

Advancing Sustainability Through Green Public Procurement: A Comprehensive Analysis.

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Abstract

Greener Supply Initiatives acquisitions have received much focus from researchers, policymakers, and practitioners all over the world in the last four decades as a new approach for green public procurement. GPP practices and policies motivate the consideration of environmental criteria in the government buying processes. The present study attempts to put GPP into a historical perspective of research evolution by conducting a bibliometric analysis for public procurement, using 704 publications obtained from the Scopus database. Content and network analyses allow us to determine the existing thematic clusters, outstanding authors, and trends, as well as gaps in this developing area. The findings of this research suggest that the need to do research in this area has been gradually rising, and studying the effects of GPP on environmental management, principles of the circular economy, and sustainable development goals are among the major milestones made. It further explains the nature of the interaction that exists between the publish and perish brackets, that is, the academia, the industry, and the government. In order to provide a framework and context for GPP research, the authors also investigate which of the most cited papers references each other. The results open and outline a number of avenues for future research, such as the combination of digital information technologies and GPP processes and the inter-sectoral angles. This knowledge is beneficial both for scholars and practitioners, making it possible to propose more creative ways of fully exploiting the opportunities offered by green public procurement practices. This paper contributes to existing knowledge instead of being the last word on the subject and simultaneously offers possibilities for cross-disciplinary research on green public procurement and its importance in attaining the goals of sustainable public procurement.

Keywords: Green Public Procurement (GPP); Sustainability; Environmental Compliance; Circular Economy; Sustainable Development Goals (SDGs); Bibliometric Analysis.

1. Introduction

Green Public Procurement (GPP) has emerged as a critical instrument in the sustainable development agenda, attracting the focus of policymakers, researchers, and practitioners at national and international levels. Thus, Green Public Procurement (GPP) refers to the process where public authorities purchase goods, works, and services in a manner that reduces the environmental impact throughout the entire life of the product. GPP enables procurement authorities to transform the market and foster sustainable production and market patterns (European Commission, 2020). In the last four decades, the field has developed considerably, indicating the growing effort to address global environmental issues such as changing climate, scarcity of resources, and degradation of biodiversity (United Nations, 2015; Bouwer et al., 2006).

There is now substantial political and scholarly work that demonstrates the direction certain countries and sectors have taken toward GPP, thereby contributing to the development of the concept. The early literature on GPP concentrated primarily on its definition and policy endorsement, advocating for the use of government purchasing power for environmental purposes (Nissinen et al., 2009; Brammer & Walker, 2011). This focus on initial policy development gave way to other studies that, while utilizing the GPP-centered perspective, examined its wider impacts on innovation stimulation, the sustenance of small and medium-sized firms, and circular economy principles. These studies include those conducted by Testa et al. (2016) and Chiarini & Vagnoni (2017).

Although GPP has received considerable attention recently, its uptake and the execution of the GPP policies as designed are patchy, depending on the existing variation in regulatory regimes, institutional capacity, and the market context. For example, European Union countries have been active in pursuing GPP with action plans and directives, while sustainability aspects of procurement have remained elusive in other areas (Rolfstam, 2012; Parrado & Van Ryzin, 2020). Unfortunately, this situation shows how important it is to have a better understanding of the things that make GPP adoption possible or not, as well as how it might help reach bigger sustainability goals.

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Fraud, corruption, and the abuse of authority have dominated the narrative of growing public distrust in government institutions, and therefore the uptake of the GPP has fallen short of expectations. The very recent development of digital tools and the data-oriented approach has, however, changed the game and improved the procurement processes. GPP practices are now witnessing the use of big data analytics, blockchain, and AI technology for better decision-making and environmental compliance monitoring (Sönnichsen & Clement, 2020). These developments have raised new research questions, suggesting that the relationship between technology, policy, and the market will transform the future of GPP.

Considering that GPP is a multidimensional construct, one would expect the scholarly literature to grow over the last four decades in policy design, implementation problems, evaluation of impact, or good practices. The increase in research activity also has its companions, which are trying to integrate knowledge with core trends or gaps in facts. Zhu et al. (2013) and Chen et al. (2019) also highlight this aspect, proposing the use of bibliometric methods to provide an intellectual history and a map of future possibilities for the GPP field, which has emerged as a result of the increased volume and multi-directional growth of GPP.

The current research focuses on offering an extensive bibliometric account of GPP scholarship from the year 1981 until 2024, drawing data from 704 documents obtained from Scopus. In particular, we analyze citation tendencies, collaboration graphs, and thematic networks with the purpose of reconstructing the intellectual core of GPP research, tracing the most important papers and key researchers, and detecting shifting boundaries and prospects for future research.

We anticipate that this study will add value to the existing body of literature by enhancing global understanding of GPP research and encouraging further work by academic practitioners and policymakers. We aim to foster interdisciplinary collaboration and pinpoint untapped directions and viewpoints in GPP, thereby stimulating innovative methods for its application.

This paper is structured as follows: Section 2 explains the methodology of the study, the employment of bibliometric techniques, and the data in hand. Section 3 describes the analytical methods and materials, which refer to the Scopus database and programs of data visualization that have been used for performing the analysis. Section 4 gives the results of the analytical part, focusing on the most prominent trends, major contributions, and problem-oriented approaches. Finally, Section 5 wraps up with practical implications and future work directions.

In conclusion, this bibliometric overview reveals GPP research development through an in-depth analysis of its publication output twenty-four years ago. By mapping the intellectual history of the field, we hope to highlight the importance of GPP in meeting sustainability goals and encourage further research and practice on this subject. As GPP performs these essential functions, it provides the global community with an innovative model for harnessing public procurement in response to compelling worldwide environmental issues. In this manner, we seek to add value to the continuing discussion on the best way to utilize GPP and enhance its adoption in international and national policy and practice.

Research Method and Questions

Research Method

Data and information published on the theme of 'Green Public Procurement' from the period 1981 to 2024 were thoroughly investigated using a quantitative technique referred to as bibliometric analysis. The major focus of this technique is to combine statistical and mathematical methods in the various aspects of study so as to relieve the concerns of the scientific community regarding the perception of the discipline, more so in the historical aspects of patterns and trends (Moed, 2006; Zhang et al., 2021). It is now impossible to find research paths, key themes, or gaps in a certain field without using bibliometric tools (van Oorschot, Hofman, Halman, & Change, 2018; Vatananan-Thesenvitz, Schaller, & Shannon, 2019; Brika et al., 2022a).

