals about their willingness to pay or accept compensation for environmental changes, and choice experiments, which present individuals with hypothetical scenarios involving multiple options or attributes and ask them to choose their preferred option. These methods are useful for valuing non-market goods and services, such as environmental amenities, that do not have observable prices in the market. However, they may be subject to various biases, such as hypothetical bias, which refers to the tendency of individuals to give different answers to hypothetical questions compared to their actual behavior, and strategic bias, which refers to the tendency of individuals to give biased answers to influence the outcome of the survey.

- Revealed preference methods. These methods infer values from observed choices and behaviors in real-world situations. They include hedonic pricing, which estimates the value of environmental attributes by analyzing the relationship between property prices and the characteristics of the property, such as the proximity to environmental amenities or the quality of the environment (Guijarro, 2019), and travel cost analysis, which estimates the value of recreational use of an environmental resource by analyzing the relationship between the cost of travel and the number of visits to the resource. These methods are useful for valuing market goods and services, such as recreational use, that have observable prices in the market. However, they may be subject to various biases, such as omitted variable bias, which refers to the inability to control for all relevant factors that may affect the observed relationship between the dependent and independent variables, and endogeneity bias, which refers to the reverse causality between the dependent and independent variables.

In light of the ongoing challenges of sustainable development, a thorough understanding of the value of the environment and its role in decision-making has become increasingly vital. The ultimate goal of this analysis is to provide a comprehensive overview of the current state of research on environmental valuation within the context of sustainable development, highlighting key themes and identifying potential directions for future research.

3. RESEARCH METHODOLOGY

3.1. Bibliometric Analysis

Bibliometric analysis, as described by Merigó *et al.*, 2015 is a method used to quantitatively analyze and evaluate a large body of research on a particular subject in order to understand the growth and quality of the literature in that field. This approach, which intends to eliminate researcher subjectivity (Kumar *et al.*, 2020), allows researchers to review past studies, identify advances in current knowledge, and lay out directions for future research (Albort-Morant *et al.*, 2017). In this article, bibliometric analysis was used to assess the scientific production and primary scholar contributors in a specific field of research, and to address research questions about authors, countries, journals, and citations (García-Berná *et al.*, 2019).

In this study, the VOSviewer software (Van Eck & Waltman, 2010) was used to visualize and analyze the bibliometric network of the research field under investigation. This tool allows to create a network map of keywords in order to examine the relationships between elements, such as documents, authors, countries, and fields of study (Durieux & Gevenois, 2010). The VOSviewer software was employed to perform co-citation analysis (Small, 1973), which measures the impact and influence of scientific papers or authors on the research topic by analyzing the patterns of citation between them. By using the VOSviewer software, the researcher was able to gain a deeper understanding of the research field's structure and the role of the research output in shaping it.

3.2. Data Collection

For the data collection in this study, the authors used a bibliometric literature search to identify relevant papers. The search involved selecting keywords, developing search strings, and using a database. The database selected for this analysis was Scopus, which is a comprehensive scientific database that offers a wide range of features for scholarly research and literature. Some of the main features of Scopus include its extensive coverage of the scientific literature, its user-friendly interface, and its advanced search and filtering options. The authors chose Scopus due to its wide coverage of literature and its comprehensiveness of bibliometric information for publications that it lists.

When searching Scopus with the keywords "Environmental Valuation," a total of 563 articles were retrieved. The data was collected in August 2022, but the results may vary in the future due to updates to the Scopus database. The relevance of the titles and abstracts of the articles was then evaluated, and a total of 531 articles were included in the analysis. The articles identified through the bibliometric literature search were narrowed down to journal articles and English-language publications. This selection criterion ensured that the analysis focused on a specific type of research output and language, and allowed for a more systematic and comparable analysis of the research field. Among these articles, 527

