




# Circular Procurement Assessment Methods in the Built Environment: A Scientometric Analysis and Systematic Review

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## Abstract

The circular economy has emerged as an alternative to the current linear model for solving global climate change challenges. Measuring circularity provides informed decision-making in circular procurement. However, a paucity of knowledge exists in circular procurement assessment methods in the built environment. This paper aims to map circular procurement assessment methods in the built environment for sustainable development. The study employed a systematic literature review and scientometric analysis to comprehensively understand circular procurement assessment methods in the built environment. Scientometric analysis was used to analyse the research patterns and trends quantitatively. A total of 146 research papers were retrieved from the Scopus database. VOSviewer was used to visualise relationships in the research. The results revealed the most prominent keywords: circular economy, life cycle, and sustainable development. The results reveal that few studies focus on circular procurement assessment methods in the built environment. The findings highlight the research gap in circular procurement assessment methods between the global north and the global south. This study significantly contributes to circular procurement assessment methods for decision-making in the built environment. Future research collaboration between scholars and institutions from the global north and the global south is encouraged for enhanced research in sustainable development.



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**Keywords:** circular procurement; assessment methods; built environment; systematic review; scientometric analysis; VOSviewer

## 1. Introduction

Circular economy and circular procurement research have increasingly gained traction with academics, industry, and policymakers. This is because of its importance in addressing global climate change challenges [1,2]. A circular economy maintains the value of products, materials, and resources by closing loops and minimising waste generation [3]. Studies [4,5] have explored the role and potential of public procurement to transition to a circular economy due to its ability to contribute to solving environmental, societal, and economic challenges sustainably. Globally, the construction industry consumes about 3 billion tonnes of raw materials annually due to its linear economic model characterised by a “take, make, dispose” approach [6]. Statistics show that the industry is responsible for 40% of global raw materials, which makes the construction sector crucial to the circular economy for environmental and economic sustainability [7]. In the UK, studies [8] suggest that the construction industry accounts for 40% of raw materials, while in the

Netherlands, the construction sector alone accounts for about 50% of the country's raw materials consumption, with many construction demolitions [9]. In Italy, the construction sector is responsible for 50% of material extraction and 37.5% of total waste production [10]. These figures highlight the need for sustainable practices in the construction industry to focus on circular strategies that promote reducing waste, reusing materials, and improving resource efficiency to minimise environmental impact.

Addressing waste in the built environment requires circular procurement strategies that harmonise metrics, definitions, and targets [5,11] to provide a unified understanding of progress towards sustainable development [12,13]. Despite the amount of materials the construction industry consumes, and the waste production from construction activities [14,15], limited studies have been conducted on circular procurement assessment methods for decision-making in the built environment [16,17]. Studies [18,19] have explored index method indicators used to assess circularity and support circular economy progress. Other studies have highlighted indicators that provide a standardised and quantifiable way to assess the performance of products, systems, or even entire economies regarding their circularity [20,21]. These studies suggest the need to explore circular procurement assessment methods for decision-making at the procurement stage to help achieve circularity, particularly in the built environment. This presents an opportunity to analyse the published literature on circular procurement assessment methods for decision-making. Therefore, the study's twofold objectives are as follows:

1. To review and identify circular procurement assessment methods in the built environment.
2. To present the gaps and provide directions for further research on circular procurement assessment methods for decision-making at the procurement stage in the built environment.

To achieve the objectives of this research, the study adopted a systematic literature review [SLR] to map, using VOSviewer, circular procurement assessment methods research in the built environment by presenting the most impactful authors, influential countries, published papers, and dominating research journals. The study is structured as follows. Section 2 presents the circularity impact of assessment methods for procurement decision-making. A detailed methodology, including the data acquisition and analysis, is discussed in Section 3. The results and discussion are presented in Section 4, while Section 5 presents the study's conclusion.