The study dataset was acquired from the Scopus database, which is one of the biggest and most complete databases of academic literature. The querying process targeted the identification of all relevant documents

published between 1981 and 2024, where ‘Green Public Procurement’ is featured in the title, abstracts, or keywords. We analyzed a sample of documents from 704 publications with the aid of bibliometric analysis in order to determine the trends of publication, authorship, geography, and citation.

The main aim of this bibliometric assessment is to assemble and evaluate extant research in such a way as to present a consistent and impartial survey of the field. This assists in establishing the cut-off point for GPP research and thus allows the formulating of recommendations aimed at academia, practicing professionals, and policymakers who wish to engage in sustainable procurement practices (Kitchenham, 2004; Prinsen et al., 2018). Besides, bibliometric techniques are appropriate for finding new topics and directions for research in the GPP, which makes it possible to develop a detailed management plan for the development of the discipline (Levy & Ellis, 2006).

We used various bibliometric software tools like VOSviewer and Biblioshiny to create co-author networks, citation trees, and theme trees for the analysis. Research output has been gauged in terms of publication volume, citation counts, h-index values, and the co-occurrence of keywords (Brika, 2022b; Brika et al., 2021). We also conducted thematic mapping to help divide the literature into essential clusters, highlighting the central issues and neglected areas in GPP research.

Aimed at appreciating the dynamic and cross-cutting nature of GPP that includes environmental science, policy, and even economics, the bibliometric approach is useful. This investigation aims to document the historical development of GPP in the field of publications and citations. As a goal, this study traces the development of research in GPP from basic studies on policy instruments and environmental assessments to recent scholarship on the circular economy, procurement technologies, and the interlinking of economies.

Along with visualizing the intellectual structure, this analysis brings out the key authors who contributed to the development of the area. The fourth milestone was the perspective of the European Union, which has been instrumental in advancing GPP through its policies and investing in research, being the focus of several studies (Bouwer et al., 2006; Testa et al., 2016). Furthermore, the importance of technology in increasing procurement efficacy and monitoring compliance has also been recognized as a valuable area of research to explore (Sönnichsen & Clement, 2020).

To increase clarity, replace with: This cross-sectional study adheres to a specific methodology, which ensures the reliability and replicability of the findings. By enhancing this analysis with bibliometric tools, it can follow the paradigms of GPP research. It is hoped that the presented results will also serve practice aiming at the development of research in a more practical context working with academics, practitioners, and especially policymakers.

Such research enables the broadening of the studied topic within the broader context of green public procurement, tracking changes in trends, engaging in significant theoretical discussions, and facilitating its practical implementation. This bibliometric analysis not only compiles literature on a specific topic, but also establishes practical and achievable objectives for future research, thereby promoting a global discussion on the sustainability aspects of procurement practices.

Research Questions

To achieve its goal, this study applies a bibliometric approach to the available GPP literature, covering the period 1981-2024 with a view to mapping the dynamics, influential literature, and research gaps. According to Moed (2006), bibliometric analysis complements other methods, like meta-analysis and systematic reviews, by assessing the development of a particular area in a quantitative and time-oriented manner. The reason for that is the very fact that the area of GPP can be well delimited in terms of coverage, trends, and contributions made in the area and hence enables a much more structured and categorized review of the literature.

Indeed, the importance and purpose of this bibliometric analysis are determined by the resolution of two main problems of the research:

- Understanding the historical and current trends in GPP literature.
- Identifying future research directions and unresolved issues in the field.

To achieve these objectives, the study addresses the following primary and sub-questions:

Research Question 1 (RQ1)

What changes have occurred in the literature on public procurement (GPP) over time?

This question explores the longitudinal development of GPP research, focusing on key trends, influential works, and publication dynamics. To provide a structured response, the following sub-questions are formulated:

- **RQ1.1:** What have been the most influential research articles, such as those published in Scopus-indexed journals?
- **RQ1.2:** Which references have had the most significant impact on subsequent studies in GPP?
- **RQ1.3:** Which journals are the most widely cited and read in this field, and how has the volume of GPP publications evolved over time?

By addressing RQ1, this study provides a quantitative and comprehensive view of how GPP literature has developed, highlighting milestones and key turning points in the field.

Research Question 2 (RQ2)

What are the most important topics and challenges discussed in the scholarly literature on GPP?

This question aims to classify the key themes and research issues that dominate GPP studies, facilitating the identification of gaps and opportunities for further investigation. Specific areas of interest include:

- The integration of GPP into policy frameworks.
- The role of GPP in promoting circular economy principles.
- The challenges of implementing GPP across different regions and sectors.

Answering RQ2 will provide a thematic categorization of GPP activities and challenges, enabling academics and practitioners to navigate the field more effectively.

Significance of the Research Questions

These questions are useful in forming the framework for the bibliometric analysis and in ensuring that the literature is evaluated in a systematic manner and also that the study is useful. This study attempts to integrate both longitudinal aspects (RQ1) and content aspects (RQ2) in order to create a more comprehensive picture of GPP research that will be useful to researchers, policymakers, and practitioners.

Moreover, the application of validated bibliometric techniques further guarantees the credibility and reproducibility of the obtained results, thus consolidating the knowledge advancement of the region (Ikpaahindi, 1985). The knowledge obtained from this analysis is expected not only to synthesize the already highly dispersed material on the topic but also to open new interdisciplinary avenues in studying the role of GPP in advancing sustainable development goals.

Methods And Materials

Bibliometric Data

Fairthorne (1969) and Pritchard (1969) first proposed bibliometrics as a measure. Bibliometrics as a measure aims to analyze and quantitatively assess literature. Over the years, bibliometric analysis has turned out to be a powerful tool that is used to assess publication trends, citation dynamics, and intellectual structures. The use of bibliometric methods in sustainability and procurement research is widespread; however, there is a dearth of such research regarding green public procurement. This research aims to fill in the literature gap by offering insights regarding GPP as well as its evolution through analysis of GPP-related metadata and publications.

