



From procedural to transformative: A review of the evolution of effectiveness in EIA

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ABSTRACT

The concept of effectiveness has become a relevant topic in environmental impact assessment (EIA) or impact assessment (IA) research in response to the need to improve the decision-making process. Although some studies have included reviews of the state of the art on the concept of EIA effectiveness, there are no reported studies that use bibliometric analysis to describe in detail the historical evolution of effectiveness in EIA. The aims of this study are to define the geographic areas where more research is being carried out on this topic, identify the coworking network developed in this field and the main trends in research on the effectiveness of EIA to review the evolution of the concept and its dimensions. To achieve these objectives, data obtained through the implementation of the PRISMA methodology and bibliometric analysis were considered. For this purpose, 280 publications on EIA effectiveness obtained from a systematic review in the Scopus database between 1997 and 2021 were selected. As a novelty, a performance analysis, a keyword analysis as well as a content analysis based on bibliometric indicators were developed. The results show that the main geographic regions where research on EIA effectiveness and cross-country collaboration is concentrated are the United Kingdom, Australia and South Africa. In addition, the most common research topics, and the evolution over the years of the dimensions of effectiveness are determined. It was found that the procedural approach still has a significant place in the analysis of effectiveness; however, the intention to study in detail the legitimacy of the EIA, the role of stakeholders, and the evaluation of EIA systems based on the dimensions of effectiveness (procedural, substantive, transactive and legitimacy) is recognized. The concept of EIA effectiveness is transforming, in fact recent research reflects a paradigm shift in which the reductionist vision of EIA is being replaced by a more complex approach. Therefore, it is concluded that it is necessary to address new elements of analysis to generate significant changes and improve the effectiveness in the EIA process.

1. Introduction

Over the years, the implications of anthropogenic actions in the transformation of the environment have been recognized, so that >190 countries worldwide have introduced EIA systems, some for >50 years (Kamijo, 2022; Morgan, 2012). EIA examines the environmental effects of projects, plans and programmes in a thorough and organized manner, thereby expanding the information base for making decisions as part of the planning and sustainable development system of nations (Pöhlönen

et al., 2011).

Considering the importance of EIA and with the need to optimize decision making, in 1996, Barry Sadler defined the Environmental Impact Assessment (EIA) effectiveness as “a process where EIA is working as intended and, secondly, whether it is meeting the purposes for which it was designed” (Sadler, 1996, p.37). This concept has become a recurring theme in EIA research since the 1970s (Khan et al., 2020; Lyhne et al., 2017) and has facilitated the development of good practices in carrying out EIA, as well as strategies aimed at

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strengthening this process in different countries. Consequently, this concept has been the heading of publications (e.g., [Hirji and Ortolano, 1991](#)) where mainly procedural elements of EIA have been analyzed and their costs and benefits have been evaluated, which has generated an ongoing debate on effectiveness from different perspectives ([Morrison-Saunders et al., 2015](#)). The result has been the publication of numerous papers ranging from conceptual compilations on EIA effectiveness ([Chanchitpricha and Bond, 2013](#); [Geißler et al., 2019](#); [Loomis and Dziedzic, 2018](#); [Pope et al., 2018](#)), consideration and analysis of different effectiveness dimensions ([Baker and McLelland, 2003](#); [Bond et al., 2015](#); [Loomis et al., 2022](#); [Pope et al., 2018](#); [Sadler, 1996](#)) and effectiveness evaluation ([Cashmore et al., 2010](#); [Morrison-Saunders and Arts, 2004](#)) to case studies in different countries ([Arts et al., 2012](#); [Caro-Gonzalez et al., 2021](#); [Kahangirwe and Vanclay, 2022](#); [Nakwaya-Jacobus et al., 2021](#)).

Since EIA effectiveness is a widely studied topic that is projected to be a long-term research trend, as a result, works have been conducted on the state of the art ([Loomis and Dziedzic, 2018](#); [Lyhne et al., 2017](#)) analyzing the publications according to the dimension studied and the methods used for this purpose. For this reason, it is common to find literature reviews in research on EIA and effectiveness dimensions (procedural, substantive, transactive effectiveness and legitimacy), in order to develop a conceptual framework to support the findings to be presented ([Jha-Thakur and Fischer, 2016](#); [Loomis et al., 2022](#); [Morrison-Saunders et al., 2021](#)). However, few studies have developed bibliometric analyses on these topics. The most notable studies address scientific production around knowledge exchange and EIA practice ([Bond and Fischer, 2022](#)), EIA and the relationship with other environmental assessment ([Kim and Haigh, 2021](#)) and EIA systems ([Chang et al., 2018](#); [Duarte et al., 2017](#); [Kamijo, 2022](#); [Nita, 2019](#)). Regarding effectiveness dimensions, we highlight the study by [Loomis and Dziedzic, \(2018\)](#), who develop a state of art on EIA systems' effectiveness dimensions and the methods to evaluate them.¹

A clear picture of EIA effectiveness as a field of research has not been defined, ignoring that it is sufficiently relevant to determine the functioning of EIA. The complexity of EIA effectiveness allows a multidimensional analysis, that may be presented from different approaches, enriching the exchange of knowledge, which is fundamental in environmental studies ([Nita, 2019](#)). Trends in EIA effectiveness research can be understood by determining the origin of academic production and the collaborations that have been established between different countries around it. For this reason, this paper develops a bibliometric analysis to review the evolution of the EIA effectiveness and its dimensions. The aims of the study are to define the geographic areas where more research is being carried out on this topic, identify the coworking network developed in this field of research since [Sadler \(1996\)](#) issued the first report on effectiveness and, finally, to present the main trends in the analysis of the dimensions of EIA effectiveness to establish a knowledge structure around it. After the introduction, this paper develops a diagnosis on the evolution of EIA effectiveness, and a review of the bibliometric analysis related to EIA effectiveness. Subsequently, the methodology used for the literature review and bibliometric analysis is explained. Finally, the results and the analysis of the data obtained are presented to conclude with the presentation of the research panorama on EIA effectiveness and its projection.

2. EIA effectiveness: Time evolution diagnoses

The effectiveness of the EIA has been addressed since EIA emerged in the United States of America (USA) in 1969 with the implementation of the National Environment Protect Act ([Emerson et al., 2022](#)), leading to ongoing debates about its role in the decision-making process ([Byambaa](#)

[and de Vries, 2020](#)). The concept of effectiveness was used by several authors to analyze the scope of the application of the EIA process, especially the prevention and correction of environmental impacts generated by projects, works or activities and establishing the first components of the EIA effectiveness assessment ([Hirji and Ortolano, 1991](#)). However, interest in this concept increased significantly after the report by [Sadler \(1996\)](#), which analyzes effectiveness from different perspectives and contexts, making the topic relevant when referring to EIA ([Getty and Morrison-Saunders, 2020](#)). [Chanchitpricha and Bond \(2013\)](#) make a great contribution to the conceptualization of EIA effectiveness and its evaluation by designing a framework that provides a starting point for developing case studies and further discussion around the concept ([Geißler et al., 2019](#)).

Following the report by [Sadler \(1996\)](#), three dimensions of EIA effectiveness were established: procedural, substantive and transactive ([Fig. 1](#)). Further studies propose the existence of other dimensions such as normative effectiveness ([Baker and McLelland, 2003](#)), pluralism and, knowledge and learning ([Bond et al., 2013a](#)). Moreover, [Pope et al. \(2018\)](#), propose the legitimacy dimension, which integrates the normative dimension, knowledge and learning and pluralism, and recently, [Loomis et al. \(2022\)](#) have proposed the transformative effectiveness based on a principle of continuous improvement in EIA, which should involve not only IA tools but also public policies and stakeholders. These dimensions have been analyzed in the following sections.

2.1. Procedural, substantive and transactive effectiveness

The dimensions proposed by [Sadler \(1996\)](#), have been extensively studied as much as the concept of effectiveness itself, which has provided the possibility of analyzing the EIA system from different perspectives. It should be noted that [Sadler](#) reviewed the report submitted in 1996 and more than a decade later evaluated the success of the EIA, framed in the different dimensions he had proposed ([Sadler, 2012](#)).

Many comparative studies have raised basic elements for an adequate EIA, including the quality of the environmental impact statement (EIS) ([Nita et al., 2022b](#)), the scoping, the alternatives considered, fit-for-purpose information, public participation, and the transparency of the process ([Wood, 2003](#)). The evaluation of these elements allows the development of specific case studies and promotes a system-wide evaluation focused on the procedures that are developed depending on the EIA regulations ([Pope et al., 2018](#)). For this reason, the vast majority of effectiveness studies focus on procedural effectiveness ([Cashmore et al., 2004](#); [Geißler et al., 2019](#); [Loomis and Dziedzic, 2018](#); [van Doren et al., 2013](#)). This dimension represents best practices, professional standards and procedures on EIA ([Bond et al., 2015](#)), also following appropriate processes that reflect institutional and professional standards and procedures in EIA ([Pope et al., 2018](#)). This represents multiple alternatives for evaluating procedural effectiveness, justifying the large number of studies that focus on this dimension.