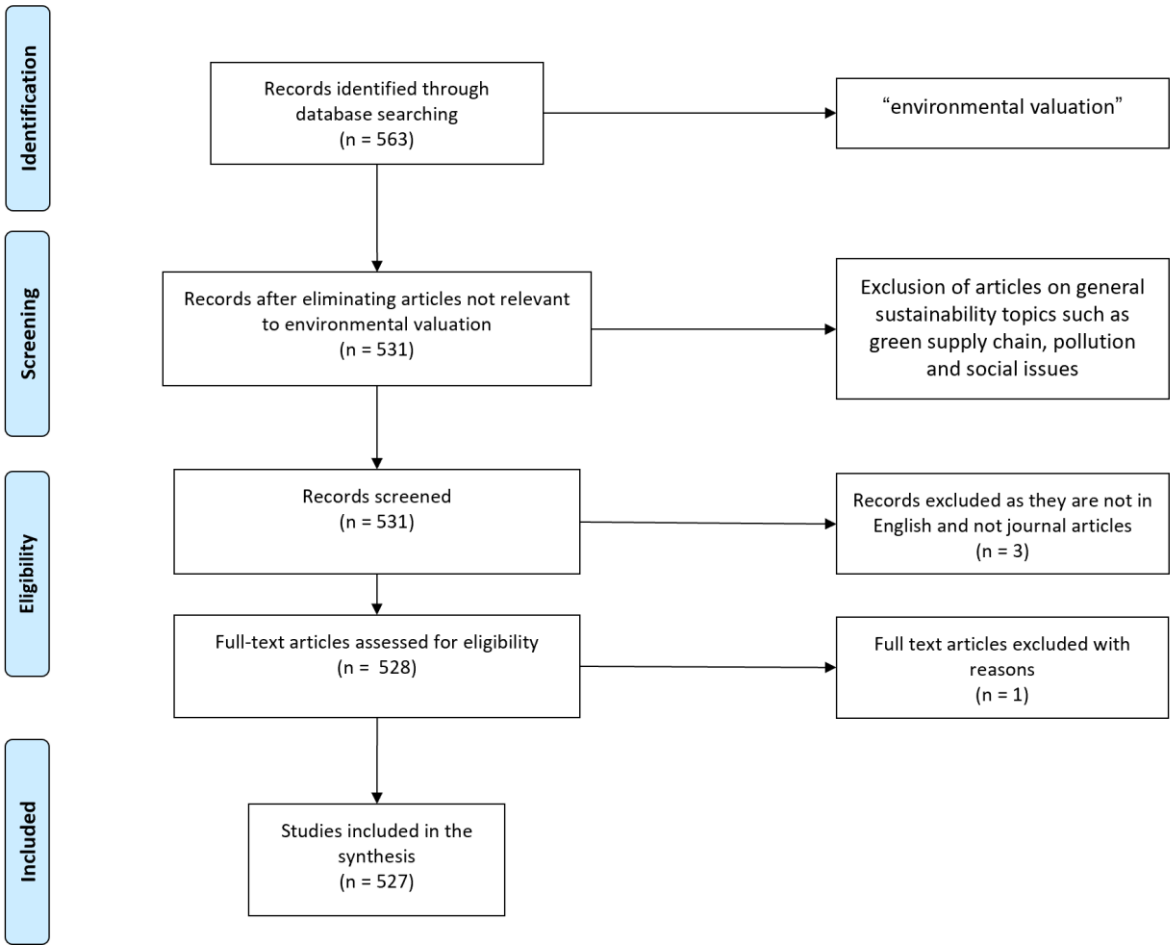

Fig. (1). Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart showing the search procedures used in the review.

research publications were included in the bibliometric analysis after excluding those that did not specifically focus on environmental valuation but rather covered topics such as pollution and its social consequences, or those that addressed environmental valuation only in a general sense as part of policy management (see Fig. **1**).

In this study, a final sample of 527 articles was selected from the Scopus database for bibliometric analysis. The articles were selected based on specific criteria that aimed to assess environmental valuation as the main topic of research. The data included the names of the authors and their institutional affiliations, the title of the document, the keywords associated with the article, the abstract or summary of the main findings, and the citation statistics.

The collected data was then uploaded into the VOSViewer software version 1.6.8, which is a tool specifically designed for visualizing and analyzing bibliometric networks. By using the VOSViewer software, the researchers were able to examine the patterns of citation, co-citation, and co-occurrence among the articles. Co- citation analysis, as described Zupic and Čater (2015), is a method that measures the impact and influence of scientific papers or authors on the research field by analyzing the patterns of citation between them. More precisely, it is a way to measure the impact and influence of these units in the research field and identify the most highly cited and influential ones. To perform co-citation analysis, the researcher counts the number of times that two units (e.g., papers, authors, journals) are cited together in the same reference list of a third article. By using co-citation analysis, the researcher is able to identify the highly cited and influential papers, authors, and journals in the research field and understand the relationships between them.

4. RESULTS

In the following part of this paper, we will share the results of our analysis on environmental valuation and its relationship to sustainable development. This analysis was conducted to address the research questions posed at the beginning of the paper, and to provide insights into the current state of the literature on this topic, as well as the contributions and citations of the primary scholar contributors. Our findings have been organized and shared in a logical and coherent manner, based on the data collected and analyzed through the VOSViewer software. Our aim is to contribute to a better understanding of the field of environmental valuation and its role in sustainable development and identify opportunities for future research in this area.

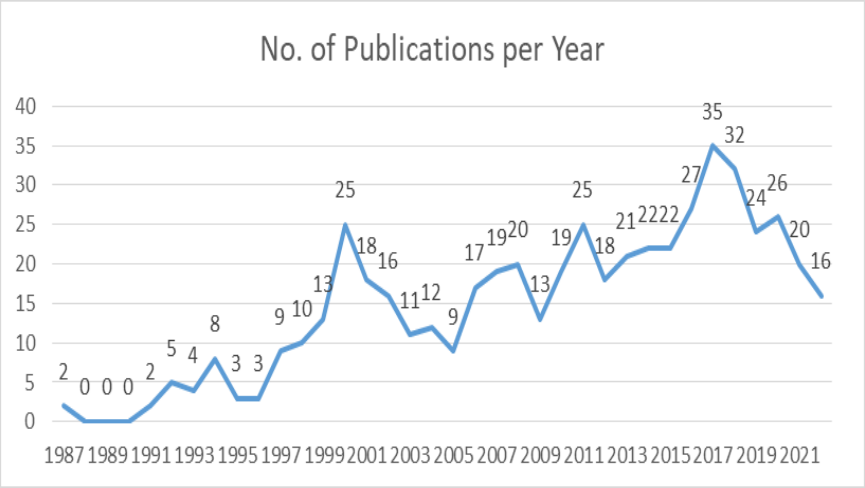

Fig. (2). Annual volume of environmental valuation scholar production.