As for this bibliometric study, the dataset has been derived from the Scopus database, known for being a robust website for academic publications. The dataset encompasses the publications that have the keywords Green Public Procurement in their title, abstract, or author keywords, and the period of publication ranges from 1981 to 2024. The research yielded a total of 704 publications, which will be further analyzed with specific search criteria that allow for the retention of high-quality and useful studies for GPP research.

In an attempt to add balance and depth to the analysis, the research pays attention to the more recent contributions to the discipline. Over the past five years, the trends in GPP have become increasingly significant, as has the collection of knowledge. Such an emphasis makes the outcome of the assessments timely with respect to the academics and policies of the day. Furthermore, we link the data to Scopus and incorporate a range of metadata, including the year of publication, individual names, affiliations, journals, keywords, and citation counts.

Various metrics, including bibliometric instruments such as VOSviewer and Biblioshiny, were employed to surgically examine the data points. The following issues have constituted the focus of the analysis:

Temporal trends: Assessing the temporal evolution and expansion of GPP research and its key milestones.

Authorship and collaboration: Cointerconnected collaboration sphere in terms of GPP research efforts sphere via co-authorship networks.

Influential sources: evaluating the major sources of revolution in the corresponding domain and discipline, inclusive of journals, articles, and authors.

Thematic clusters: The location of major themes and growing keywords The co-occurrence of the field of research has been studied throughout.

With this analysis, the trends that are forming in the field of GPP will be easily interpreted based on a wide range of empirical information. Taking into consideration the recommendations for further studies, this work draws attention to GP as a vital aspect of sustainable development. This analysis provides a basis of knowledge in GPA that will be beneficial for academic research, policymaking, and the application of green procurement internationally.

Study methods and tools

Many researchers (Hood & Wilson, 2001; Osareh, 1996a, 1996b; Tsay, 2005) have identified three key bibliometric rules. The first of these, according to Hood and Wilson (2001), the earliest of these is Lotka's Law; Lotka (1926) established a relationship between authors and papers. Bradford's Law; Bradford (1934) deals with scattering articles on a scientific subject through scientific journals. Law Zipf (1949) is interested in the concept of frequency or occurrences.

This study uses bibliometric methods to analyze the GPP research field from 1981 to 2024 systematically and quantitatively. Bibliometric analysis has long been used as a method whereby mathematical and statistical techniques are employed to analyze the scientific literature and retrieve patterns, trends, and significant contributions to the literature (Fairthorne, 1969) and (Pritchard, 1969). It uses basic laws of bibliometrics, such as Lotka's Law on authors' productivity, Bradford's Law on the dispersion of articles and journals, Zipf, (1949),

on the keyword frequency in the literature (Hood & Wilson, 2001) These principles guided the design and implementation of the analysis presented here to provide a comprehensive understanding of the GPP domain.

This research examined articles that had in their title or abstract the words "green public procurement," cross-checking Google Scholar, which is a database. A total of 704 such documents, such as journal articles, conference papers, and reviews, were found. Data cleaning and filtration were conducted to remove duplicates and irrelevant entries, leaving a high-quality dataset for analysis. By using more specialized bibliometric tools such as VOSviewer and Biblioshiny, the dataset was able to process citation networks, co-authors' relationships, and thematic clusters. These tools allow deep investigation of publication patterns, methods, some leading publications, document keywords as frequency, and dependencies of changes in GPP research (Zupic & Čater, 2015).

The entire process of the analysis was broken down into key stages: design of the study, data gathering, data analysis, visualization, and interpretation. This form of textual citation analysis was able to figure out essential body citations for a paper and journals. Following this, co-citation analysis and bibliographic coupling analysis revealed the internal structure of civilization and various clusters. The focus of the co-authorship analysis was on the networks of collaboration co-arising out of GPP. The co-occurrence of GPP keywords was dominant and encompassed emerging research themes. This methodological rigor ensures the reliability and reproducibility of the findings, providing a comprehensive overview of the intellectual landscape and research trends in GPP (Lobato, Cristino, Faria Neto, Costa, & Produção, 2021). By combining quantitative bibliometric techniques with advanced visualization tools, this study contributes significantly to the understanding of GPP's role in advancing sustainability goals.

Results and Discussion

Descriptive of bibliometric data

Analysts provide comments on the state of the research and its scholars' contributions in the specific field that they focus on. This knowledge is constantly evolving as new technologies and modern studies introduce fresh perspectives into the academic sphere. The core of this purpose is bibliometric analysis, a quantitative approach that utilizes mathematical techniques to evaluate scholarly activities such as articles, books, and other publications. These studies encompass geo-based patterns of research output and distribution, identify the most productive researchers, identify the most productive countries and institutions, track the yearly output of papers, analyze the frequency of article citations, and explore other aspects. In this instance, we extracted the literature sources from Scopus, which enabled us to trace the networks established by keywords, titles, authors, and sources published on Green Public Procurement (GPP).

We performed the article choice in three structured steps. Using relevant keywords, we collected journals (including articles, review articles, book chapters, and other types of documents) in the first step. We conducted the search in Scopus, with no date restriction until December 31, 2024. We found a total of 704 titles, collected and extracted meta-information about their titles, authors' names and affiliations, abstracts, keywords, and references, and saved it in a CSV file for analysis.

We then conducted a more focused search, utilizing specific keywords like 'Green Public Procurement,' 'Sustainable Procurement,' and other related terms that only appeared in the title, abstract, and keywords of the documents. The study period, which spanned from 1981 to 2024, yielded a sample of 704 publications spanning various document types, including 447 journal articles, 40 review articles, 77 book chapters, 112 conference papers, and numerous others. These bibliometric data, summarized in Table 1 along with other data, provide a more quantitative approach to presenting the optimal research picture in GPP. This approach reveals the substrates of trends, patterns of collocation, and the emphasis on research within the given scope throughout the history of GPP. The dataset helps begin to answer how GPP research and its sustainability contributions have developed over time through a wide range of quantitative descriptors.