Substantive effectiveness is related to the accomplishment of the objectives proposed in the EIA ([Sadler, 1996](#)). This dimension considers several factors such as the regulations associated with environmental assessment and decision making, the context in which decision making takes place, public participation and governance mechanisms ([Chanchitpricha and Bond, 2013](#)). [Cashmore et al. \(2004\)](#) analyzed the substantive perspective pointing out three sub-dimensions: i) the rationality dimension focusing on decision making which is understood as a rational exercise or a political exercise, ii) the decision dimension which questions whether the purpose of EIA is to influence or inform decisions, and iii) the sustainability dimension which encompasses the relationship between EIA and sustainable development ([Kolhoff et al., 2016](#)). Several authors argue that the substantive dimension has received less attention than the procedural dimension ([Cashmore et al., 2004](#); [Lyhne et al., 2017](#)), however, a relationship is established between these two dimensions, because as long as adequate procedures and practices are not developed in the EIA, the established objectives will not be met ([Fig. 1-](#)

¹ This study considers four dimensions to evaluate EIA systems' effectiveness: procedural, substantive, transactive and normative.

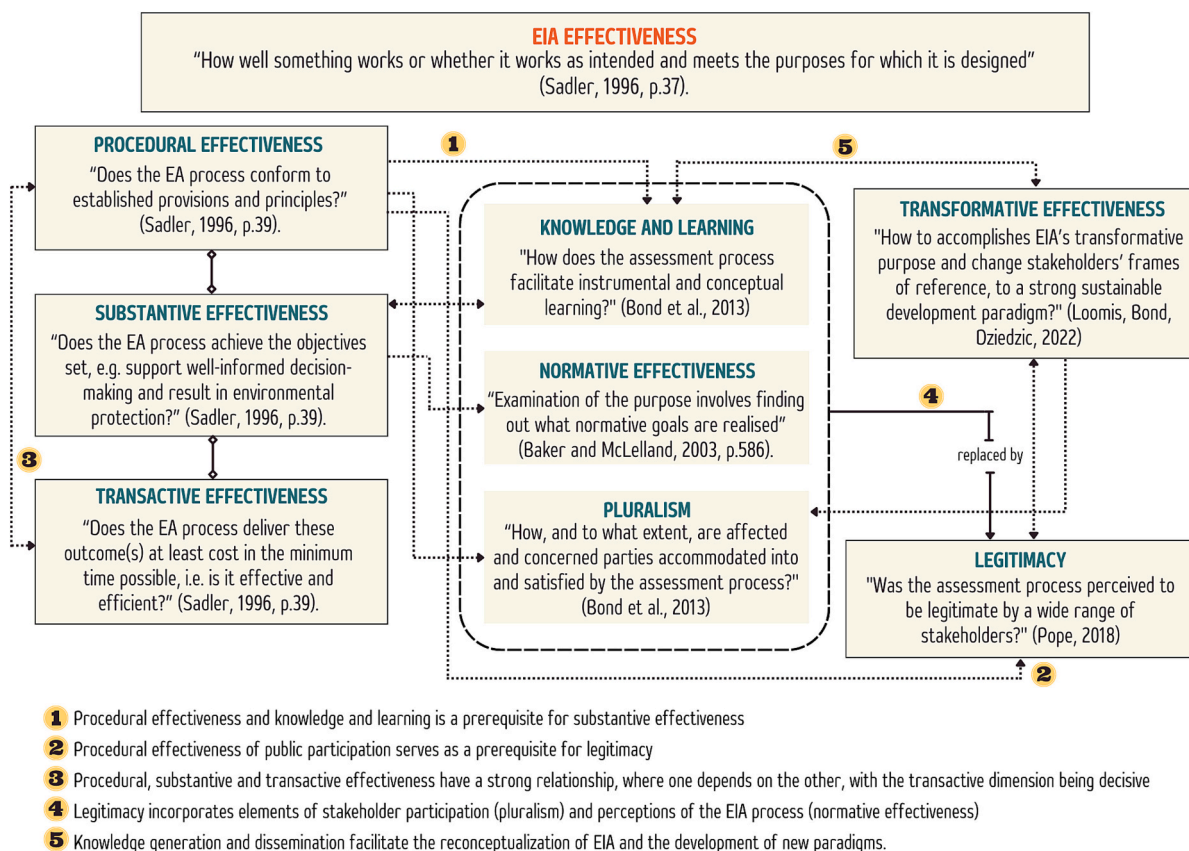


Fig. 1. Effectiveness dimensions and their conceptual linkages (own design, based on Baker and McLelland (2003); Bond et al. (2013); Chanchitpricha and Bond (2013); Geißler et al. (2019); Loomis et al. (2022); Pope et al. (2018); Sadler (1996)).

3). While procedural effectiveness focuses on the quality of the tool, substantive dimension can explain how the tool influences decision making (van Doren et al., 2013).

Substantive and transactive effectiveness have been referred to as “the least researched types of effectiveness” (Theophilou et al., 2010). Transactive effectiveness approaches the EIA process in a proficient way, looking at the achievement of objectives and the resources invested in terms of human resources, cost and time (Baker and McLelland, 2003; Chanchitpricha and Bond, 2013; Sadler, 1996). It is important to recognize that the assessment of transactive effectiveness depends on the judgements of regulators and supporters of the EIA process, given that cost and time constraints may be embedded in the regulations (Getty and Morrison-Saunders, 2020). According to Theophilou et al. (2010), the investment of resources during the impact evaluation implementation process can be evaluated based on four criteria, i) time, ii) financial resources, iii) skills, and iv) role specification.

2.2. Normative effectiveness

The normative dimension was proposed by Baker and McLelland (2003), and focuses on the role of the regulations and the purposes established in them to achieve the objectives of the EIA. Understanding that a norm represents, among other things, a widely accepted behaviour in society, normative effectiveness is associated with the acceptance of behaviours in society, which itself related to perceptions (Chanchitpricha and Bond, 2013). Therefore, the objectives of normativity are the combination of individual and collective norms (Pröbstl-Haider, 2022), which can be evidenced in changes in institutions, science, philosophy or culture that can impact decision making. Like the substantive dimension, the normative dimension depends on the context in where the impact assessment is developed, and decisions are made. Many

investigations on this dimension have focused on the transparency of EIA, public participation and stakeholder interaction (Loomis and Dziedzic, 2018).

2.3. Effectiveness dimensions and the sustainability assessment approach

According to Morrison-Saunders and Fischer (2006), the targets of environmental assessments have changed and now focus on sustainable development, integrating social and economic aspects along with the biophysical aspect of the environment, within the framework of a sustainability assessment (SA). This tool is defined as any process (like EIA or SEA) where decision making is aimed at sustainability,² a discussion that relates directly to sustainable development and environmental governance (Bond et al., 2013a). Following this approach, Bond et al. (2015) developed a framework for determining the effectiveness of sustainability assessment process, which addresses the dimensions of effectiveness mentioned in the previous section and proposes two new dimensions of effectiveness: pluralism and, knowledge and learning.

Pluralism recognizes the complexity in the diversity of perceptions and arguments that justify the ideas of the actors involved in an impact assessment process (Bond et al., 2013a; Nita et al., 2022a), hence, this dimension analyzes how and to what extent affected and interested parties are involved in the impact assessment and their degree of satisfaction with the process (Pope et al., 2018). Knowledge and learning as a

² There is no agreement on the concept of “sustainability”, however, most definitions are consistent with the definition presented in the Brundtland Report (Brundtland, 1987), which refers to the integration of different dimensions of development (environmental, social, economic) and to the responsibility in decision making to ensure a healthy environment and a habitable planet for the next generations.

dimension of effectiveness refers to the importance of knowledge management and continuous learning of stakeholders to improve the impact assessment process over time. Both instrumental learning (learning that promotes modifications in policies to achieve objectives with a sustainable approach) and conceptual learning (learning that modifies changes or paradigms in the actors involved) can be acquired through experience, and it is precisely on practice that it is proposed to modify and optimize the impact assessment process under the approach of sustainability (Bond et al., 2013b).

Pope et al. (2018) refined the framework proposed by Bond et al. (2015) by identifying a conceptual overlap between knowledge and learning and substantive effectiveness, also between normative effectiveness and pluralism (Fig. 1-1). As a result, the legitimacy dimension is proposed, a category that includes the concept of legitimacy, understood as the acceptance of the results of the impact assessment by the actors involved in the process. This proposal combines three dimensions previously explained: knowledge and learning; pluralism; and the normative dimension (Fig. 1-4). Transformative effectiveness is the most recent proposal focused on the categorization of effectiveness in impact assessment. This dimension, presented by Loomis et al. (2022), refers to the extent to which EIA fulfils a transformative purpose, in which stakeholders' frames of reference are changing, to increasingly consolidate a strong sustainable development paradigm (Fig. 1-5).

3. Methodology

3.1. Methodological approach

This literature review consists of a methodical search that identifies, selects and evaluates studies of a previously established level of quality (Booth et al., 2016). In this way, it has positioned itself as a replicable methodology that allows making sense of a large amount of scientific information, reducing the complexity that a researcher may face when exploring a research topic and encountering variable or conflicting findings. Among the advantages of applying this methodology is the minimization of biases, which ensures quality in the review process and its replicability, which allows validation of results (Siddaway et al., 2019). Considering the purpose of the study, a systematic review is conducted on the effectiveness of environmental impact assessment, to examine the state of the literature and an analysis based on the use of statistical techniques that allow the integration of the results of the data obtained in the review (Moher et al., 2010).