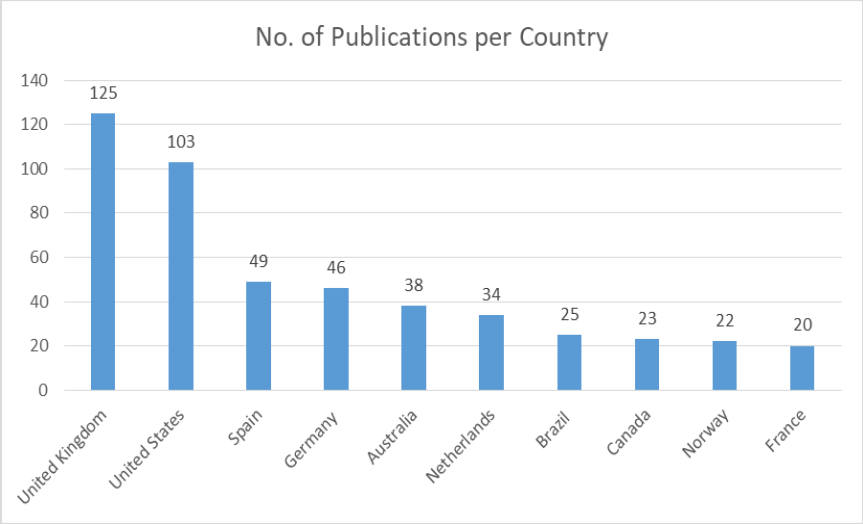

Fig. (3). Global dispersion of the literature on environmental valuation.

4.1. Literature Volume, Growth Trend, and Geographic Distribution

As mentioned above, our analysis of the current literature on environmental valuation using Scopus resulted in a knowledge base of 527 journal articles. The literature included in this analysis was relatively recent, with a slow start in 1987 and gradually increasing production until it peaked in 2017 with 35 articles. A detailed analysis of the available literature revealed a noticeable upsurge in academic activity in this area over the recent years as shown in Fig. (**2**). This exponential increase may be due to a shift in the dominant keyword categories over three subperiods: 1987-2000, 2001-2011, and 2012-2022. During the first two subperiods, cost-benefit analysis and contingent valuation were the main focus, while choice experiments emerged as the dominant theme in the 2012-2022 subperiod. This trend may reflect the evolution of research interests and priorities within the field of environmental valuation over time.

Fig. (**3**). illustrates the geographical distribution of research publications on environmental valuation. An examination of the data shows that the United Kingdom (125), the United States (103), and Spain (49) are the most productive countries in this area, with a combined total of 236 published articles, or 53% of the total analyzed in this bibliometric study. It is notable that Spain, in particular, has become a major center for research on environmental valuation, particularly in relation to policy making and the sustainability of its industries. Brazil has also placed a focus on environmental valuation, particularly in relation to deforestation and its negative impact on ecosystems. It is worth noting that the dominance of Anglo-American production in this area may be due to the fact that this study focused on English-language publications.

4.2. Evaluation of Prominent Authors

This section examines the Scopus-indexed authors who have had the greatest impact on the literature on environmental valuation. By identifying these prominent authors, we can gain insights into the patterns of knowledge development and dissemination in this field. Table **1** displays the top ten authors with the highest citation count within the database.

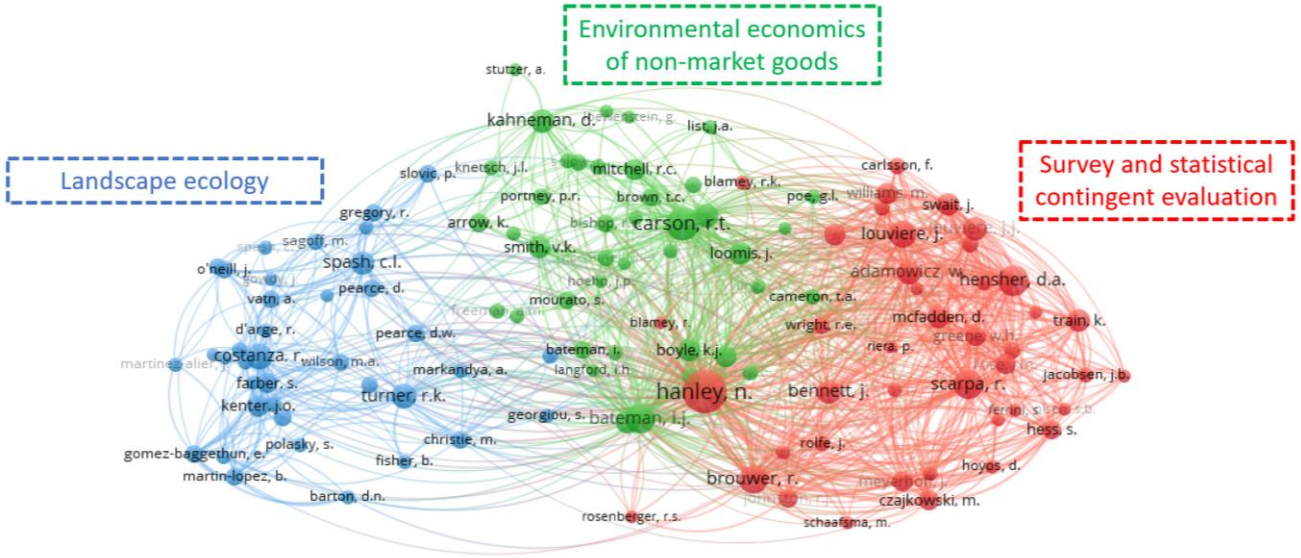

Fig. (4). Three clusters, representing the intellectual structure of environmental valuation' literature.