## 2. Circularity Impact of Assessment Methods for Procurement Decision-Making

Assessment tools for circularity in the built environment lead to a more sustainable and resource-efficient construction industry [16,17]. It enables the tracking and optimising of waste flows and their reduction, and promotes reuse and recycling throughout the built life cycle [22]. This ensures waste tracking and optimisation, which are key components of sustainable development, promoting responsible resource use and minimising environmental impact [23]. Furthermore, assessment tools can predict the environmental consequences of any planned project development by considering all facets of the environment, which is important for environmental protection and economic benefits [24]. Economically, waste reduction and reuse create new jobs and business opportunities in the recycling and waste management sectors [25]. And, environmentally, they help identify and evaluate the potential impacts of projects and policies on the environment [26]. Thus, they allow decision-makers to make informed choices and mitigate consequences [27]. Individual circularity indicators offer a concrete contribution to improving circular decision-making, though there are limits to applying such measurement tools [28]. For example, ref. [29] cites LCA's lack of clear guidelines for accounting for multiple material uses with changing

material qualities when used as a single indicator. As such, it may not be suitable in a specific context, such as the built environment [30].

Assessment methods for procurement decision-making are applied in the procurement evaluation process of submitted bids [31]. In construction procurement, assessment indicators provide bidders with clear and measurable criteria for evaluating circularity [32]. However, evaluation criteria in the solicitation documents must be objective and relevant to the specific services procured. It should stipulate the evaluation criteria to ensure transparency and a fair process, and minimise potential bias [33]. This enables bidders to demonstrate compliance and commitment to sustainable practices [2]. Clarity in circular procurement criteria improves the competitiveness of circular economy solutions. It also provides a level playing field for bidders to demonstrate their commitment to a circular economic approach, thus stimulating demand for sustainable goods and encouraging eco-innovations [34]. Ref. [32] posits that circularity evaluation criteria provide clear and measurable criteria for evaluating the circularity of their products and services, enabling bids to tailor their solutions to meet specific sustainability goals, primarily SDG 12 (responsible consumption and production), which aims to ensure sustainable practices in the production and consumption of goods and services [35].

Implementing a circular strategy at the procurement stage can significantly reduce the extraction of raw materials [29,30]. In addition, it can help reduce supply chain pressures and provide infrastructure without negatively impacting the environment and biodiversity [8]. Hence, circular strategies can help the construction sector reduce its carbon footprint by 34%, 30% by avoiding demolition, and 20% by switching to the most material- and carbon-efficient technological options [36].

### 3. Research Methodology

To map circular procurement assessment methods at the procurement stage in the built environment, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Supplementary Material) were applied to published articles between 1999 and 2025 [37]. The study followed four key steps: Database selection, document identification, selection and inclusion, and data analysis.

#### 3.1. Database Selection

The study utilised the Scopus database to comprehensively evaluate the research output of circular procurement assessment methods. Scopus was used to extract bibliometric information for the research. It is a popular database and a trustworthy source containing peer-reviewed, high-quality journals [38]. The advantage of Scopus over other popular databases, such as Web of Science and Google Scholar, is that a significant portion of the literature available in other databases is also covered by Scopus [39]. Scopus has a high data quality suitable for research evaluation, despite its limited coverage of other scientific knowledge sources, such as books, proceedings, and reports [40]. An important feature of the Scopus database is that it contains other scientometric analysis studies from other disciplines, including science, technology, medicine, social sciences, and humanities. Furthermore, the database allows the application of bibliometric analyses across various research domains [40].

Scientometric analysis was used to analyse scientific research and knowledge production in circular procurement assessment methods. The scientometric analysis assesses the contribution of authors and institutions, including their scientific collaborations, to the broader research domain [41]. This method statistically analyses published research and its impact by examining the quantitative aspects of the scholarly literature, including citations. By quantifying publications, citations, and collaborations, scientometric analysis enhances

visibility, serves as a performance assessment, and drives research quality [42]. VOSviewer is an open-source software tool for creating and visualising bibliometric networks [43]. It was selected to analyse the scientific literature from Scopus to achieve the study's objective. VOSviewer is easily accessible and easy to use. It generates visual representations to show the relationship between terms. Further, VOSviewer can visualise research trends, identify keyword co-occurrences, and perform cluster analysis to reveal thematic clusters within the research domain. Unlike qualitative review techniques, VOSviewer allows map visualisation to show research areas [43].

### 3.2. Document Identification, Selection, and Inclusion

A literature search focusing on circular procurement assessment methods was performed. The study employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [44] in searching for relevant documents in the Scopus database, as shown in Figure 1. PRISMA is well-known for improving clarity and consistency. It provides a clear method for reviewing literature and helps identify, screen, and select relevant articles thoroughly. PRISMA follows a transparent and structured approach [37].