This research follows a methodological design similar to the studies by Wimbadi and Djalante (2020) and Nita (2019), where a systematic review is presented employing a defined protocol for data collection and subsequently develops a bibliometric analysis that allows comparing several variables that provide answers to the research questions posed in their corresponding papers (Sweileh et al., 2017)

3.2. Bibliometric database

To generate the data collection, 280 papers were extracted from Scopus (Elsevier B.V., <http://www.scopus.com>). This database allows to examine a considerable number of peer-reviewed articles in order to establish a set of papers based on search parameters and boolean operators that filter the publications. The database was chosen due to its functionality and scope, because compared to other databases such as Web of Science or PubMed, Scopus has a 20% higher coverage, representing a greater range of journals (Mongeon and Paul-Hus, 2016) with approximately 22,000 publications in the scientific, technical, medical and social fields (Sweileh et al., 2017), rigorously selected through a peer reviewed process (Booth et al., 2020).

Data collection was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2010). This protocol was designed to reduce bias and increase the reliability and validity of the data obtained during a systematic review.

It consists of a series of search strategies, eligibility criteria, and a checklist that improve the reporting of systematic reviews and a four-phase flow diagram that ensures the transparency and thoroughness of the article selection process (Booth et al., 2020). This technique has been widely used, because although it was first developed as a guideline to health care systematic reviews (Moher et al., 2010), it has become a universal tool that has been adapted to research in various fields, such as life cycle modelling, greenhouse gas emissions, health impact assessment and social impact assessment, among others.

The PRISMA methodology was used for the data collection process and the phases of the systematic review (Fig. 2). The search parameters used were "EIA" AND "effectiveness" and "impact assessment" AND "effectiveness" in the title, abstract or keywords of articles published between 1997 and 2021. This reference period was determined based on the publication of the report on effectiveness by Sadler (1996), which provides an overview of the effectiveness of EIA and its study dimensions. Documents catalogued as articles, conference papers, reviews, book chapters and books were chosen. The language of these documents was not relevant since it is expected to find records worldwide. Once the duplicate documents were eliminated, a document selection was made which excluded publications related to subject areas that are far from EIA's field of research. An eligibility criterion for the documents was that the publications referred to the concept of effectiveness in EIA or mentioned some of its study dimensions, culminating in the selection of 280 records.

3.3. Data analysis

A bibliometric analysis was carried out under a qualitative and quantitative approach, using the information provided by the database to perform a performance analysis, a keyword analysis and a content analysis (Wimbadi and Djalante, 2020). Performance analysis summarizes the quantitative information provided by the database, generating trends that allow us to interpret the annual distribution of publications, the journals with the highest number of publications associated with the field of research, the publications made by each country and the collaborations between different countries. This identifies the countries that are actively working on EIA effectiveness research and contributing to the formation of knowledge. The country aspect is examined in more depth using a bibliometric tool - An R-tool for comprehensive science mapping analysis (Aria and Cuccurullo, 2017). This tool identifies the "Corresponding Author's Country" for each article by considering the affiliation of the author listed as the corresponding author. The analysis counts how many articles are associated with each country, providing a frequency count for each country based on the total number of articles. Additionally, it calculates the proportion of articles in which there is at least one author whose affiliation is from a country different from that of the corresponding author. This proportion is represented by an index known as "Multiple Country Publications". This information was used to calculate the intra-country (SCP) and inter-country (MCP) collaboration indices which helped us to have an overall picture regarding the research and collaboration regarding EIA effectiveness.

Keywords represent the main research elements of the academic literature from research topics and methodologies to the purpose that motivates such research. Therefore the analysis and classification of keywords is fundamental to identify main and secondary topics as well as emerging themes in a research field (Wu et al., 2018). Keyword analysis establishes the relationship between keywords in the literature to approach an understanding of the knowledge structure and its components (Radhakrishnan et al., 2017)

Content analysis is a qualitative analysis based on a reflective process that involves the codification and categorization of information in order to reach a high level of abstraction that allows to reflect the latent interpretation of a text (Erlingsson and Brysiewicz, 2017). To analyze the content of the documents, the title, keywords, abstract and introduction of the documents were reviewed, then the publications were

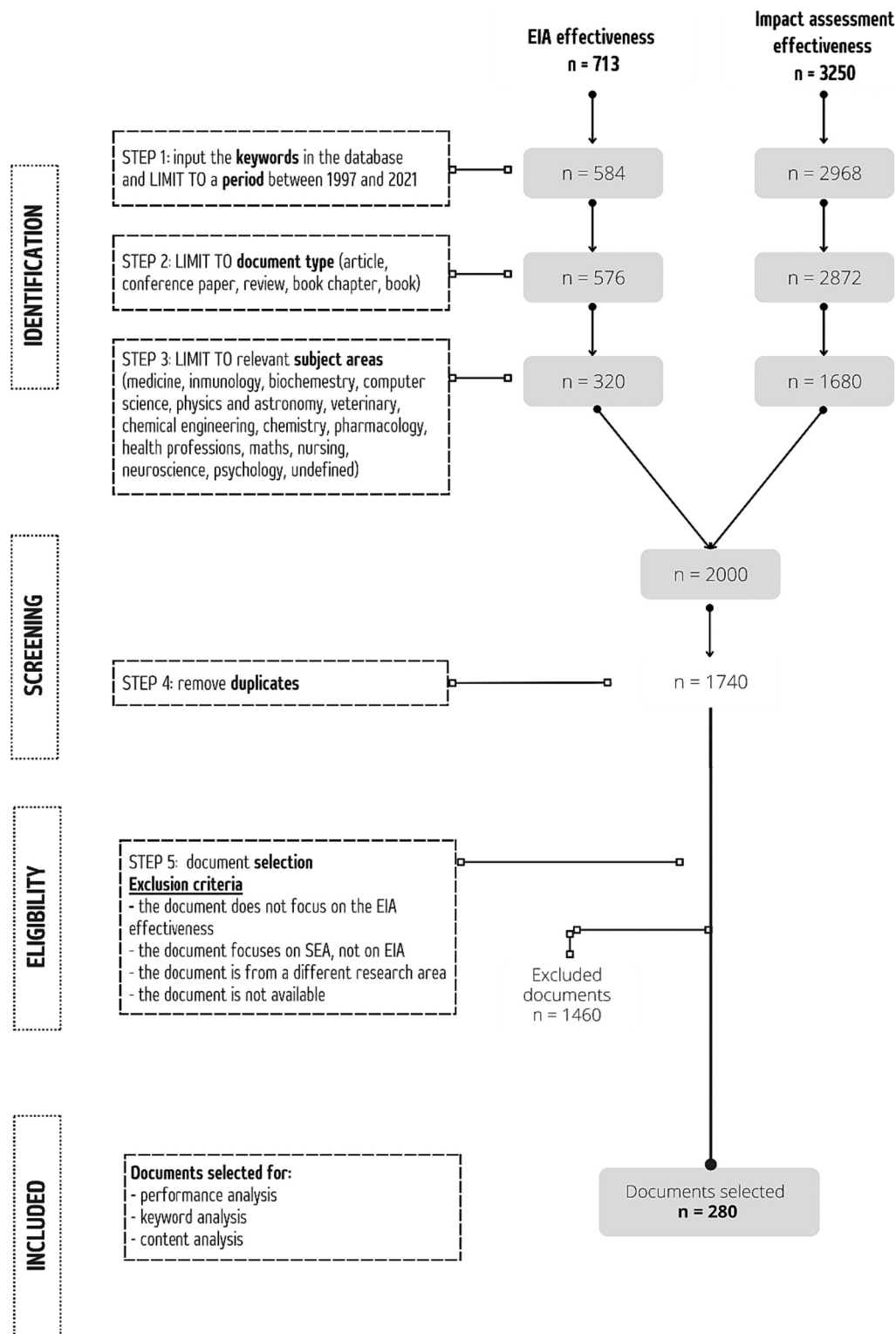


Fig. 2. Flow of information through the phases of systematic review using the PRISMA statement.

classified considering the dimensions of effectiveness: procedural, substantive, transactive and legitimacy. Given the possibility of finding documents that address elements of analysis of different dimensions of effectiveness, the multidimensional category was proposed. Also, subcategories are established for each dimension of effectiveness based on the components/criteria proposed by Chanchitpricha and Bond, (2020), in order to establish parameters for interpreting the way in which effectiveness is approached in the literature. Table 1 lists the dimensions

of effectiveness and the subcategories that were included, where the criteria or components represent the deductive codes and the complementary data represent the inductive codes for the content analysis.

To perform the content analysis, the bibliometric data were processed through Microsoft Excel®. Keyword analysis were performed in VOS viewer®, a software tool for constructing and viewing bibliometric maps (Van Eck and Waltman, 2010).

Table 1
Dimensions of effectiveness and subcategories to develop the content analysis. Own elaboration based on the criteria proposed by Chanchitpricha and Bond (2020).