Table 1. Highly cited Authors on Environmental Valuation.

Rank	Author	Country	Articles	Citations	Total Link Strength
1	Hanley N.	UK	13	1477	15
2	Brouwer R.	Canada	7	603	14
3	Spash C.L.	Germany	7	465	10
4	Navrud S.	Norway	10	362	8
5	Gowdy J.M.	USA	5	257	0
6	Börger T.	Germany	8	245	9
7	Rolfe J.	Australia	5	245	4
8	Meyerhoff J.	Germany	10	212	19
9	Moran D.	UK	5	205	2
10	Thorsen B.J.	Denmark	9	204	17

Based on the number of Scopus articles analyzed, Hanley N. (13 articles), Navrud S. (10 articles), and Meyerhoff J. (10 articles) are the most productive researchers in the field of environmental valuation. However, if authors are ranked based on the total number of citations received to determine the most influential authors, Hanley N. (1477 citations), Brouwer R. (603 citations), and Spash C.L. (465 citations) are the top three. It is also worth noting that these highly cited authors tend to specialize in different disciplines within environmental valuation. Hanley N. focuses on environmental economics, Navrud S. focuses on the benefit transfer to local communities through better evaluation of communities, and Meyerhoff J. focuses on choice experiments.

4.3. Collaboration Analysis Map and Intellectual Structure of the Literature

In this part of the paper, we conducted an author co-citation analysis (ACA) to examine the intellectual structure of the literature on environmental valuation. ACA is a method that identifies similarities between authors based on the number of co-citations they receive (Bush & Gilbert, 2002). The results of this analysis are displayed in Fig. (**4**), which shows the relationships between academics as nodes, with network ties indicating the similarities between them. The size of the nodes reflects the number of co-citations received, with larger nodes indicating a higher number of co-citations. Adjacent nodes in the diagram are considered to be intellectually comparable based on the ACA.

Scholars affiliated with the Environmental economics of non-market goods (represented by the green cluster in the ACA) have published extensively on the financial impact of environmental policies and how they can be used to benefit local communities. This school of thought focuses on the economic effects of environmental evaluation.

The red cluster, as identified through co-citation analysis, is largely composed of studies that examine the use of the contingent valuation approach and choice experiments in environmental valuation (Guijarro & Tsinaslanidis, 2020). This cluster is led by the work of Boxall *et al.*, 1996 which compares these two methods empirically. Many other studies in this cluster follow the methodology established by Boxall et al., while some also investigate the choice experiment as a variation of the contingent valuation approach (Adamowicz *et al.*, 1997). Additionally, Adamowicz et al. (1993) investigated the differences between a stated preference model and a revealed preference model in determining the selection of locations for outdoor leisure activities.

Landscape ecology (represented by the blue cluster in the ACA) examines the structure and dynamics of the larger landscape system (Cushman *et al.*, 2010). To understand the

ecology of a landscape, it is necessary to understand the interactions between different landscape elements and activities. The term "landscape" was first defined by the German geographer Alexander Von Humboldt in the early 1800s as the complete character of a place (Bastian, 2001). It is interesting to note that the term "landscape" has been interpreted in various ways over time, ranging from a spatial scale to a place where human and ecological dimensions can coexist (Sayer et al., 2013; Wu, 2013). In the dataset examined, landscape ecology includes articles that combine ecology and geography. These studies aim to understand the interactions between different landscape elements and activities in order to better understand the ecology of a landscape. By analyzing the structure and dynamics of the larger landscape system, researchers can gain insights into the ways in which human and ecological dimensions coexist and interact within a specific environment.

4.4. Most Prolific Sources of Publication and Most Cited Documents in the Field of Research on Environmental Valuation

This review identified 527 publications in 20 journals within the field of environmental valuation. The most productive journals were determined based on the total number of articles published, the total number of citations, the journal's quartile rating, and its TP CiteScore. According to these criteria, Ecological Economics was the most productive journal, with 89 publications and the highest number of citations at 6023. This journal is published by Elsevier and is ranked Q1. Environmental and Resource Economics came in second place, with 2003 citations and 35 articles, followed by Journal of Environmental Management with 847 citations and 20 publications. The Journal of Environmental Economics and Management ranked fourth with 749 citations. Of the ten most productive journals in the field of environmental valuation research, five are published by Elsevier and all are ranked Q1. Academic Press publishes two of the top ten journals.

Table 2. Top 10 Publishing Sources in the field of Environmental Valuation.