Finding key publications that made an impact helps identify the preferred journals in the area of green public procurement (GPP). Table 1 illustrates the types of gearing and publications related to this research area, all of

which are geared towards those publications. Research articles make up the bulk of publications, with book chapters following closely behind, demonstrating the predominance of peer-reviewed published knowledge.

Table 1. Statistics of previous studies

Description	Results
<u>MAIN INFORMATION ABOUT DATA</u>	
Timespan	1981:2024
Sources (Journals, Books, etc)	402
Documents	704
Annual Growth Rate %	10.94
Document Average Age	5.71
Average citations per doc	19.52
References	29764
<u>DOCUMENT CONTENTS</u>	
Keywords Plus (ID)	2622
Author's Keywords (DE)	1790
<u>AUTHORS</u>	
Authors	1726
Authors of single-authored docs	128
<u>AUTHORS COLLABORATION</u>	
Single-authored docs	144
Co-Authors per Doc	2.93
International co-authorships %	17.76
<u>DOCUMENT TYPES</u>	
article	447
book	13
book chapter	77
conference paper	112
conference review	15
review	40

The information in Table 1 demonstrates the continuously developing character of GPP as an area of research; there is the apparent positive trend in its expansion, especially during the last three years. This trend is consistent with the increased international attention paid to the inclusion of principles of sustainable development in the policies of public procurement. The dominance of research articles and book chapters within this data set evidences their importance in the development of knowledge and practice in the field.

These illustrations demonstrate the active publishing efforts of scholars working on the GPP, with an increasing number of different types of publications emerging. The main contributions of articles and book chapters are complemented by other types of documents, like conference papers and reviews. This shows that there is a rich ecosystem for sharing knowledge in this field. A visual depiction of these trends further elucidates the dynamic expansion of GPP research in recent years. This explains the abundance of production in this type of research, which can be clearly shown in the following figure.

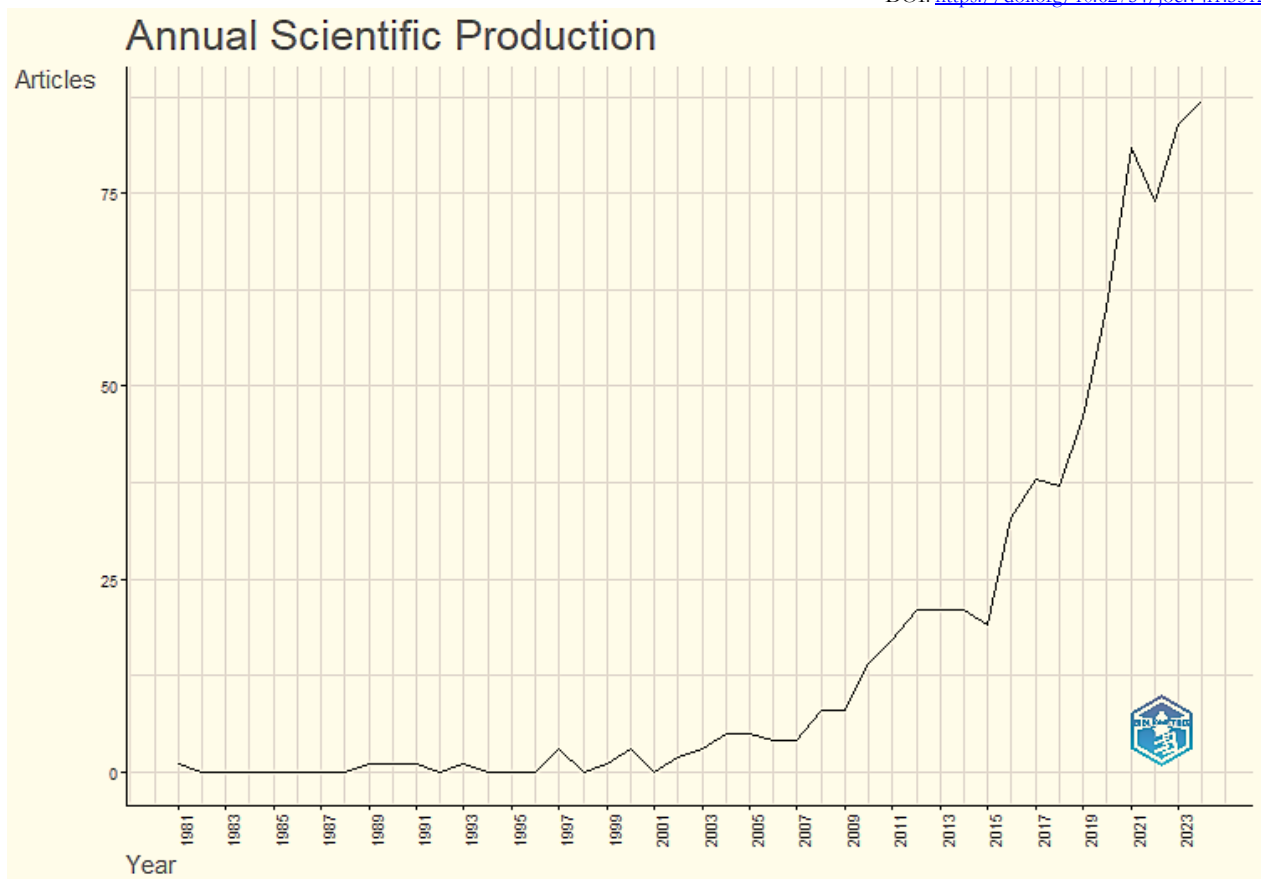


Fig. 1. Publications per year

Figure 1 illustrates the consistent increase in the quantity of publications on green public procurement over time, notably accelerating in recent years. Research output shows an upward trajectory, particularly from 2016 onward, with a peak of 87 publications in 2024. This upward trend indicates that there is an increasing worldwide tendency to include sustainability parameters within public purchasing practices as well as their developed political and scholarly orientation towards green public procurement.

Previous studies indicate that there has been uneven growth in the area, with the number of new publications appearing each year limited. For instance, in the period between 1981 and 2005, the number of publications was low, averaging 5 publications per 5-year period, or less than 5 articles a year. However, since 2006, there has been a clear shift toward growing involvement in research, which coincides with the general tendency to adopt environmental sustainability implications for business practices.