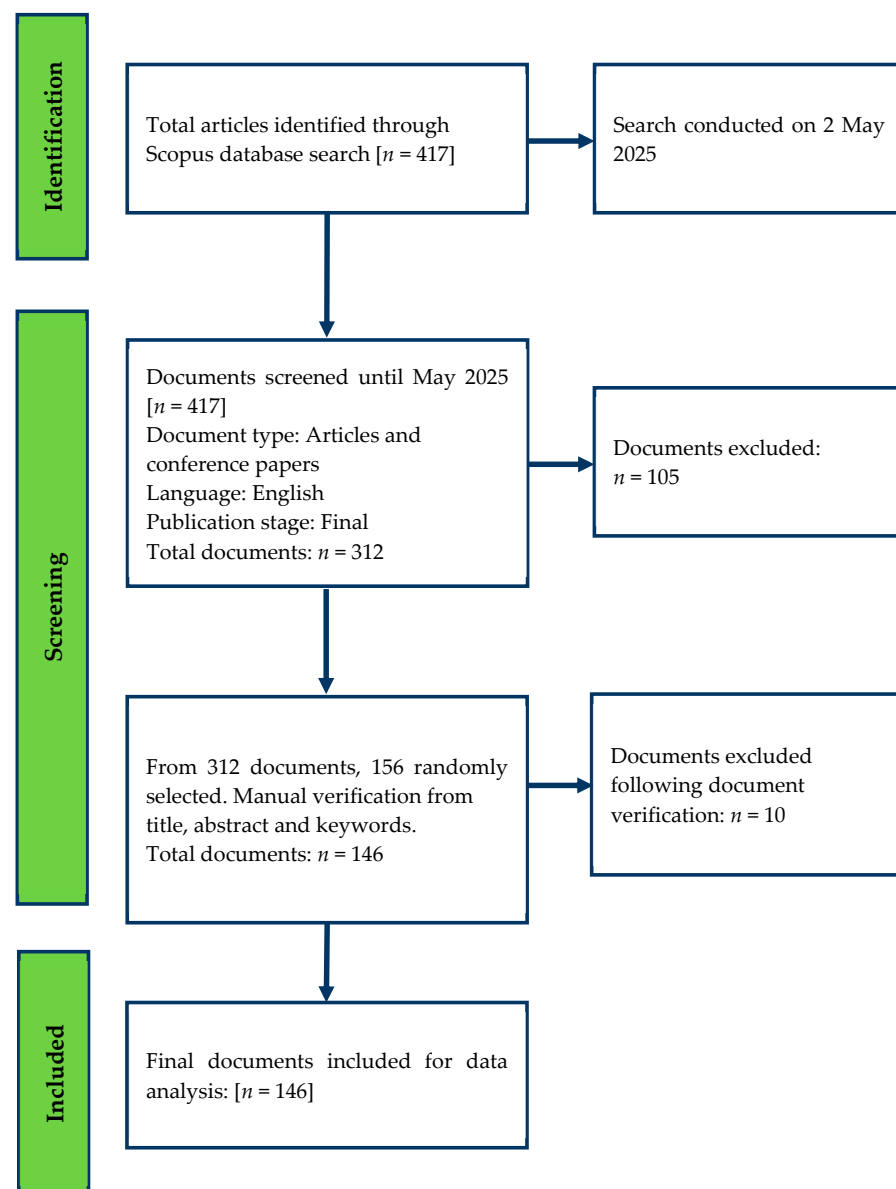


Figure 1. Document identification process for circular procurement assessment methods.

The search was conducted on the Scopus database using a combination of keywords as follows (TITLE-ABS-KEY (“Circular procurement” OR “Sustainable procurement” OR “Circularity” OR “Circular economy”) AND TITLE-ABS-KEY (“Assessment methods” OR “Evaluation techniques” OR “Measurement procedures”)) AND PUBYEAR > 1998 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “cp”)) AND (LIMIT-TO (PUBSTAGE, “final”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (SRCTYPE, “j”) OR LIMIT-TO (SRCTYPE, “p”)) in the title, abstract or keywords. The Scopus database returned 417 results. The search criteria and exclusion process were as follows: The search was conducted on 2 May 2025. The year was restricted from 1999 to 2025, allowing the inclusion of when formal circular procurement gained traction and the development of the literature in the research domain under review. The search was restricted to the English language and document type (articles and conference papers). A total of 105 documents were excluded. To reduce the subjectivity of manual screening, 50% of the retained publications (312) were selected using a simple random selection method for review [45]. After screening the title and abstract, 10 documents were removed because they did not align with the specific study area or the research theme [46]. The selected articles are those that have a bias towards the built environment. The publishers and journals of 146 documents, with details including keywords, abstracts, authors’ affiliated institutions, and citation counts, were downloaded in CSV for analysis in VOSviewer.