Rank	Source	TP	Citations	Quartile	Publisher
1	Ecological Economics	88	6023	Q1	Elsevier
2	Environmental and Resource Economics	35	2003	Q1	Springer
3	Journal of Environmental Management	17	847	Q1	Academic Press
4	Journal of Environmental Economics and Management	20	749	Q1	Academic Press
5	Environmental Values	18	486	Q2	White Horse Press
6	Ecosystem Services	13	364	Q1	Elsevier
7	Australian Journal of Agricultural and Resource Economics	11	254	Q1	Wiley
8	Global Environmental Change	5	196	Q1	Elsevier
9	Environmental Science and Policy	5	185	Q1	Elsevier
10	Science of the Total Environment	11	151	Q1	Elsevier

Document citation analysis is a widely used method in the field of scientific research to identify the most influential documents within a particular domain. In this study, we employed this technique to identify the most significant articles within the field of environmental valuation.

According to our analysis, the work of Boxall and Adamowicz (2002) stands out as the most influential, receiving the highest number of citations among the top ten papers on this topic, with a total of 746 citations (as shown in Table **3**). By introducing a novel econometric approach, the authors used attitudinal measures of motivations and preferences to determine distinct segments or classes in the choice behavior of recreationists. Despite being a more recent publication, the work of Kenter et al. (2015) has also received a considerable number of annual citations. In their paper, the authors present a framework of shared and social values of ecosystems, identifying seven main types of shared values and illustrating their interplay with individual values. The article highlights the importance of considering shared/social values in decision-making and critiques the neoclassical economic approach in assessing social value.

The choice experiment model is prevalent among the highly rated publications in Table **4**, which present various environmental valuation situations and provide recommendations from the authors. Some of these highly ranked publications are dedicated to case studies or literature reviews.

4.5. Analysis of Keyword Co-occurrence

The authors of this study conducted a keyword co-occurrence analysis to identify the most common themes in the literature on environmental evaluation and to address the research question "What are the most prevalent themes in the literature on environmental evaluation?". This type of analysis involves identifying recurring keywords and examining their co-occurrence, which allows for the identification of patterns and the drawing of generalizations about their relationship (Walter and Ribiere, 2013). Keyword analysis is a useful tool for gaining insight into the literature on a particu-

Table 3. Top 10 highly Cited Published Documents in the Field of Environmental Valuation.

Rank	Title	Authors	Journal	Year	Total Citations	Total Citation per Year
1	Understanding heterogeneous preferences in random utility models: a latent class approach	Boxall et al.	Environmental and resource economics	2002	746	37.3
2	Choice modelling approaches: a superior alternative for environmental valuation?	Hanley et al.	Journal of economic surveys	2001	682	32.5
3	Valuing nature: lessons learned and future research directions	Turner et al.	Ecological economics	2003	537	28.3
4	A comparison of stated preference methods for environmental valuation	Boxall et al.	Ecological economics	1996	436	16.1
5	Environment and happiness: Valuation of air pollution using life satisfaction data	Welsch	Ecological economics	2006	358	21.1
6	The use (and abuse) of meta-analysis in environmental and natural resource economics: an assessment	Nelson et al.	Environmental and resource economics	2009	334	25.7
7	Designs with a priori information for nonmarket valuation with choice experiments: A Monte Carlo study	Ferrini et al.	Journal of environmental economics and management	2007	333	22.2
8	Perceptions versus objective measures of environmental quality in combined revealed and stated preference models of environmental valuation	Adamowicz et al.	Journal of environmental economics and management	1997	318	12.7
9	A typology for the classification, description and valuation of ecosystem functions, goods and services	De Groot et al.	Ecological economics	2002	299	15.0
10	What are shared and social values of ecosystems?	Kenter et al.	Ecological economics	2015	276	39.4

lar topic, as it offers a snapshot of the research that has been conducted (Khanra et al., 2020) and reveals the themes that have been explored over time (Pesta et al., 2018).

To conduct the keyword co-occurrence analysis, the authors utilized software called VOSviewer, which generated a density diagram based on terms extracted from a database (Fig. **5**). The results of this analysis showed that the most frequently used keyword among the authors was "environmental valuation" (377 instances), followed by "environmental economics" (237 instances), "willingness to pay" (217 instances), and "contingent valuation" (188 instances). Table **4** lists the top ten most frequent keywords.

The results of the keyword co-occurrence analysis, as depicted in Fig. (**5**) provide useful insights into the ideas that have been examined in prior research on environmental valuation. In the figure, we can observe three main clusters where the concept of environmental valuation has been explored alongside related experimental survey techniques, such as contingent valuation and choice experiments. Overall, the use of keyword co-occurrence analysis in this study allows for a deeper understanding of the themes and ideas prevalent in the literature on environmental evaluation.

The findings of the keyword co-occurrence analysis of journal articles related to environmental valuation provide insights into the most commonly mentioned concepts and themes within the literature on environmental valuation. This analysis allows for a deeper understanding of the themes and ideas prevalent in the literature on environmental evaluation. More precisely, it can be observed that there has been a significant amount of research on the use of choice experiments in conjunction with willingness to pay and non- market valuation of products (represented in the green cluster). This methodology is frequently used during the preliminary phases of environmental impact assessment: it has been presented as a stated preference valuation method and as a tool for assigning monetary values to environmental externalities in various studies (Grunert *et al.*, 2018; Gutsche & Ziegler *et al.*, 2019). Choice experiments involve presenting hypothetical scenarios to respondents, such as restoration options for an impacted good, and can help to elicit meaningful estimates of willingness to pay for environmental services. The incorporation of economic characteristics like willingness to pay and non-market valuation can significantly improve the environmental impact assessment process, despite its inherent limitations.