The diversity of publication types—from articles and journals to conference papers and book chapters—indicates a strong, multidisciplinary approach to exploring green public procurement. Articles dominate as the most common form of publication, reflecting their central role in academic discussions, while conference papers contribute significantly to real-time knowledge exchange. The upward trend from 2016 on demonstrates the increasing novelty and maturity of GPP as a critical research area, underscoring its importance in advancing the Sustainable Development Goals. The line graph below shows this trend.

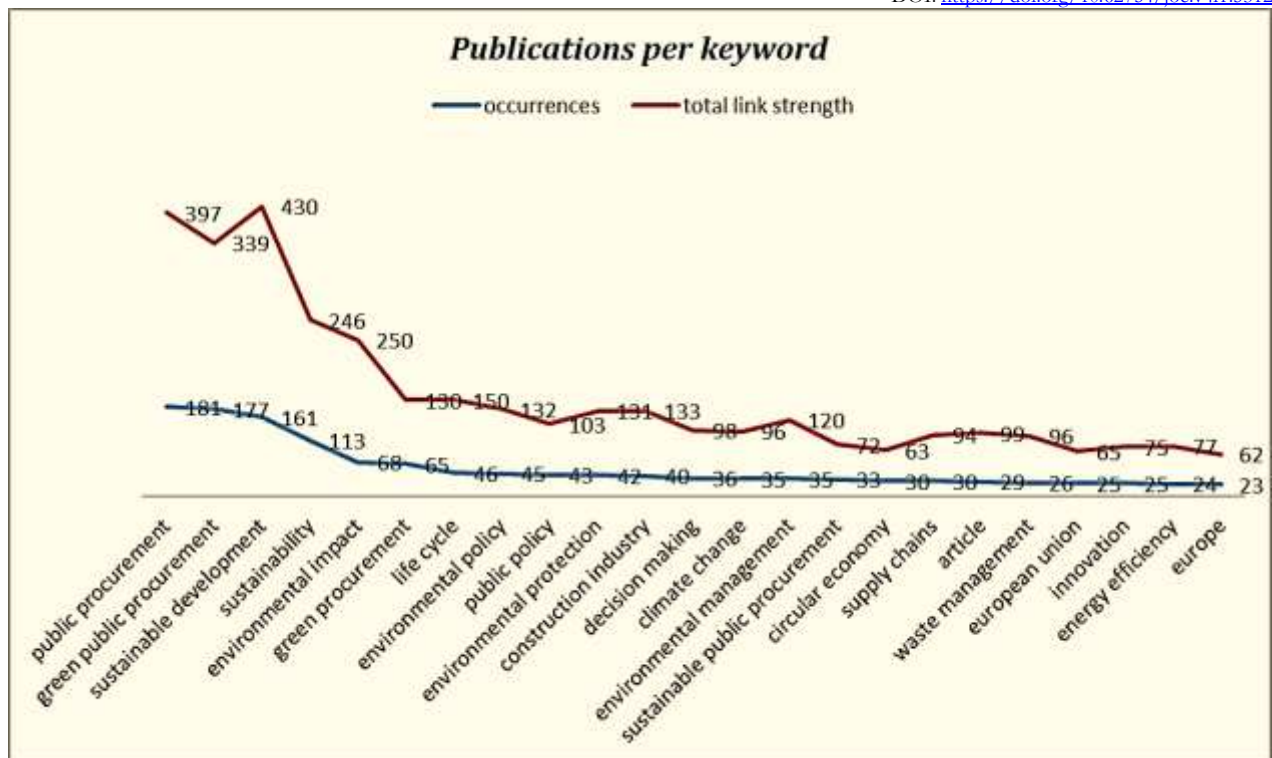


Fig. 2. Publications per keyword

Figure 2 illustrates that the majority of studies in the field of Green Public Procurement (GPP) have utilized keywords such as "public procurement," "green public procurement," "sustainable development," "sustainability," and "environmental impact," among others. This indicates a strong research focus on environmental and sustainability-related themes within the domain of GPP. Furthermore, expressions like "circular economy," "waste management," and "energy efficiency" point to an enhanced interest in novel ways of conserving resources and the environment. These trends show how GPP studies fit in with global sustainability norms, showing how important it is for using procurement processes to solve environmental problems.