### 3.3. Database Analysis

The SCV file containing data exported from Scopus was analysed using VOSviewer version 1.6.20 [43]. VOSviewer supports collaboration, co-authorship analysis, citation analysis, co-occurrence keyword analysis, document co-citations, and geo-spatial visualisation [47]. Network extraction was conducted by extracting author collaborations, co-citation networks, and keyword co-occurrences to draw maps for visual representation of circular procurement assessment methods. To visualise keyword analysis, keyword networks were generated using VOSviewer to obtain insight into the knowledge structure and analyse the relationships in scholarly articles. Keyword network analysis was used to analyse the topic distribution and identify emerging themes in circular procurement assessment methods from articles [48]. Co-authorship analysis of authors and organisations was conducted to detect and map knowledge in the circular procurement assessment methods research community [47]. Citation analysis created a network of related journal outlets, representing their association [49]. The cluster size was set to a threshold of 10% of the total sample size to ensure representation in the sample. To improve reproducibility of the analysis and achieve a more detailed classification of the network, the resolution parameter was set to the value of 2.00 [50].

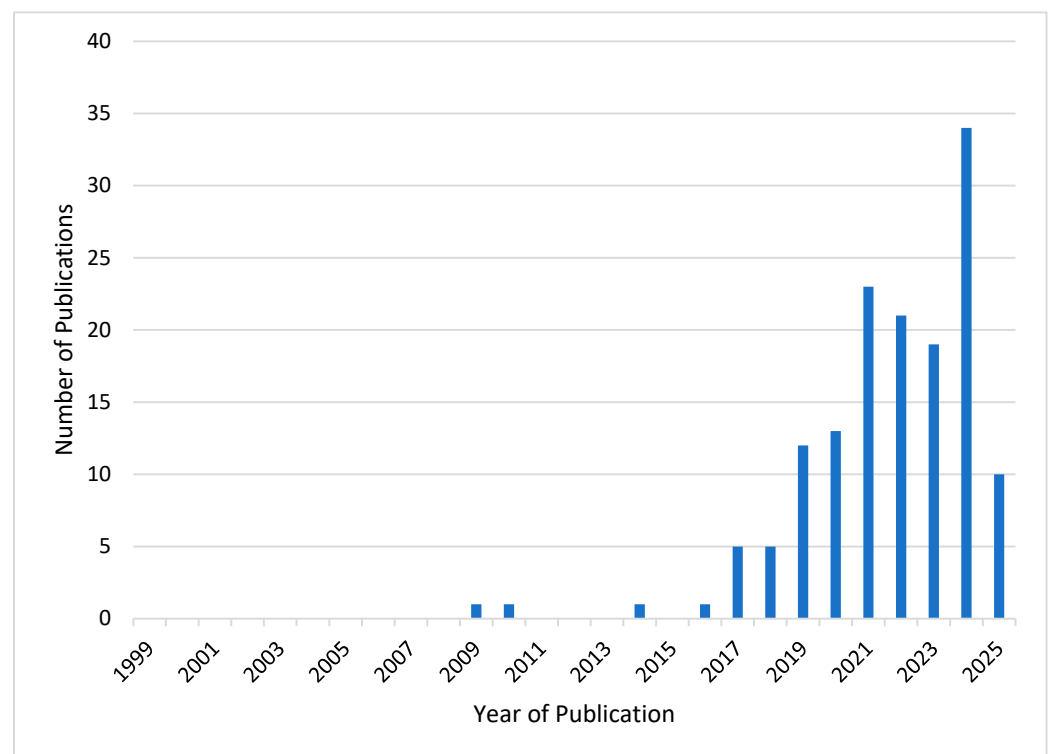
## 4. Results and Discussion

The results aim to provide a synthesis of the review conducted. The distribution of publications, trends, authorship, productive journals, and most cited research articles from the review was established. Further, circularity assessment methods and areas for future research are identified. The analysis in the subsequent sections of this review addresses the following research questions:

1. What assessment methods are employed to measure circular procurement in the built environment?
2. What is the current state of research on circular procurement assessment methods for decision-making at the procurement stage in the built environment?