The second cluster with the highest number of occurring keywords is the red cluster, which focuses on environmental economics and specifically on studies that employ cost-benefit analysis. This method aims to improve the natural environment or to influence policy-making decisions that have indirect or negative impacts on the environment.

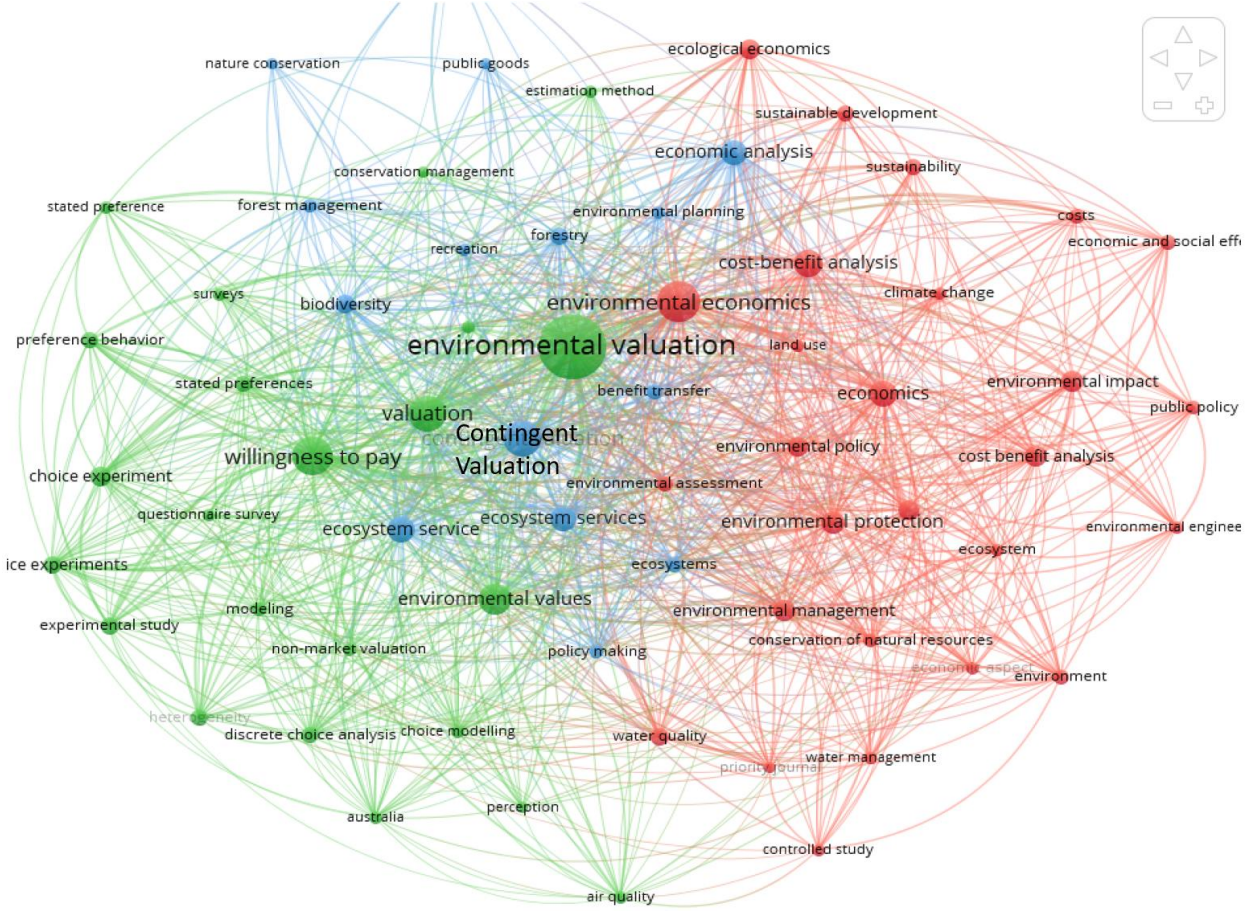

Fig. (5). Keywords co-occurrence map. Threshold: 3 co-occurrences.

The blue cluster focuses on the use of the contingent valuation method, which involves directly asking respondents about how much they would be willing to pay for specific environmental services through survey questions. In some cases, individuals may be asked how much money they would be willing to accept in exchange for giving up certain environmental services (Bishop & Heberlein, 2019; Huang et al., 2019; Wu, 2013). Overall, the results of the keyword co-occurrence analysis provide a comprehensive overview of the concepts and methods that have been addressed in past research on environmental valuation.

Table 4. Frequency of Occurrence of Top 10 Keywords.