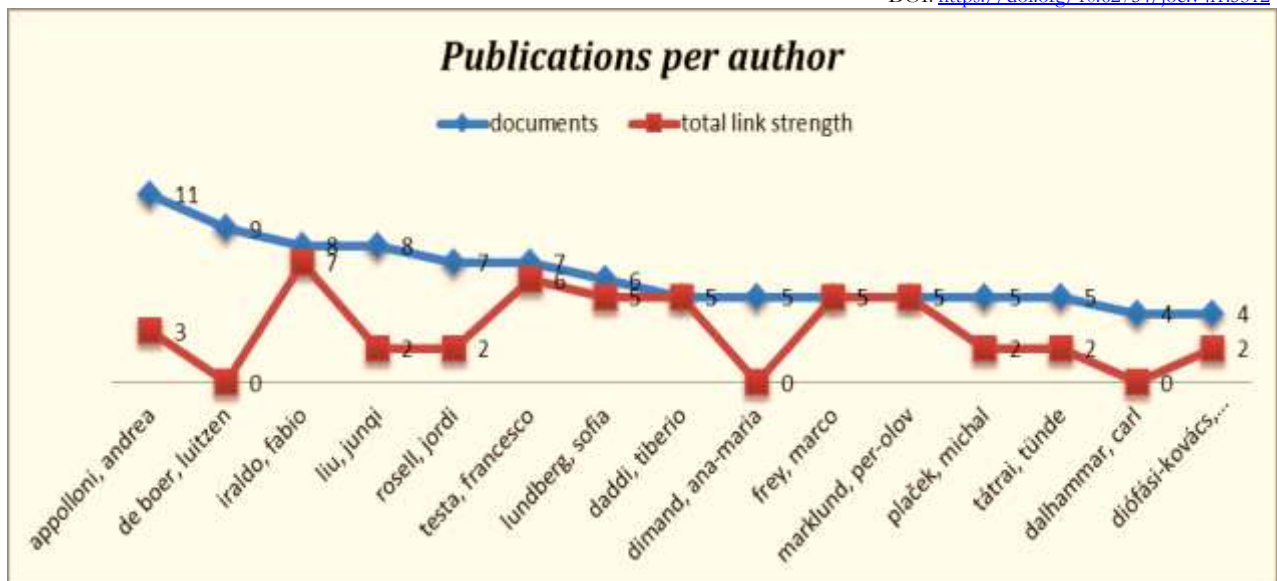


Fig. 3. Publications per author

Fabio Iraldo, Luitzen de Boer, and Andrea Appolloni have contributed to the recent introduction of green public procurement.. In regard to this paper, Anderson Appolloni is notable for possessing 11 documents regarding this GPP, which have a major link breadth, which implies that he is active and seriously collaborates with other people’s works. Likewise, Testa Francesco and Iraldo Fabio made outstanding contributions to documents and linkages. Scholars exploring green public procurement should cite those contributions to make further steps in well-established contexts and go deeper into crucial ideas that are shaping the field.

Bibliometric analysis and networks

Items: 216 / Clusters: 8 / Links: 5651 / Total link strength: 10672

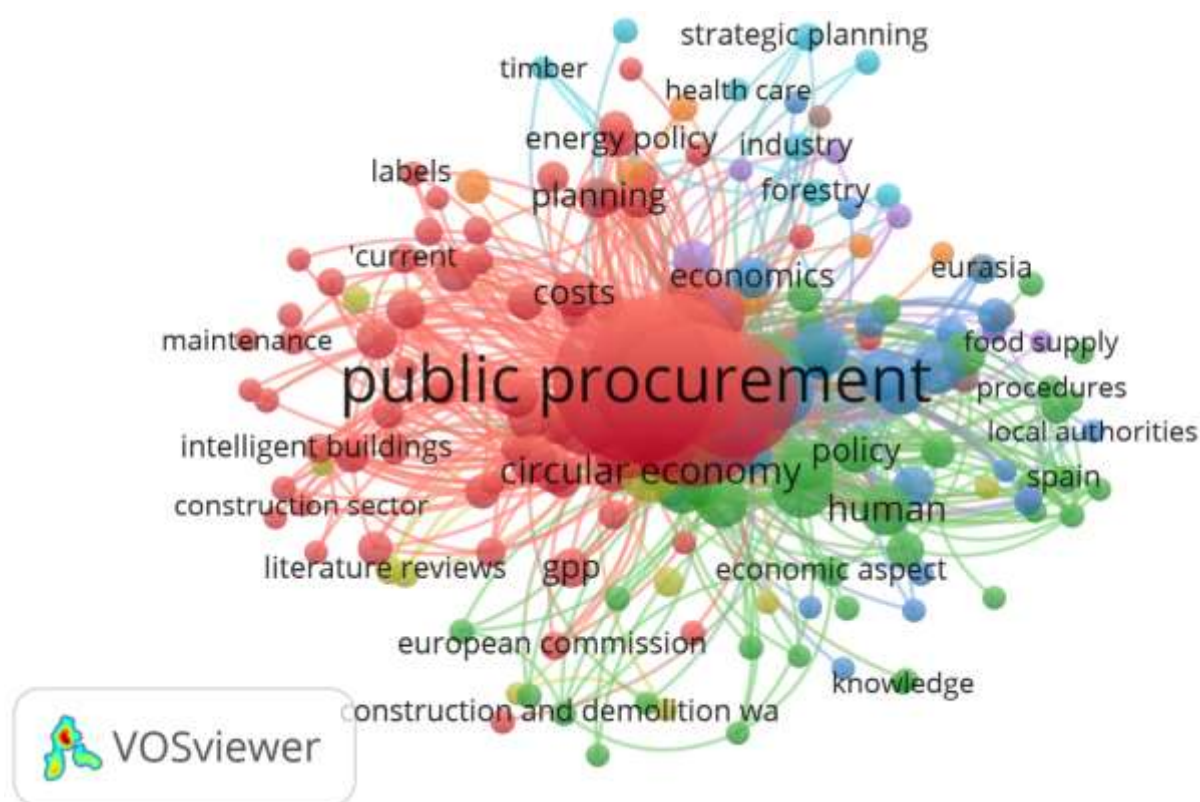


Fig. 4(1). Network of keywords

The figure highlights several noteworthy clusters within the network that researchers can explore in the field of green public procurement. With respect to the occurrence of keywords and total link strength, the major clusters include "public procurement," "green public procurement," "sustainable development," and "sustainability," all of which, to a greater extent, fall under the green procurement umbrella. Other notable areas that have adequate coverage include "environmental impact" alongside "green procurement" and "life cycle," which are indicative of the increasing focus on sustainability parameters in procurement processes.



Fig. 4(2). Density of keywords

Moreover, there is a significant link to policy-oriented and environmental protection efforts in purchasing practices as implied by the terms “environmental policy,” “climate change, and “environmental management.” Also, the terms “circular economy,” “supply chains,” and “waste management” seem to be emerging as new topics, which indicates a greater focus on resource utilization and sustainability in procurement. This highlights the cross-cutting characteristic of green public procurement, with the possibility of the scholars addressing environmental as well as economic aspects. They may also aim to explore the connections between green public procurement and broader issues like innovation, energy efficiency, and European Union policies. At this point, we focus on the most prominent researchers in the area.

Table 2: The occurrence of keywords in network

Keywords	Occurrences	Total link strength
public procurement	181	397
green public procurement	177	339
sustainable development	161	430
sustainability	113	246
environmental impact	68	250
green procurement	65	130
life cycle	46	150
environmental policy	45	132
public policy	43	103
environmental protection	42	131
construction industry	40	133
decision making	36	98
climate change	35	96
environmental management	35	120

Table 3 displays the authors' presence in the Green Public Procurement research social network, along with the number of works they have contributed and the extent of their collaborations. The most frequently occurring author is Appolloni, Andrea, with 11 occurrences, which is much less than the total link strength of 3. This means that the author has a fair amount of works published in his/her name but does not have many collaborative networks in the published works. On the other hand, Iraldo Fabio exhibits a higher level of sharpness, with 8 occurrences and a slightly stronger link strength of 7, indicating his active participation in the network and the extensive connections his works have with other scholars in the field.