Effectiveness dimension	Components/criteria	Complementary data
Multidimensional	Mtd1. Evaluation of two or more effectiveness categories	Evaluation of one or more EIA systems under criteria addressing different dimensions of effectiveness
	Mtd2. Conceptualization or review about effectiveness in general or one of its categories	Theoretical contribution on the effectiveness of EIA and its dimensions
Legitimacy	Lg1. Organizational legitimacy	Stakeholder perception on IA practice and EIA system
	Lg2. Knowledge legitimacy	Recognition and integration of knowledge in EIA
Procedural	Prd1. Techniques and procedures	Methods, EIA follow-up strategies, screening and scoping practices
	Prd2. Policy framework, EIA reports and licensing	Quality of IA reports, good practices in IA, environmental licensing procedures
	Prd3. The role of stakeholders in the process	Public consultation, interaction between stakeholders
Substantive	Sbt1. Regulatory framework	Institutional infrastructure, legislation about EIA and IA
	Sbt2. Decision-making process	Strategies to optimize decision making, stakeholder dialogues, importance of decision making, decision making
Transactive	Tr1. Financial resources	Topics associated with the time required and the costs to develop the process
	Tr2. Human resources	Topics associated with EIA staffing requirements, responsibilities, skills and availability

4. Results and discussion

4.1. Performance analysis

4.1.1. Distribution of scientific production in journals and annual publication trends

Fig. 3 shows the annual publication trend, represented in the data that were selected for the study, noting that the concept of effectiveness in EIA and its respective dimensions is a topic with an increasing trend over the last 25 years. A total of 280 documents were identified during the period from 1997 to 2021, with an average of 11 documents per year, and a maximum of 24 in 2020. Among the documents identified are articles (226, 80.71%), reviews (27, 9.64%), conference papers (13, 4.46%), book chapters (10, 3.57%) and books (4, 1.43%). This dataset consists of publications written by 520 authors, of which 68 are single-authored and 452 are multi-authored.

Fig. 4 shows the distribution of selected papers in key journals on EIA and environmental assessment research between 1997 and 2021. A total of 280 records were published in 106 sources. Environmental Impact Assessment Review (27.14%), Impact Assessment and Project Appraisal (16.43%), Journal of Environmental Assessment Policy and Management (7.14%) and Journal of Environmental Management (3.93%), were the journals that gathered most of the publications on EIA effectiveness, concentrating 54.64% of the total data. We can state that these journals are very influential on this topic, based on the quartiles³ on

³ Quartiles: relative importance of the journal compared to other journals in the same field of research.

which the H Index⁴ and the impact factor⁵ were established for the year 2021 (Table 2).

4.1.2. Contribution of countries and international collaboration

In the period under analysis, publications from >20 countries were published, the United Kingdom being the country with the highest productivity with a total of 77 documents, representing a share of 27.5%, followed by Australia with 64 documents, representing 22.9%, China and Brazil, both with 42 documents, representing 15% respectively. Brazil stands out as the only South American country to register a significant number of publications, even surpassing the United States of America, the country with the highest number of publications related to EIA in general (Nita, 2019). USA (Number of Published Documents = 36), Netherlands (NPD = 30), Canada (NPD = 30) and South Africa (NPD = 37) complete the group of countries that contribute with the highest scientific production focused on EIA effectiveness. The remaining publications are mainly affiliated to Western European countries (e.g., Denmark (NPD = 9), Italy (NPD = 8), Finland (NPD = 8), Germany (NPD = 11), Ireland (NPD = 13) and Portugal (NPD = 14)) and to a lesser extent with Eastern European countries (e.g., Slovakia (NPD = 7)), Asian countries (Japan (NPD = 11), Thailand (NPD = 6), India (NPD = 6) and Pakistan (NPD = 2)) and New Zealand (NPD = 9). Besides Brazil, only two other South American countries report publications, Colombia and Chile with 8 and 2 publications affiliated, respectively (Fig. 5). The countries with the most single-country publications are the United Kingdom, China and Australia, whereas, the United Kingdom, Australia and Brazil have the most multi-country publications. Finland, Germany, Ireland, India and Slovakia are also countries with single publications (Fig. 6). Understanding the patterns in country productivity (Fig. 5) and collaboration (Figs. 6 and 7) helps identifying the brokers in EIA effectiveness research and further proper implementation (Niță et al., 2023).

In terms of international collaboration, Fig. 7 shows the partnerships established between different countries, clearly identifying the United Kingdom as the country leading the international scientific cooperation related to EIA effectiveness, as partnerships are reported with at least five countries not restricted to the European area (e.g., South Africa, Australia, Canada, New Zealand and Thailand), compared to reports associated with Australia and South Africa. This is consistent with the review established by Nita (2019), in which the United Kingdom is identified as one of the countries with the highest potential to play a research broker role and initiate research interactions between different countries focused on the field of impact assessment. The most frequently identified collaborations between countries are between Australia and South Africa (Number of Publication Collaborations = 13), between the United Kingdom and South Africa (NPC = 13), and between the United Kingdom and Australia (NPC = 10), followed by the collaboration between the United Kingdom and Canada (NPC = 7) and between Australia and Canada (NPC = 6) respectively.

The predominance of English-speaking countries in the academic output on the EIA effectiveness is remarkable, which may be associated with the difficulties that non-native speakers have in conducting scientific activities in English. This bias can be solved by encouraging multilingualization of the science and its communication by promoting equity and diversity in science (Amano et al., 2022).

4.2. Keyword analysis

As previously mentioned, keyword analysis helps to understand the structure of knowledge and its elements around EIA effectiveness. After unification, we obtained a total of 705 unique author keywords that we

⁴ H-index: journal's number of articles (h) that have received at least h citations over the whole period.

⁵ Impact factor: yearly average number of citations on articles published by a particular journal in the last two years.

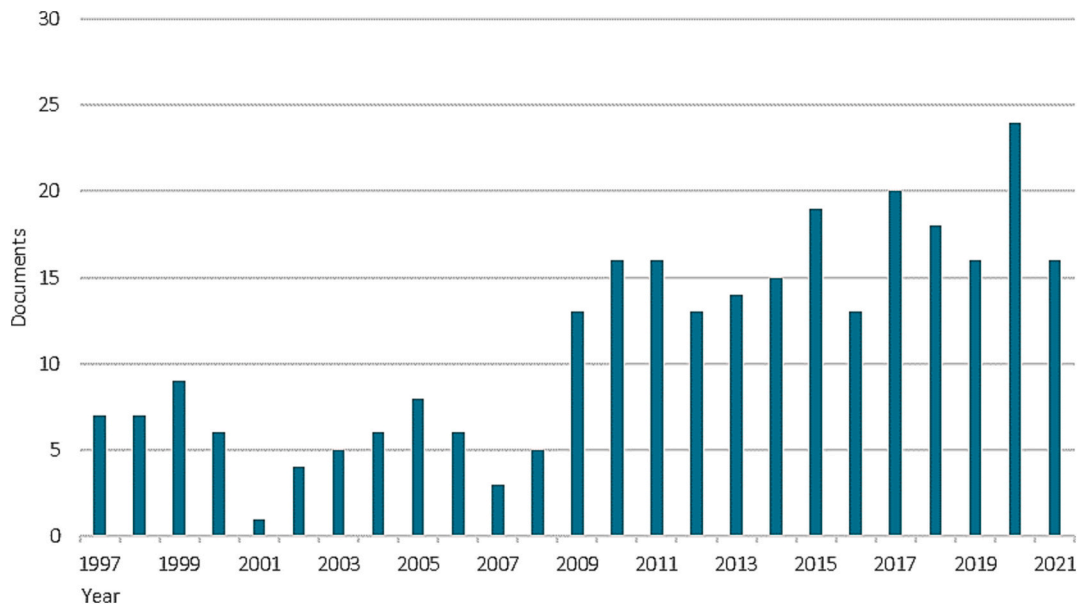


Fig. 3. Annual scientific production related to EIA effectiveness between 1997 and 2021.

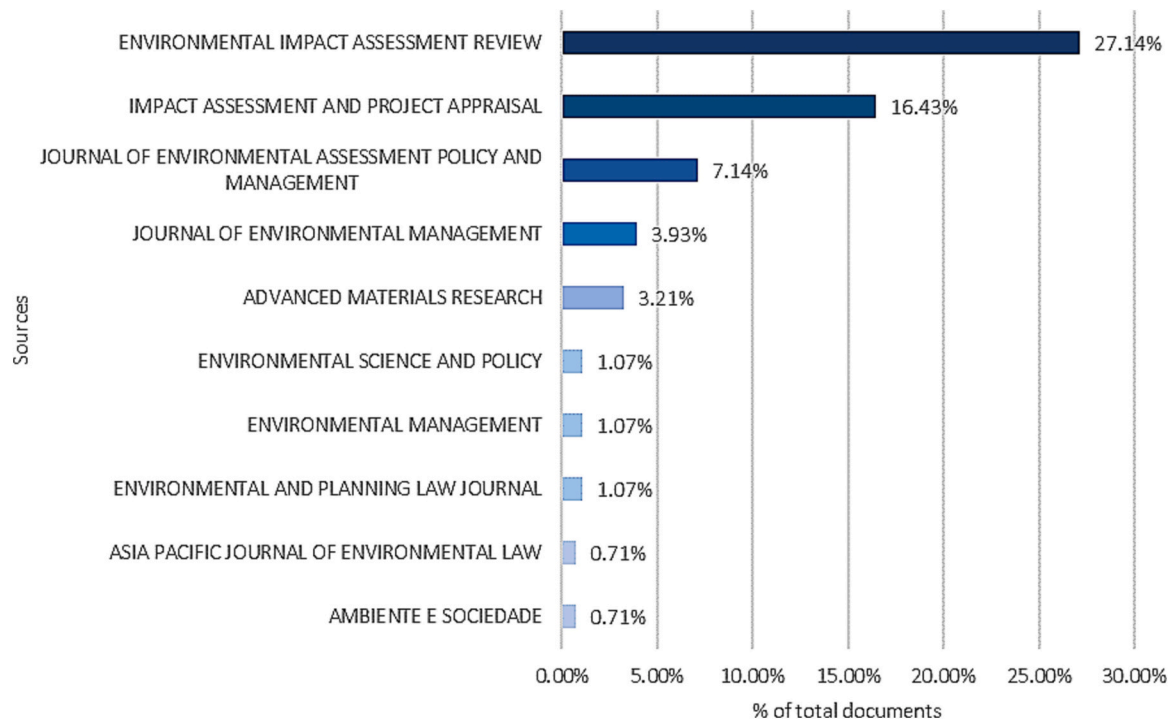


Fig. 4. Top ten most relevant sources that publishes research related to EIA effectiveness.

used to create a conceptual structure map showing the cluster analysis of the most common keywords. Fig. 8 illustrates the grouping of the keywords after excluding the countries, with at least two occurrences in five clusters of keywords related to the research on EIA effectiveness. Cluster 1 is based on the association between EIA (frequency = 83) and effectiveness (frequency = 87). As can be seen from the thickness of the lines, most of the documents reviewed have these keywords and present a strong relationship that gives rise to the other clusters. A link between the terms EIA report, biodiversity and monitoring is evident in publications focused on the development of various methods to improve system performance. Most of the documents that include these keywords have similar themes such as the identification of weaknesses and

strengths of the EIA system (e.g., [Pediaditi et al. \(2018\)](#)), use of surveys and protocols to evaluate EIS (e.g., [Duarte et al. \(2017\)](#)) and EIA follow-up strategies (e.g., [Chang et al. \(2018\)](#)).