Keyword	Occurrences
environmental valuation	377
environmental economics	237
willingness to pay	217
contingent valuation	188
environmental values	132
ecosystem service	128
cost-benefit analysis	113
ecosystem services	100
economic analysis	88
environmental protection	78

5. DISCUSSION

The current research was designed to identify and evaluate the dominant methodologies used in the field of environmental valuation. Through a review of the literature, it was found that stated preference methods are more frequently employed than revealed preference methods in environmental valuation. Additionally, the study found that only a small number of publications have considerably influenced the field. To further investigate this topic, 527 publications on environmental valuation from 1987 to 2022 were identified through a search on the Scopus databases. The analysis revealed that the most commonly used keywords among authors were "environmental valuation," "environmental economics," and "willingness to pay," appearing 377, 237, and 217 times, respectively. These findings suggest that the contingent valuation method and choice experimentation method are the most popular tools for environmental valuation, and that the field has seen significant progress and development since the emergence of the term "environmental valuation" in 1987, with numerous studies and significant advances in theory and application being published on the topic. Through this

review of the literature, the authors observed that environmental valuation presents important challenges due to the scarcity of true environmental valuation scenarios and the specificity of environmental assets. Additionally, the analysis revealed that stated preference methods have often replaced revealed preference approaches, with the choice experiment method dominating any other environmental assessment approach. It must be added that the complexity of the choice experiment approach has led to new academic issues and research avenues, including the need to develop and refine statistical techniques to better capture and analyze the complexity of choice experiment data, as well as to integrate behavioral and psychological factors into the modeling framework. Interestingly, the analysis revealed that none of the travel cost and hedonic price methods were among the top ten most popular methods of environmental valuation.

From the collaboration map and authors co-citation analysis we were able to identify environmental valuation studies that have been carried out in different regions other than Europe and America. Studies focusing on Africa have used a range of valuation methods, including contingent valuation, choice experiments, and travel cost method, to assess the economic value of various environmental assets. For instance, contingent valuation has been used to value the economic benefits of wetlands, forests, and wildlife, while choice experiments have been used to assess the economic benefits of biodiversity conservation and ecotourism (Lindsey *et al.*, 2005; Navrud & Vondolia, 2005; Swallow & Woudyalew, 1994). Additionally, the travel cost method has been used to value the economic benefits of national parks and other protected areas (Twerefou & Ababio, 2012). However, environmental valuation studies in Africa have also highlighted the challenges of applying these methods in the context of limited resources and data, and the need for more context-specific valuation methods that consider the unique social and cultural context of the region.

Authors from Asia have also used a range of valuation methods, including contingent valuation, choice experiments, and revealed preference methods, to assess the economic value of various environmental assets. For example, contingent valuation has been used to assess the economic benefits of forests, water resources, and biodiversity (Baral *et al.*, 2007; Jabarin & Damhoureyeh *et al.*, 2006). Choice experiments have been used to evaluate the economic benefits of ecosystem services such as carbon sequestration and soil conservation (Chaikaew *et al.*, 2017). Meanwhile, revealed preference methods such as hedonic pricing have been used to value the economic benefits of clean air and water (Yusuf & Resosudarmo, 2009). However, environmental valuation studies in Asia have also highlighted the need for more robust and transparent valuation methods that consider the unique social and cultural context of the region (Stem *et al.*, 2005).

Environmental valuation studies in Latin America have used a range of valuation methods, including contingent valuation, choice experiments, and travel cost method, to value the economic value of various environmental assets. For example, contingent valuation has been used to assess the economic benefits of forests, marine resources, and cultural heritage (Vásquez et al., 2014), while choice experiments have been used to assess the economic benefits of biodiversity conservation and ecotourism (Hearne & Salinas, 2002). Similarly, the travel cost method has been used to value the economic benefits of national parks and other protected areas (Alvarez & Larkin, 2010). These studies have also highlighted the challenges of applying these methods in the context of diverse cultural and social contexts, and the need for more inclusive and participatory valuation methods that consider the diverse perspectives and values of local communities.

From the co-citation analysis conducted by the authors, it has also been observed that the most prestigious and influential publications in the area of environmental valuation are rated highly by Scopus in their respective fields. This demonstrates that environmental valuation is recognized as an important research field, and the area is well-established with a number of high-quality articles on the topic. The co-citation analysis also identified two separate author groups of authors depending on their publication history. The first group initiated the growth of the field in the mid-1990s (red cluster), while the second and third groups have a greater influence beginning in the 2000s.

It is interesting to note that several scholars highlighted biases in contingent valuation methods, demonstrating that the principal critique of their results studies focuses on two aspects: dependability and validity (Mitchell and Carson, 1989). Dependability refers to the reliability of the results, while validity refers to the extent to which the results accurately reflect actual behavior (Loomis, 1990). Critics argue that contingent valuation methods suffer from theoretical contradictions that challenge their validity. According to Wattage et al. (2000), contingent valuation has generated the most comprehensive study of individual preferences yet conducted in economics. In this regard, it is now evident that benefit-cost analysts have depended for too long on the far better-developed theoretical framework for price changes, the same framework that critics rely on intuitively to evaluate the theoretical coherence of empirical contingent valuation data. The forced quantity adjustments that define many environmental amenities have fundamentally different welfare economic features than price increases for marketed products (Hanemann 1991; Ebert 1998). While many of these conclusions were previously known, only lately has the theoretical framework's full depth and the general coherence of empirical contingent valuation results with it become clear.

However, there is a long-standing issue with contingent valuation methods in which asking individuals about their willingness to pay for an item is often perceived as a simplistic or inaccurate method. Critics of this approach argue that if preferences can be evaluated in any manner through survey questions, then the plausibility of these questions or the number of hypothetical scenarios respondents are asked to " suppose" should not matter. Given this assumption, if the answers to such questions are deemed unrealistic or violate economic theory in some way, the validity of contingent valuation is called into question. Conducting a reliable survey using this method is neither simple nor cost-effective. Despite these criticisms, contingent valuation methods have been widely used in the area of environmental valuation, with some arguing that it is one of the most comprehensive

ways of evaluating individual preferences regarding environmental goods and services.