Items: 26 / Clusters: 8 / Links: 52 / Total link strength: 44.50

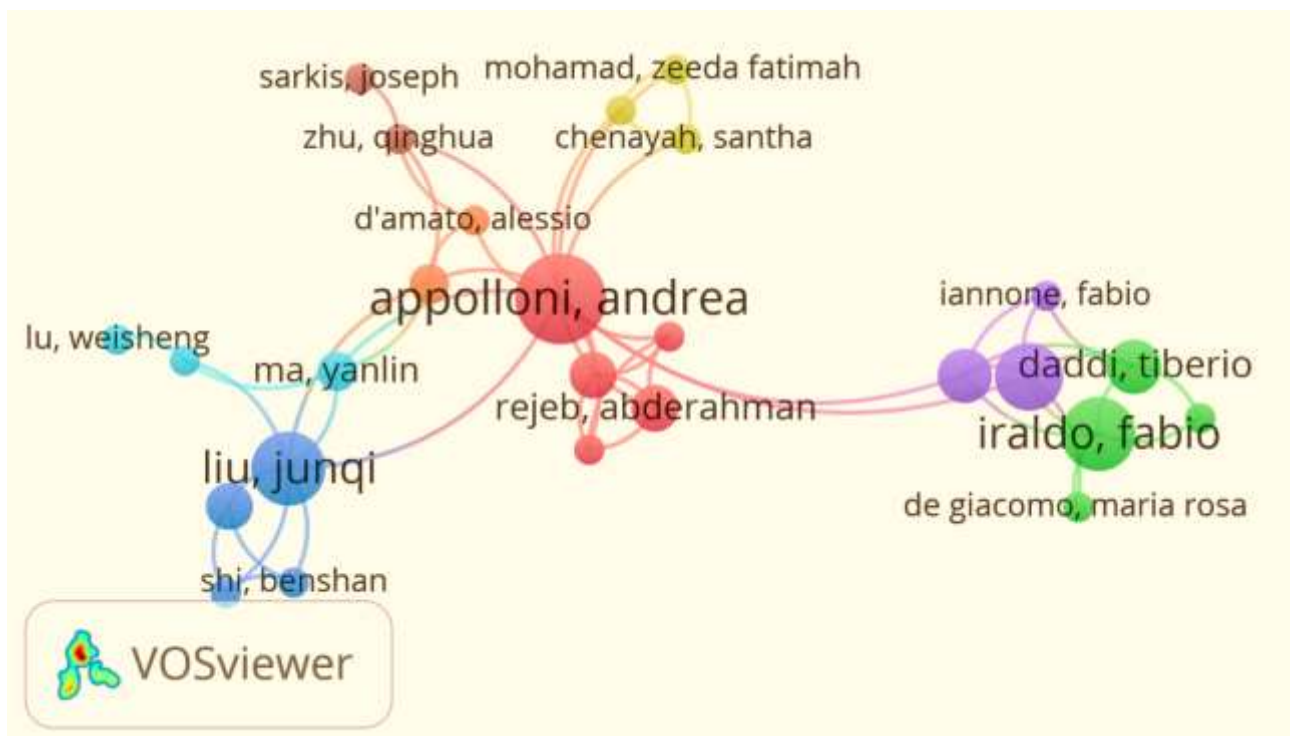


Fig. 5 (1). Network of authors

Other authors, such as Testa, Francesco, and Lundberg, Sofia, who have 7 and 6 occurrences, respectively, also exhibit low link strengths (6 and 5), meaning that they put in much effort and resources and are willing to cooperate more in the domain. On the contrary, De Boer, Luitzen, and Dimand, Ana-Maria, with 9 and 5 occurrences, have a cumulative strength of links equal to null, which may be interpreted as saying that quite a number of their publications remain independent from each other and from the works of other scholars in that network of collaborative research.



Fig. 5 (2). Density of authors

Also, the authors Rosell, Jordi, Frey, Marco, and Plaček, Michal, have moderate occurrences and link strengths, which shows that they are still working in the field with a balance of publishing often and working with others.. These authors are important for anyone looking to explore green public procurement further, as they have established themselves as key contributors to the field.

Table 3: The occurrence of authors in the network

Authors	Occurrences	Total link strength
appolloni, andrea	11	3
de boer, luitzen	9	0
iraldo, fabio	8	7
liu, junqi	8	2
rosell, jordi	7	2
testa, francesco	7	6
lundberg, sofia	6	5
daddi, tiberio	5	5
dimand, ana-maria	5	0
frey, marco	5	5
marklund, per-olov	5	5
plaček, michal	5	2
tátrai, tünde	5	2
dalhammar, carl	4	0
diófási-kovács, orsolya	4	2

The table displays Appolloni et al. (2014) as the most frequently cited author in the field of green public procurement, with 11 occurrences. However, his low total link strength (3) indicates his work is not as widely

cited or integrated into the academic network. In contrast, Iraldo, Fabio, and Testa, Francesco, each with 8 and 7 occurrences, have stronger link strengths (7 and 6), indicating that their research is more influential and widely cited. While Appolloni's research is valuable, the studies by Iraldo and Testa are more impactful. Researchers should reference Appolloni's work for foundational knowledge while considering the more influential contributions by others.

Conclusion and limitation

The objectives of this study were to investigate the evolution of the research pertaining to the landscape of GPP as well as to adopt a bibliometric method to analyze publications indexed in the Scopus database. The results give a closer perspective on the development of GPP research as well as its increasing relevance within the context of research on governance and society/ecology. In the last few decades, it has emerged that GPP is a potent weapon in fighting for sustainable procurement practices and dealing with environmental issues. The growing number of publications, especially in the recent past, indicates this geographical region has not only pursued active academic work in this regard but also policy work. The increase in the volume of these publications corresponds to evidence of the efforts being made at the international level to incorporate environmental objectives in systems of public procurement for the purposes of SDGs (Lundberg, 2020; Testa et al., 2020).