#### 4.1. Distribution of Circular Procurement and Assessment Method Publications

The distribution of published articles in the analysis period [1999–2025] is illustrated in Figure 2. The analysis of results reveals the publication trends in circular procurement and assessment methods. Figure 2 shows that the first article was published in 2009, co-authored by Shao-Iun Zeng, Hong Hu, and Wei Wang, who are all affiliated with the University of Science and Engineering in China. No paper was published in the following years: 1999–2008. The amount of research on the topic of interest remained low over the following eight years [2009–2016]. From 2017 to 2024, there was a positive increase in published articles from 5 to 34. Though there are various reasons for increased publications, one could be the growing interest in circular procurement strategies and assessment methods to achieve a circular economy.



**Figure 2.** Circular economy assessment method publications per period indexed in Scopus.

Analysis of results in Figure 2 shows that the year with the most published articles was 2024 [ $n = 34$ ], with 24 more research publications than in 2025. This is suggestive of the growing recognition of the potential of circular procurement research to transition to the circular economy and enhance sustainability and resource efficiency. The search in Scopus was conducted in May 2025. A year is usually considered completely indexed in Scopus in June of the following year. Though considered incomplete, data for 2025 are included in the analysis to highlight the degree of progression in circular procurement assessment methods research. As of 23 May, articles were published in 2025, and more research in the field is expected to be released.

#### 4.2. Co-Authorship Analysis

##### 4.2.1. Authors

The top-most productive authors with three or more published research articles on circular procurement assessment methods are presented in Table 1. In addition, the table shows the number of citations for each author. Ulgiat Sergio, of Beijing Normal University, China, published the most studies, with seven research papers. This was followed by

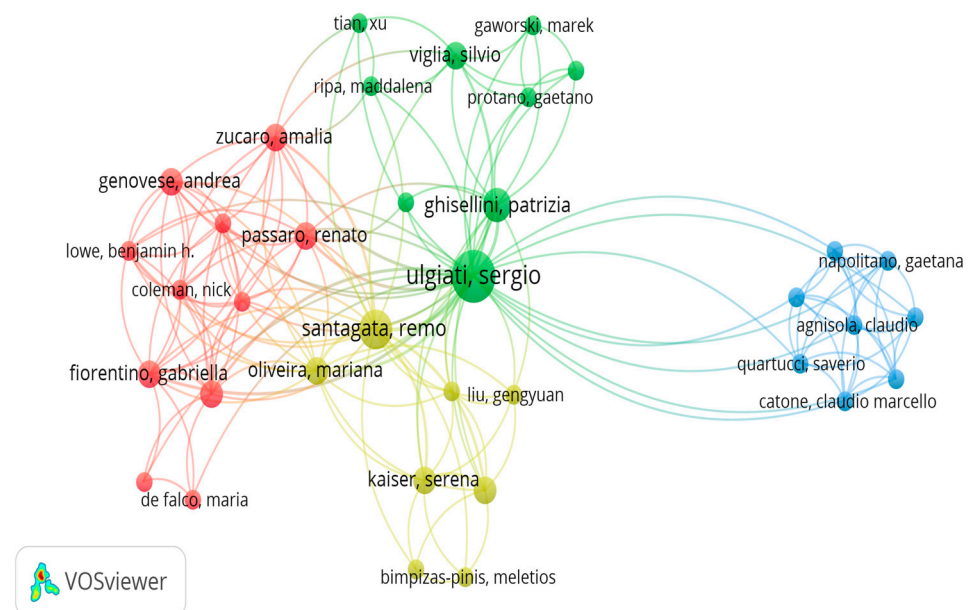
Santagata Remo from Parthenope University of Naples, Italy, with four published articles over the period under research.

**Table 1.** Top 10 most productive authors by documents and citations.

Author	Document	Rank	Author	Citations	Rank
Ulgiati, S.	7	1	Azapagic, A.	401	1
Santagata, R.	4	2	Ulgiati, S.	258	2
Beylot, A.	3	3	Niero, M.	208	3
Ghisellini, P.	3	4	Santagata, R.	186	4
Havukainen, J.	3	5	Van Stijn, A.	179	5
Hellweg, S.	3	6	D'Adamo, I.	149	6
Horttanainen, M.	3	7	Rosa, P.	149	7
Meijer, A.	3	8	Zucaro, A.	146	8
Van Stijn, A.	3	9	Fivet, C.	143	9
Wouterszoon Jansen, B.	3	10	Meijer, A.	133	10

The results show the trend of research among authors in circular procurement assessment methods to transition to a circular economy. In terms of citations, analysis of results in Table 1 shows that Azapagic Adisa of the University of Manchester, United Kingdom, is the most cited author with 401 citations. Surprisingly, it is noted that Azapagic does not appear in the table of authors with the most research publications. However, Ulgiati Sergio, with the most research output, is ranked 2nd with 258 citations. The top three cited authors received 40% of the total citations, which suggests the impact and influence of the authors' published works in the research domain.