Cluster 2 is derived directly from the keyword EIA and brings together concepts related to the planning and technical part of the EIA system, where screening and scoping practices and integration are some of the most frequent terms. Regarding the concept of integration (or integratedness), it is interesting how it represents an association between the impact assessment tools and the UN Sustainable Development Goals ([Morrison-Saunders et al., 2020](#)), correlating with cluster 4 and the approach to sustainability proposed by [Bond et al. \(2012\)](#). The publications associated with this cluster implicitly focus on procedural

Table 2

Top 4 journals with the highest number of publications on EIA effectiveness from 1997 to 2021. TP: Total publications. R (%): Rank and the percentage of total publications. IF: Impact factor (2021).

Source	TP	R (%)	Quartile	H-Index	IF 2021
Environmental Impact Assessment Review	76	1 (27.14)	Q1	99	5.83
Impact Assessment and Project Appraisal	46	2 (16.43)	Q2	55	2.086
Journal of Environmental Assessment Policy and Management	20	3 (7.14)	Q2	31	1.286
Journal of Environmental Management	11	4 (3.93)	Q1	196	8.626

effectiveness, as they address topics such as EIA legislation (e.g., Pölonen et al. (2011)), environmental licensing (e.g., Pereira et al. (2021)) or policy instruments (e.g., Almeida and Montaño (2017)). Also, a tendency for the evaluation of EIA systems is identified, but unlike Cluster 1, there is a strong tendency towards the analysis of good practice criteria.

Cluster 3 highlights trends related to public participation as part of the EIA analysis. Local government, stakeholders, collaboration and uncertainty are the keywords most frequently associated with this cluster. The publications related to these terms focus on the role of the institutional and regulatory bodies that determine the guidelines that govern the EIA process. The relationship established with Cluster 2 consists of integrating best practices and the regulatory structure that determines the effectiveness of the EIA system. Considering these characteristics, it can be stated that this cluster contains some elements of substantive effectiveness and procedural effectiveness in terms of institutional infrastructure (e.g. Rozema and Bond (2015)) and involvement of the stakeholders in the process (e.g., Soria-Lara et al. (2020); Yao et al. (2020)).

Cluster 4 is derived from the term “effectiveness” and clearly

represents the elements of the analysis of the impact assessment and the sustainability approach. As mentioned previously, Bond et al. (2013b) developed a framework that analyzes the effectiveness of EIA in terms of sustainability, generating interest among different authors who have analyzed the process and dimensions of effectiveness taking into account decision making, the implementation of new practices and impact assessment in terms of sustainable development (Aung et al., 2020; Bond et al., 2012; Morrison-saunders and Retief, 2012). This stream of research frequently includes keywords such as policy integration, legislation, development projects and strategic environmental assessment (SEA), a process that has been analyzed in parallel due to its close relationship with EIA.

Cluster 5 brings together terms associated with publications that have focused on the analysis of effectiveness and its dimensions explicitly, either as a review of the state of the art (e.g., Loomis and Dziedzic (2018)), generating proposals on emerging dimensions (e.g., Pope et al. (2018)), or evaluating EIA systems (e.g., Chanchitpricha and Bond (2018); Khan et al. (2020); Çolakkadıoğlu (2021)). This explains the presence of keywords such as transactive effectiveness, substantive effectiveness, normative effectiveness and procedural effectiveness, with this last dimension being the most frequently used. This cluster derives from the term impact assessment, this could be explained by the multiple publications that have analyzed the dimensions of effectiveness under the sustainability approach. Finally, based on the conceptual structure represented in Fig. 8 and the common factors in the clusters, we can affirm that the key points in the research on the dimensions of EIA effectiveness are: EIA performance (cluster 1, 2, 4), the context in which EIA is implemented (cluster 1, 3 and 5) and stakeholder involvement and perception of the process (cluster 3, 4 and 5).

4.2.1. Trends in EIA effectiveness research

Fig. 9 shows the historical evolution of the terms associated with research in EIA effectiveness. This network presents the keywords with ≥ 2 occurrences in the dataset, therefore the keywords that are included in at least two articles are displayed. The 73 keywords (nodes in the

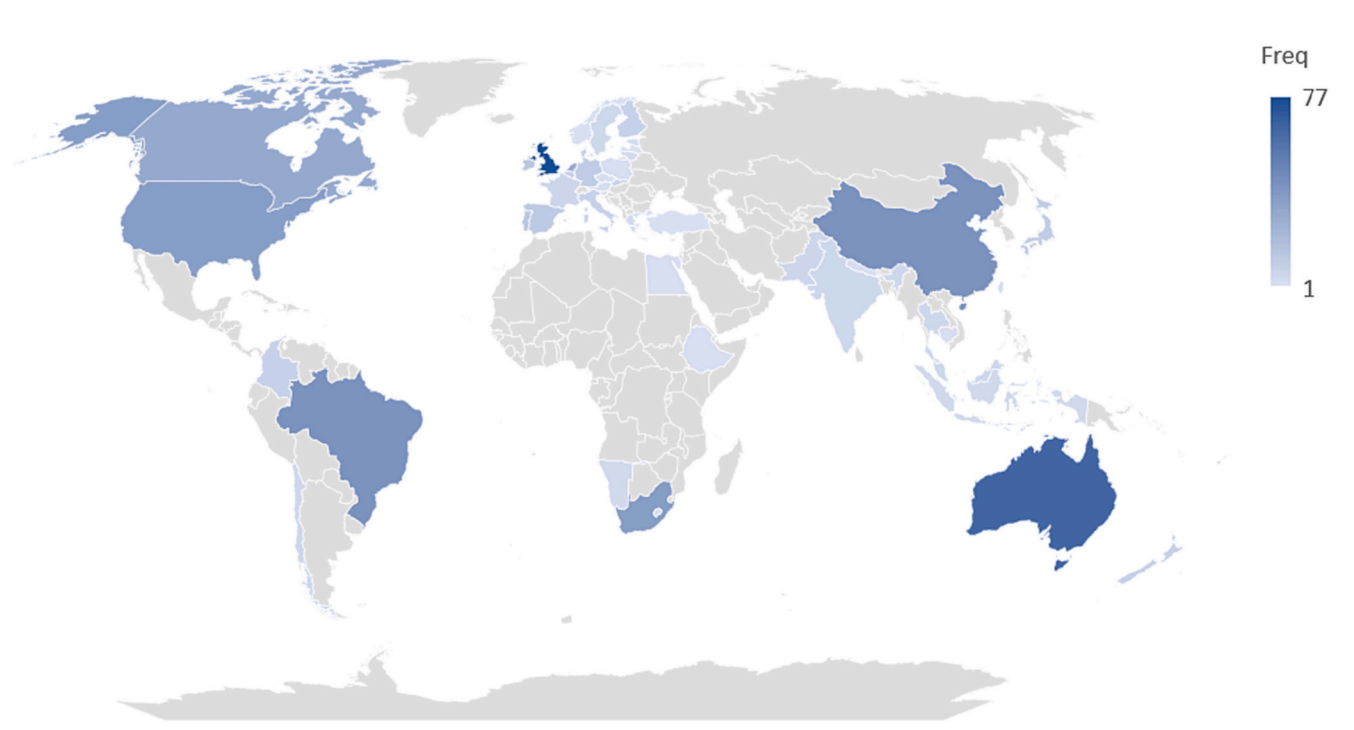


Fig. 5. Country level scientific productivity. (Colour scale is given by the number of documents published about EIA effectiveness, light blue – low productivity, dark blue – high productivity). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