The bibliometric analysis shows that the number of GPP publications rose sharply, especially after 2010. This period also corresponds to the further global embracing of sustainability and green policy objectives in society and in the economy (McCrudden, 2004). There is a definite relationship between changes in international policies, like the European Union's green procurement directives and other initiatives on global sustainability and emerging GPP research. Also, the COVID-19 pandemic has been one of the issues that has accentuated the need for sustainable practices in procurement, even if it caused disruption to some traditional research procedures (de Boer & Appolloni, 2019). This change brought about by the pandemic also contributed to greater use of digital technologies in procurement, which encouraged more sustainable practices in public procurement processes (Rossi et al., 2021). Consequently, research on the GPP is not only in tune with the goal of sustainability, but it is also developing in the context of new challenges, such as the use of digital tools for green purchasing.

There was a massive increase in the number of published papers between 2018 and 2020 due to the increased recognition of the environmental influence of buying and tackling climate change while focusing on innovations in policy. This increase indicates a link between public policy changes in Europe and other regions and public procurement research productivity. The sharp growth of concern regarding environmental sustainability across the globe in this period has also been documented (Lundberg, 2020). In addition, the increase in the volume of sustainable procurement research comes with the increase in international collaboration, especially between these European, US, and other developed nations that practice sustainable procurement standards.

The key research areas that are found in the article include sustainability, the environment, climate change, and green purchasing, which over time have been the main topics in the GPP literature. There is a clear trend for these topics to tie in with the general effort of the world to promote sustainability in public purchasing and attempt to minimize carbon emissions. Most notably, it can be noticed how sustainability, in many cases, has become one of the main factors for public purchasing policies worldwide, given the number of initiatives and policy papers framing this presented by governments and international institutions (Appolloni et al., 2020).

Nevertheless, the review also identified a number of gaps in the literature. First, while the significance of sustainable development in GPP is largely recognized, there is not enough literature on how GPP contributes to the development of innovation and advancement of technologies that enhance sustainability. For example, the effects of GPP on the development of green technologies across construction, energy, manufacturing, and others have not received much attention. Studies on these subjects would yield important information on how procurement strategies can be designed in order to support green technology development (Lundberg & Marklund, 2019). Furthermore, the ethical and legal aspects of GPP remain largely unexplored. Further research is also needed on the adoption and effectiveness of green purchasing legislation in different countries, especially

the developing ones where the regulations are under construction (de Boer et al., 2020). Such studies would help enhance the design of more effective and standardized mechanisms for operationalizing GPP policies.

The bibliometric analysis demonstrates the high level of international interaction among the members of the GPP research community, especially between those based in Europe and North America. Their geography covers many vital areas of critical importance to the field, highlighting the role that such international efforts can play in the enhancement of GPP practices and the transfer of knowledge. This is very important given that GPP is quite inherently international, with many countries pursuing different sourcing and policy regimes that have global ramifications (McCrudden, 2004).

Still, the analysis shows that collaboration is rather sparsely spread in the Latin America and Africa regions, where GPP could potentially have far-reaching effects. Increasing research activities in these regions would not only make GPP research more representative but would also help in the spread of green procurement in developing nations. These regions face significant environmental challenges, and GPP could serve as an appropriate vehicle in the built environment, especially on issues of resource use, social inclusion, and poverty alleviation (Lundberg, 2020). Further engagement with these regions might also improve the diversity and hence the applicability of GPP research.

While developing GPP research, a greater effort has been and continues to be placed on effective and meaningful forms of research publication. During this stage, advances in literature about GPP constructs are observed, which reflects the consolidation stages where researchers are integrating accumulated knowledge and exploring the advanced ramifications of GPP (Testa et al., 2020). For example, literature comprising review articles is important in aggregating large volumes of data on practice and showcasing the developments in certain domains. The introduction of numerous non-technical papers and reposts confirms the request for more original research that could contribute to a deeper understanding of specific policy arrangements around GPP. Problematically, future studies would be concerned with the consequences of GPP, especially in terms of how it results in compliance, its effectiveness or non-compliance, and addressing particular sectors (Lundberg & Marklund, 2019).

Also, growing interest can be noted very much in relation to the GPP integration, which engages a few fields, including environmental science, economics, democracy policy, and management science. It enables the scholars to navigate through the GPP from the more practical dimensions, which would lead and enhance these GPPs focus on the desirable environmental and socially economic outcomes. Innovative and cross-boundary research will empower theorems of GPP and its developed frameworks as practical solutions to governments, business heads, and practitioners (Appolloni et al., 2020).

There is no exaggeration whatsoever in stating that GPP research has significance. With countries, businesses, and international bodies accepting the need for green procurement, GPP has a role to play in the orientation of world sustainability strategies. The investigation AMT did on GPP shows that GPP can have a considerable impact on the environmental as well as the social dimension of sustainability. The green purchasing activities can lead to the development and use of cleaner processes, efficient use of resources, and lower carbon emissions, thus assisting in meeting the United Nations' Sustainable Development Goals (Testa et al., 2020).

Additionally, the social returns of GPP, such as alleviation of poverty, creation of jobs, and equity, are also very important. Social factors, which are often not integrated into the procurement process, accompanied by environmental factors, could enhance the contribution of GPP towards addressing social issues. Thus, through responsible procurement, GPP targets the creation of a just and sustainable world (Lundberg & Marklund, 2019).

This bibliometric analysis also manages to achieve an overarching understanding of progress and the present context of green public procurement research. The study shows that, as GPP has become more sophisticated, so has the emphasis on its scientific literature, leading to a greater growth of publications as well as new themes that need to be researched. Given that GPP is still a nascent discipline, it is, however, developing rapidly and in many directions, which gives hope. In order for GPP to reach its full potential globally, some things need to change: there has to be more targeted research, international networking has to be deepened, and the emphasis on the practical side of GPP has to be maintained. All in all, the increasing volume of GPP research clearing

international barriers will assist in the realization of sustainability ideals in the world and support the global targets of achieving a more just and sustainable world in the coming days.

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