Figure 3 visualises the structure and interconnectedness of the most cited authors' network. Analysis of the generated VOSviewer visualisation network shows that the cluster with the highest number of authors is red, with eleven authors. This is followed by the green cluster, which contains nine authors. Ulgati, S., Ghisellini, P., and Zucaro, A., all belonging to cluster colour Green, and Santagata, R. [Yellow] are the core of the most cited authors in circular procurement assessment methods. This suggests strong collaboration between authors based on their publications.



**Figure 3.** Network visualisation of most cited authors in circular procurement methods.

#### 4.2.2. Co-Authorship Analysis of Organisations

The top ten institutions working on the circular procurement assessment methods research area, based on their number of citations, are shown in Table 2. Most of the top ten institutions are from Italy [ $n = 3$ ]. They are followed by two research organisations from the United Kingdom. The findings reveal that Delft University of Technology from the Netherlands is the most productive institution according to citations [ $n = 896$ ] and research quantity [17 documents]. The high number of total link strengths that Delft University of Technology has received [ $n = 59$ ] demonstrates the strong relationship and frequency of the institution's co-authorship with other institutions in circular procurement assessment methods to transition to a circular economy. Ghent University, Belgium, followed this with 437 citations. The University of Birmingham, United Kingdom, is the 3rd most productive institution with 424 citations. The results demonstrate the involvement of organisations from the global north in creating local regenerative solutions aimed at lessening dependence on raw materials, reducing greenhouse gas [GHG] emissions [51], and promoting a low-carbon and resource-efficient society to transition toward regenerative [52].

**Table 2.** Top 10 organisations in circular procurement assessment methods based on documents and citations.

Organisation	Country	Documents	Citations	Total Links
Delft University of Technology	The Netherlands	17	896	59
Ghent University	Belgium	8	437	31
University of Birmingham	United Kingdom	8	424	56
Parthenope University of Napoli	Italy	8	379	19
University of Napoli Federico II	Italy	7	374	38
CNRS Centre National de la Recherche Scientifique	France	11	293	35
Beijing Normal University	China	6	222	26
Parthenope University of Naples	Italy	9	189	30
Brunel University London	United Kingdom	7	166	13
Universitat Autònoma de Barcelona	Spain	5	57	35

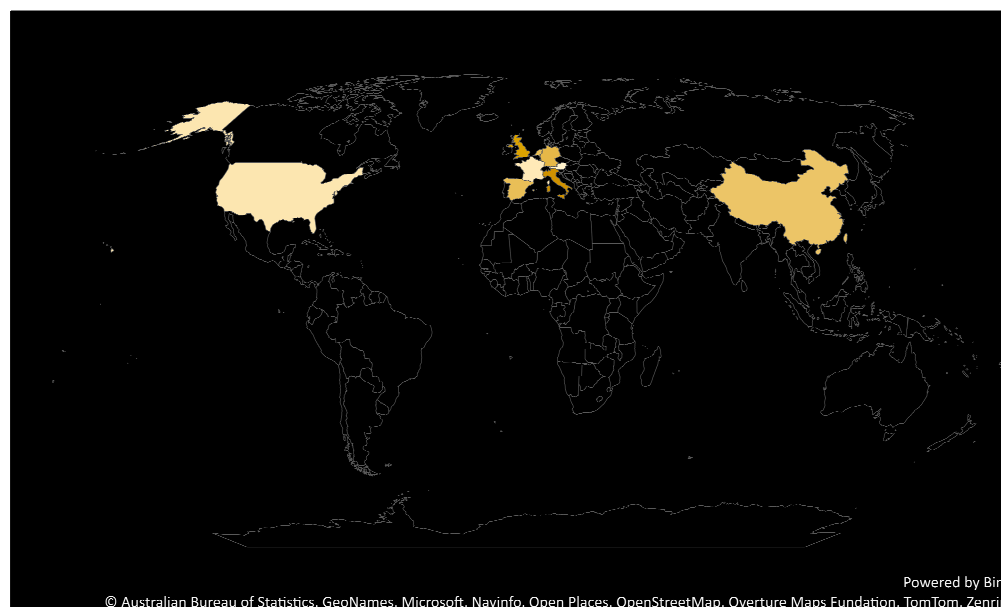
#### 4.2.3. Countries' Research on Sustainable Public Procurement and Circular Economy