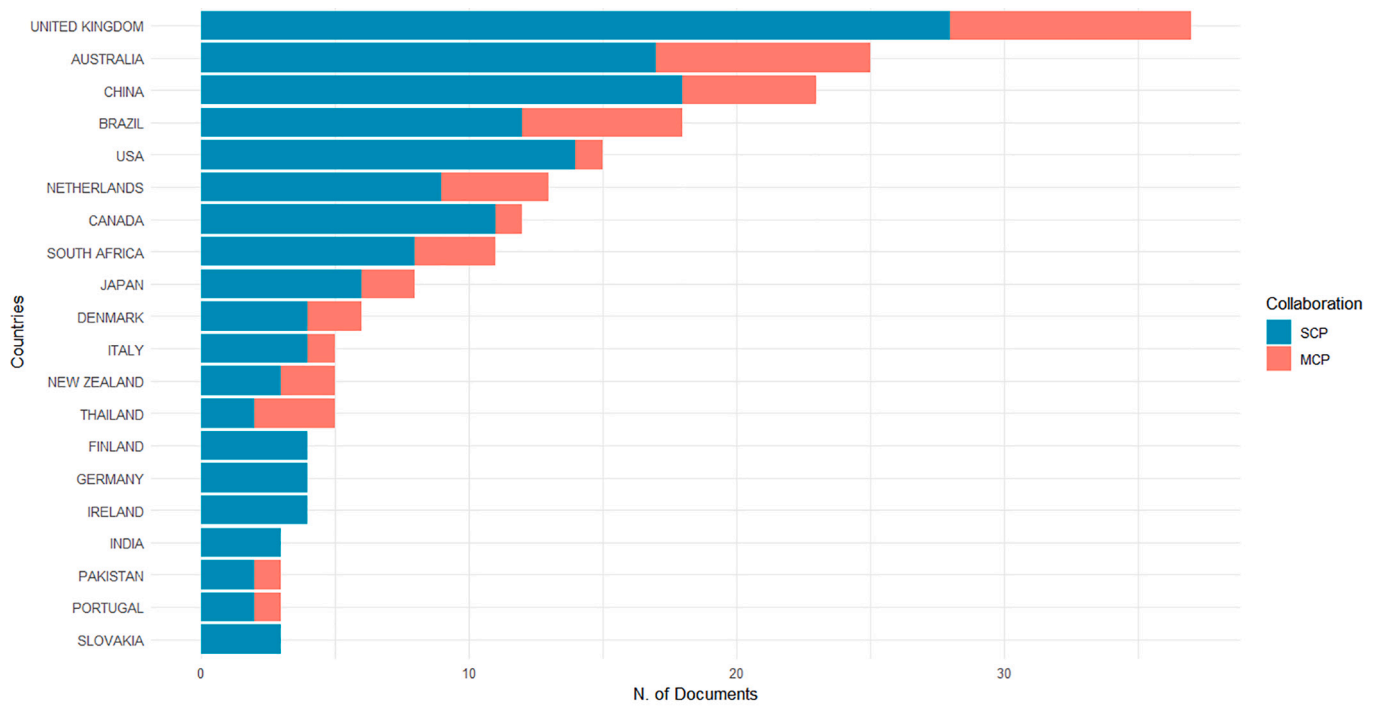


Fig. 6. Corresponding Author's country. SCP: single country publications, MCP: multiple country publications (top 20 countries of corresponding author's affiliation is illustrated in the graph).

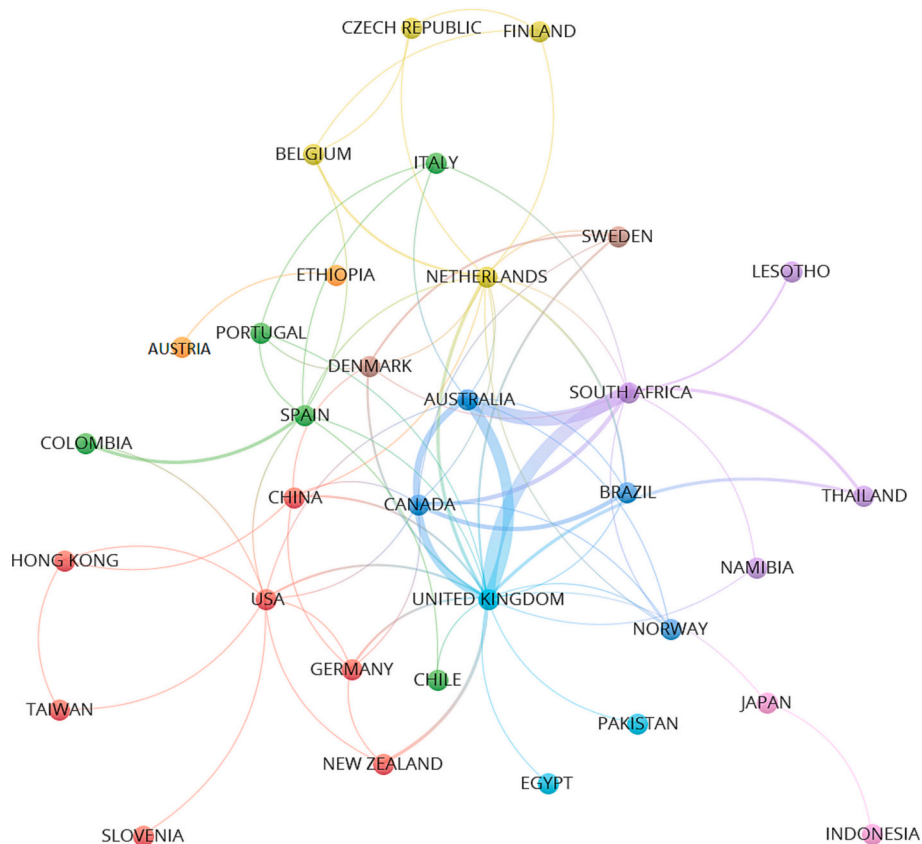


Fig. 7. Country collaboration network resulted from the bibliometric analysis (weight of link between two countries given by collaboration frequency).

graph) were organized in groups with the same colour according to their average publication year and the size of the node corresponds to the number of occurrences. It can be observed that between 2010 and 2012

the main publications were oriented towards EIA under a procedural approach in which the most representative keywords were: policy integration, public participation, consultants, local government,

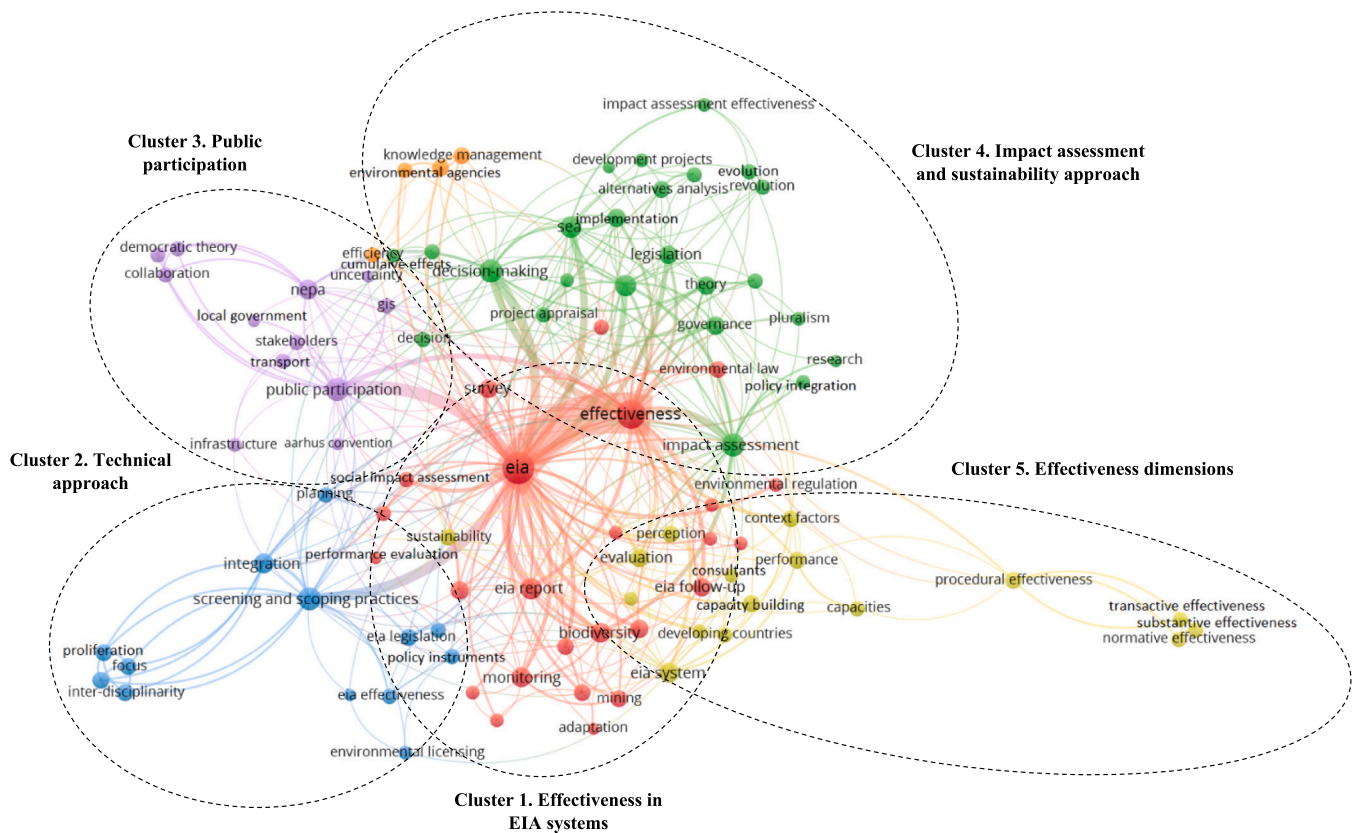


Fig. 8. Conceptual structure map and keywords clusters resulted from dataset bibliometric analysis.

legislation, project appraisal and performance evaluation. These terms are directly associated with EIS elaboration, environmental licensing, and compliance with established regulations. However, the graph shows that this trend is evolving and incorporating conceptual elements of sustainable development. From 2012 to 2014, the concept of effectiveness was consolidated under the sustainability assessment approach and a relationship was established with the concept of impact assessment. There is an increasing frequency of research that includes keywords such as: alternatives analysis, knowledge management, governance, uncertainty, decision making and, screening and scoping practices. For the period between 2014 and 2016, the discussion focuses on EIA report quality, the EIA system and the relevance of the EIA follow-up. This period also saw publications focused on the conceptualization of the dimensions of effectiveness (procedural, substantive, transactive and normative) and new proposals based on pluralism and legitimacy. Finally, the topics that have been addressed after 2016, and remain in place to date, relate to the role of stakeholders, cumulative effects, EIA performance, evolution of the EIA system and biodiversity monitoring as an EIA follow-up strategy. Current research makes explicit the need to transform the paradigms surrounding the EIA system and its effectiveness (Loomis et al., 2022), in fact, the reductionist vision in which EIA is defined strictly as a technical process has changed (Jha-Thakur and Fischer, 2016) and now it is conceived as a system that is constantly changing and must be evaluated to ensure its effectiveness where the role of stakeholders and the inclusion of principles that promote sustainability are key aspects (Morrison-Saunders and Fischer, 2006; Morrison-saunders and Retief, 2012).