Another significant finding of this research was that a relatively small number of academic papers have had a significant effect on scholars in the environmental valuation field. One reason for this may be due to the constantly evolving nature of the field, with influential papers often being published in highly regarded journals. It is also possible that in more complex cases, the use of multiple methods may be necessary, as no single approach is suitable for all types of valuations. The study found that papers utilizing choice experiments to evaluate the value of environmental quality had the greatest impact on public policy debates while the travel cost and hedonic price methods did not appear among the top 10 most commonly used environmental valuation methods according to the dataset articles. Choice experiments require significant resources in terms of time and money, as they involve complicated questionnaires and data analysis. This is probably due to the fact that these methods, which involve real-world choices, are often preferred by policy-makers due to their perceived reliability.

6. CONCLUSION

This bibliometric analysis has provided an overview of the state of the field, highlighting key trends and gaps in the literature. It pointed out a propensity for the use of stated preference methods over revealed preference ones, despite their intricate application and criticisms. The study also demonstrates the continued relevance and influence of a handful of pioneering studies, underscoring the importance of high-quality research. While challenges persist in contextualizing these methods across diverse geographical and socio-cultural landscapes, the strides made in the field over time are significant. The analysis further sheds light on the necessity for adaptive, detailed, and context-specific valuation techniques that address the unique socio-cultural factors of various regions. The evolution of the field and its dynamic nature also points to the need for continuous exploration of new techniques and refinement of existing ones. Looking ahead, the complexity and cost of certain methodologies, such as choice experiments, may necessitate more practical and cost-effective approaches to environmental valuation, which will enable more effective policy-making in this crucial field.

It is important to note that while the use of environmental valuation in policy-making is the ultimate goal, academic works are not always directly used by decision-makers in revising policies. Nevertheless, these discussions are still vital as they provide insight and considerations for policy-makers when making decisions. The application of environmental valuation techniques and the knowledge generated through research in this area can inform policy decisions and help decision-makers understand the potential consequences of different choices. These academic discussions can also contribute to the development of a shared understanding of the issues at hand and help build consensus among stakeholders, which is crucial for effective policy-making. The knowledge generated through academic research can also feed into the broader societal discourse about the values and trade-offs related to environmental protection and natural resource management.

7. LIMITATIONS

It is important to note that our literature search was restricted to articles written in English, which could have led to the exclusion of relevant studies published in other languages and can help explain the lack of articles from countries such as China. Studies conducted in countries with a different official language or studies in fields where English is not the predominant language, may not have been included. The authors conducted a search by adding synonyms to the search query: 'environmental valuation' OR 'environmental evaluation' OR 'environment value' and found that, despite the increase in number of publications, the predominant research tendencies were identical to those identified earlier on in the first database search.

Additionally, it should be acknowledged that the findings of this study should be viewed as preliminary and exploratory. Our literature search was restricted to the Scopus database, which is comprehensive but does not cover all literature on environmental valuation. While co-citation analysis was used to identify additional relevant papers from the reference lists of the articles examined, alternative review procedures such as mining or context analysis may produce slightly different results. Therefore, caution should be exercised when interpreting the results of this study, and future research should seek to expand the scope of the search by employing alternative bibliometric techniques or by expanding the keyword pool.

8. FUTURE RESEARCH AVENUES

In the future, it may be useful to examine the incorporation of machine learning techniques in environmental valuation as a way to more effectively analyze and utilize the large amounts of data being collected. The ability to collect more data allows for the creation of large databases that can be used to improve environmental valuation methods through the incorporation of machine learning techniques. By utilizing these advanced analytical methods, researchers can acquire a better understanding of the values and interdependencies of various ecological functions and uses in a specific location, as well as monitor their changes over time at different sites. This type of approach is particularly important for policymakers, who often have to balance conservation and development, especially when land use changes are involved.

In this regard, it is also important to note that the use of machine learning techniques in environmental valuation may allow for more accurate predictions of the impacts of conservation efforts on various stakeholders. This could facilitate the design of more equitable and effective policy measures that consider the needs and values of all affected parties. In addition, machine learning methods may also help to overcome some of the limitations of traditional valuation approaches, such as the reliance on hypothetical scenarios or self-reported data. By using more diverse and real-time data sources, researchers can gain a more realistic understanding of the costs and benefits of conservation efforts, and better inform policy decisions (Streimikiene *et al.*, 2019).

In utilizing machine learning techniques in environmental valuation, it is essential to consider the ethical implications of such methods. The reliance on vast quantities of data and

complex algorithms in these techniques may introduce biases and inaccuracies in the analysis. Additionally, there is a potential for ethical concerns to arise from the utilization of data from marginalized communities or vulnerable ecosystems, including but not limited to issues of privacy infringement and resource exploitation. To mitigate these risks, it is crucial for researchers and policymakers to incorporate a robust ethical framework throughout the development and implementation of machine learning-based environmental valuation methods. This may involve engaging with stakeholders, conducting comprehensive impact assessments, and incorporating transparency and accountability mechanisms into the research and decision-making processes.

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