4.3. Content analysis

Content analysis establishes parameters for interpreting how effectiveness is approached in the literature. EIA and its effectiveness are

topics addressed in different ways over time. The first publications implicitly addressed effectiveness under a procedural approach; but later there was a growing interest in analyzing other elements of EIA, which are associated with other dimensions of effectiveness. Fig. 10 shows the classification of the documents analyzed according to the dimension of effectiveness that was identified: procedural, multidimensional, substantive, transactive and legitimacy.

Out of the 280 documents analyzed, 62.5% (NPD = 175) are related to procedural effectiveness. Most of the publications related to this dimension focus on techniques and procedures associated with EIA (NPD = 82). This group includes publications that refer to methods for predicting and assessing environmental impacts or optimizing the IA process, as well as EIA follow-up strategies and screening and scoping practices. Another component of procedural effectiveness that is highly studied is related to the policy framework of IA, EIA reports and licensing (NPD = 64), the publications in this category are associated with the quality and evaluation of EIS and IA reports (generally evaluated with the protocol developed by Lee et al. (1999)), the good practices in IA, the procedural guidelines for environmental licensing (e.g. terms of reference) and the evaluation of procedural effectiveness in a general way. These results are consistent with the statements of several authors (Geißler et al., 2019; Loomis and Dziedzic, 2018), where procedural effectiveness is recognized as the dimension that has historically received the most attention. As Cashmore et al. (2004) explain, the tendency to investigate the procedural part of EIA effectiveness is caused by the early evolution of EIA, which emerged in the USA as a political element rather than a tool with a scientific approach and therefore did not have a detailed conceptual basis. Additionally, the procedural approach of the environmental legislation in most of the countries requires a specific route of action which must be verified. In consideration of these results, this phenomenon is still present today, evidencing the difficulties in defining the legal and technical aspects of EIA in a

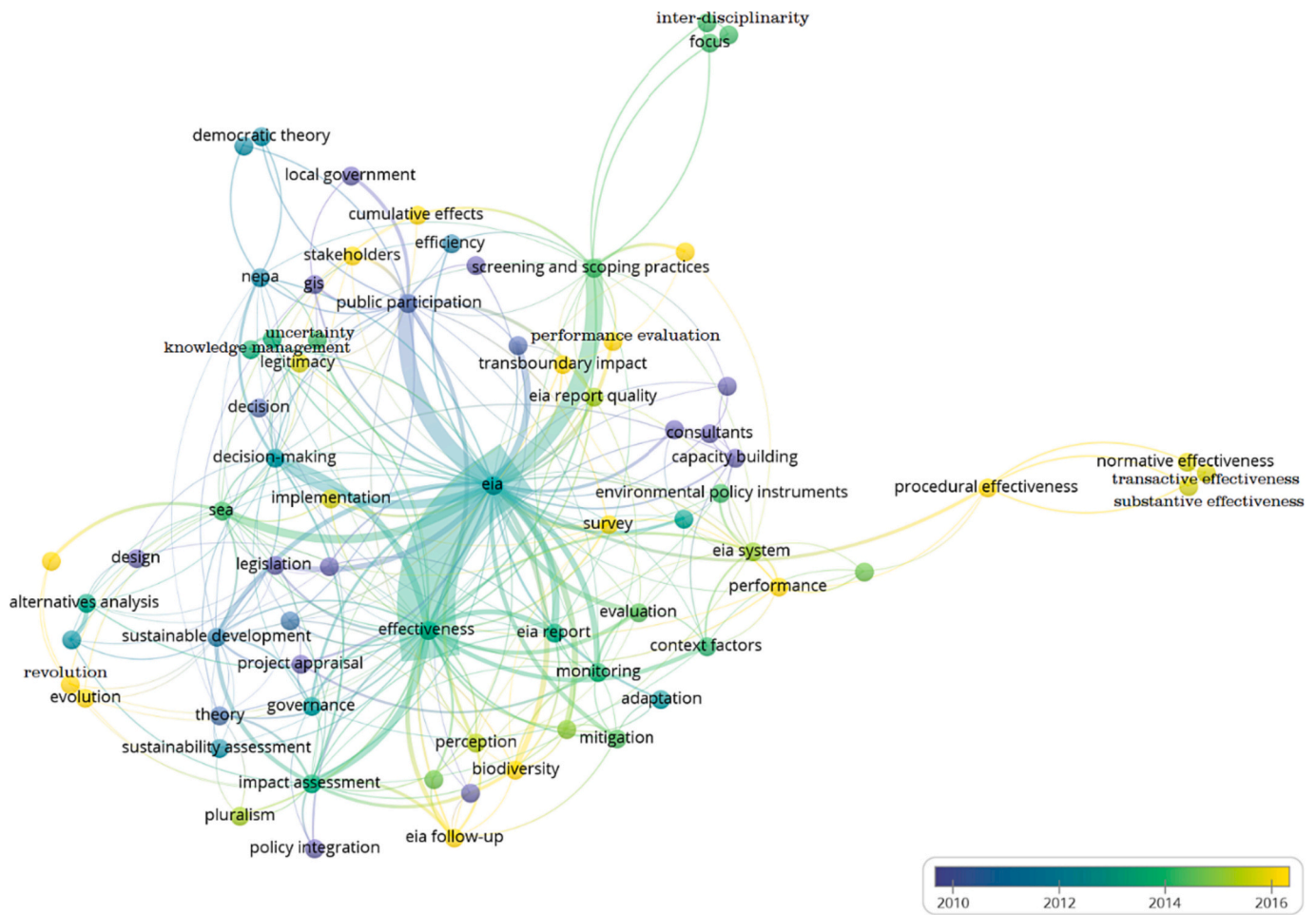


Fig. 9. Historical evolution of the terms associated with research in EIA effectiveness based on the keyword network analysis with a temporal overlay as resulted from the bibliometric analysis. The size of nodes given by keyword occurrences (≥ 2), legend – average publication year.

comprehensive manner.

The second category with the highest number of publications is multidimensional with 46 records (16.4%), a number well below that reported for procedural effectiveness. Over time, research emerged that focused on the conceptualization and categorization of effectiveness (e.g., Bond et al. (2018); Cashmore et al. (2009); Loomis and Dziedzic (2018); Lyhne et al. (2017)), or in the evaluation of EIA systems by considering criteria related to one or several dimensions of effectiveness (e.g., Alberts et al. (2021); Byambaa and de Vries (2020); Getty and Morrison-Saunders (2020); Almeida and Montaña (2017)). This group of publications stands out for the theoretical contribution they make to research on EIA effectiveness, generating debates around the concept of effectiveness or proposing new dimensions, which makes them conceptual references for further studies. This is the case of some authors such as Chanchitpricha and Bond (2013) and their conceptualizations of effectiveness, Bond et al. (2013b) and the approach to sustainability, or Pope et al. (2018) by proposing the legitimacy dimension.

Cashmore et al. (2004) argued that most of the literature does not clearly discuss the substantive purposes of EIA and that only some elements of substantive effectiveness emerge when procedural, methodological or quality elements of EIA are discussed. This is currently evident, since only 33 (11.8%) publications refer to substantive effectiveness and its components. References in the analysis of this dimension are Cashmore et al. (2004) and Jay et al. (2007). According to the proposed classification, 21 documents focused on the EIA regulatory framework, institutional infrastructure and legislation about EIA and IA were identified. Moreover, 12 publications were identified that analyze

the decision-making process, its importance, and strategies to optimize it. The low incidence of this dimension in the literature is due to the difficulty in evaluating it. As explained by Loomis and Dziedzic (2018), there is an impossibility to perform analyses comparing the negative effects of decision making on EIA.

Legitimacy includes elements of pluralism, knowledge and learning, and normative effectiveness, dimensions that have been the focus of several investigations. Twenty-two publications (7.9%) were identified, with a predominant focus on organizational legitimacy (18 publications), understood as the analysis of stakeholders' perceptions of IA practice and the EIA system. (e.g., Kurniawan et al. (2021)). There are also 4 publications on knowledge legitimacy where knowledge (in its different variants) is recognized, integrated and analyzed in EIA (e.g., Sánchez and Mitchell (2017)). This dimension is relatively new compared to the dimensions traditionally linked to EIA effectiveness. However, the proposal of Pope et al. (2018) provides conceptual elements that facilitate its subsequent evaluation, as identified in some multidimensional studies (e.g., Chanchitpricha and Bond (2020); Geißler et al. (2019)).

Transactive effectiveness, as previously mentioned, has received much less attention compared to other dimensions of effectiveness (Loomis and Dziedzic, 2018; Pröbstl-Haider, 2022; Theophilou et al., 2010). This is consistent with the results obtained in this study, since only 4 (1.4%) publications were specifically focused on this dimension, and mainly address the cost-efficiency of the process (e.g., Macintosh (2010)). However, several multidimensional analyses have included the transactive component in the evaluation of EIA systems (e.g., Getty and

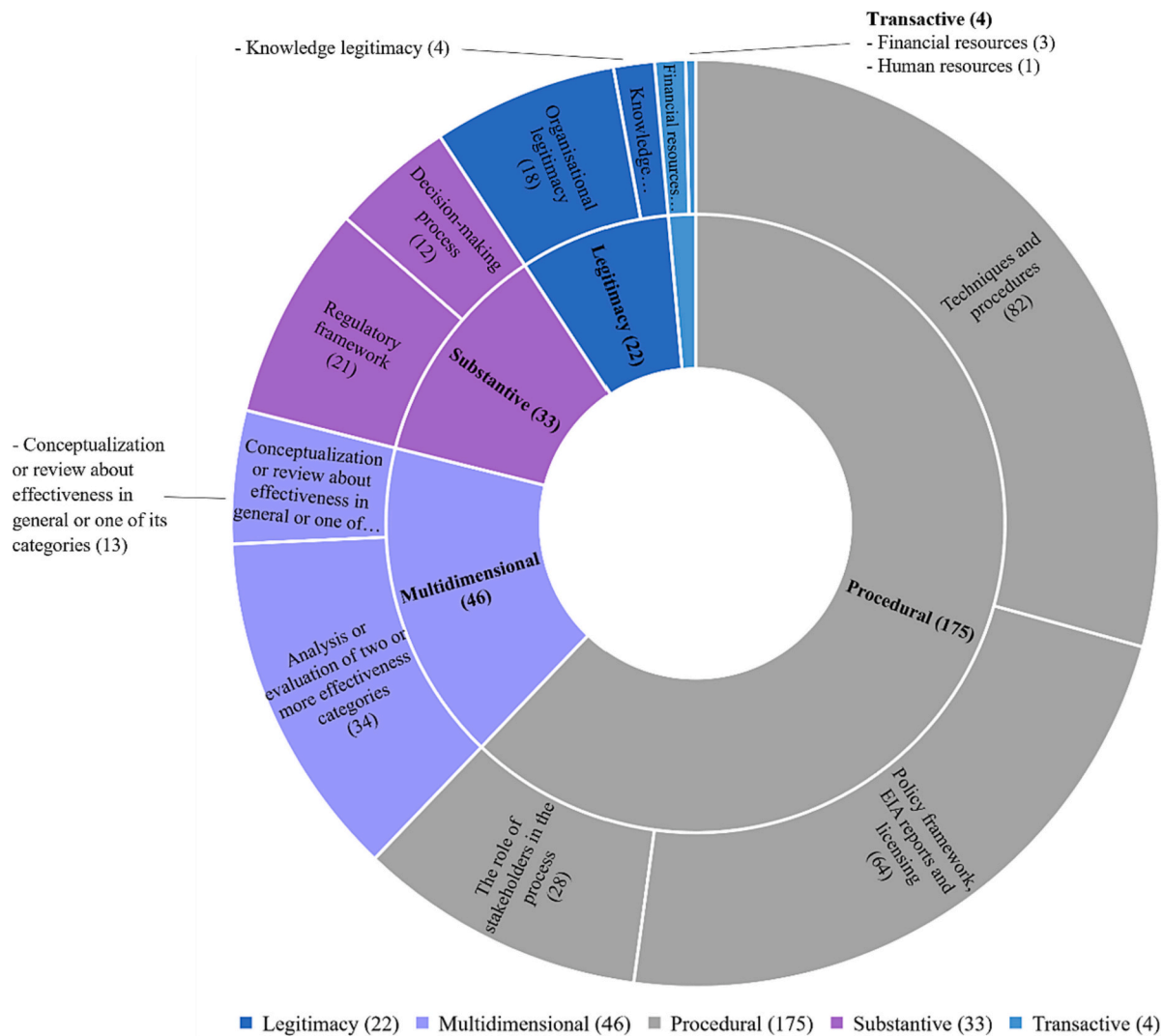


Fig. 10. Dimensions of effectiveness and subcategories identified from content analysis.

Morrison-Saunders (2020)). It is generally known that there are few studies related to this dimension; however, no initiative has been taken to investigate it in depth, even though it is recognized that the transactive effectiveness would impair the procedural and substantive effectiveness. These results are analyzed with concern, since, as several authors have mentioned, ignoring the economic outlook and the tendency to reduce costs may jeopardize the projection of the EIA (Pope et al., 2018).

EIA effectiveness has become a recurring theme in the specialized literature. The interest in this topic comes from the need to improve the decision-making process, but it was assumed that strengthening the procedural component of EIA would increase its effectiveness (Jay et al., 2007). Research in EIA effectiveness has evolved, as it not only investigates the limitations of EIA, but also constantly establishes new paradigms that allow reaffirming the founding goals of EIA. The literature review shows how the concept of effectiveness has been transformed from a strictly procedural approach to an analysis in which sustainability, the role of stakeholders and the legitimacy of the process become relevant. It is necessary to make visible the increase in publications that use the concept of effectiveness and the criteria of analysis of each dimension to evaluate EIA systems, as this shows that the theory around effectiveness becomes a very useful tool to improve the process and generate alternatives that adapt to the continuous changes in society.

5. Conclusions

Several studies have conducted conceptual reviews on EIA effectiveness that have become benchmarks for various studies (Chanchitpricha and Bond, 2013, 2020; Lyhne et al., 2017; Morrison-Saunders et al., 2015; van Doren et al., 2013). However, a limited number of studies have been interested in developing bibliometric analyses that focus on the evolution of research on EIA effectiveness, namely Loomis and Dziedzic (2018), who approach the exploration of this concept through literature review. Considering this background, the aims of this study are to define the geographic areas where more research is being carried out on this topic, identify the coworking network developed in this field and the main trends in research on the effectiveness of EIA to review the evolution of the concept and its dimensions. To achieve these objectives, this paper presents the results of a systematic literature review based on the PRISMA protocol to perform a standardized search of indexed publications related to EIA effectiveness during the period from 1997 to 2021.

The performance analysis determined that the countries with the highest scientific production focused on EIA effectiveness are the United Kingdom and Australia, countries that also stand out for international collaboration in their publications. A strong coworking network is identified between countries such as Australia and South Africa, United Kingdom and South Africa, and United Kingdom and Australia. The

keyword analysis has identified five main trends in EIA effectiveness: effectiveness in EIA systems, technical approach, public participation, impact assessment and sustainability approach, and effectiveness dimensions. Based on the conceptual structure map and keyword clusters, four key points are identified in the research on the dimensions of EIA effectiveness: EIA performance, the context in which EIA is applied, stakeholder involvement, and their perception of the process. From the content analysis, it is confirmed that the effectiveness dimension that receives the most attention in the literature is procedural effectiveness, a fact reported by the literature and that has not lost validity over the years. Also, transactive effectiveness is identified as the dimension with fewer publications, demonstrating the little interest that academia has directed towards cost estimation and resource use, ignoring the significant influence that the transactive component has on the EIA process. In addition, it highlights the increase in multidimensional publications that evaluate EIA systems based on criteria for analyzing the dimensions of effectiveness. Therefore, this study indicates that the concept of effectiveness has evolved over time, as it is no longer limited to the procedural component and has been transformed by making its analysis more complex in terms of sustainable development and stakeholders' perceptions. As Loomis et al. (2022) points out, the transformative approach to EIA effectiveness invites us to think about a paradigm shift in EIA from a weak sustainable development paradigm to a strong sustainable development paradigm. This requires a continuous improvement of public policies associated with EIA systems and IA tools. A challenge that involves all stakeholders.

The results obtained represent an input to develop a bibliometric analysis that allows defining the main research trends related to EIA effectiveness and its dimensions. The analysis carried out has described the panorama of research on EIA effectiveness, demonstrating its evolution over time and the relevance it has taken on today. From this work, researchers and their groups can identify research problems, knowledge gaps, topics or potential studies on EIA effectiveness, thus making it possible to improve EIA processes and contribute to sustainability, as has been the goal of EIA since its formation in the 1960s and a constant demand from the administration and communities. However, some limitations should be noted. Although the study focused on the concept of "EIA effectiveness" and "impact assessment effectiveness" as search terms, derived terms such as efficiency, effectiveness, success and/or performance were not considered. Therefore, future work should include these search terms, even though they are used less frequently than the term "effectiveness", they will uncover more publications that contribute to the construction of knowledge about EIA. It is recommended that grey literature be included in future analyses, in order to incorporate documents issued by official agencies or authorities that contribute to the progressive improvement of EIA systems. It is also necessary to include regional research from country-specific journals, which may not be included in the review that was conducted. Based on the results obtained, we suggest the need to develop studies on EIA effectiveness in areas where there are no publication records, as they may represent a novelty and a contribution to the evaluation of EIA systems. It is also a call for studies focused on dimensions that require further study to strengthen the EIA process.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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