Table 3 shows the list of top active countries in the circular procurement assessment methods domain based on the number of research publications, total citations, average citations per year, and the total link strength. Italy has the highest number of citations [ $n = 1955$ ] and total link strengths [ $n = 39$ ]. The results suggest Italy's research impact and collaborations in the research domain are under review. Globally, Italy is recognised for circular procurement research, particularly in implementing circular economy principles [53]. The results show that the top three cited countries account for 54% of the total link strength. This demonstrates the strong relationship and co-authorship of researchers in Italy, the United Kingdom, and the Netherlands with other researchers in the circular procurement domain. This could be attributed to the global north's great research capacity to invest in research and implement circular procurement strategies [54], the necessity to transition to a circular economy due to resource scarcity, and the need for sustainable development models [55] and proactive government policies to promote and implement circular economy principles in these countries [56]. Analysis of results shows that China is the only country in the global south that makes the list of the top ten most productive countries, with 834 citations. China's lead in sustainable public procurement and circular economy in the global south is attributed to China's agenda to address environmental degradation associated with the rapid economic development and eco-industrial initiative taken in China [57].

**Table 3.** Top 10 Countries' research origins on circular procurement and circular economy.

Country	Global Classification	Documents	Citations	Average Citations	Total Link Strength
Italy	Global north	44	1955	44	39
United Kingdom	Global north	39	1272	33	23
The Netherlands	Global north	30	1060	35	12
Germany	Global north	32	925	29	14
Spain	Global north	30	870	29	20
China	Global south	28	834	30	10
United States	Global north	18	579	32	4
Austria	Global north	14	405	29	6
France	Global north	17	357	21	8
Switzerland	Global north	14	342	24	2

The geographical distribution of published research on circular procurement assessment methods among the countries by region is depicted in Figure 4. Research in circular procurement assessment methods is concentrated in the global north (color cluster gold), suggesting a weaker effort to adequately address the impact of circular procurement assessment methods in addressing circular economy initiatives in the global south (grey/black). No research publication was from Africa in the research domain for the period under review. The results suggest a lack of skills and technology required to drive sustainable circular economy research in Africa [58] and a lack of specific regulatory policies to transition to a circular economy [59]. Further, other factors that contribute to the global research imbalance between the global north and global south are driven by structural barriers [60], such as imbalances in research funding, exploitative practices around intellectual property and data ownership, and unequal recognition of contributions and career incentives that disadvantage researchers from the global south [61]. This demonstrates the need for more collaborative research among countries in the global north and global south, particularly African countries, in the field of circular procurement assessment methods in the African context.

**Figure 4.** Country-specific circular economy assessment methods production (authors generated).

### 4.3. Citation Analysis

#### 4.3.1. Top Research Outlets in Circular Procurement Assessment Methods

The study sought to establish the most productive journals in circular procurement assessment methods. Citation analysis identifies top journals in the field under review.

It also explores the linkage between the citing and cited published research papers [62]. Table 4 presents the top ten productive journal sources. The *Journal of Cleaner Production* is the most cited research outlet in circular procurement assessment methods. *Cleaner Production* received 1610 citations and published 20 research articles during the period under review. *Sustainability* [Switzerland] is ranked 2nd with 1578 citations. Analysis of results shows that *Resources, Conservation and Recycling*, ranked third in terms of citations, has the highest CiteScore and impact factor for 2024, as shown in Table 4. This suggests the journal's broader readership and the potential for its articles to contribute significantly to circular procurement assessment methods research. Further analysis of results shows that, in total, 36 per cent of the analysed research publications are concentrated in one journal. Though the findings reveal that research is concentrated in one publication outlet, nine top research outlets represent 64% of the top journals. This demonstrates that other top research journals are beginning to publish research on circular procurement assessment methods.

**Table 4.** The top-most productive journals.

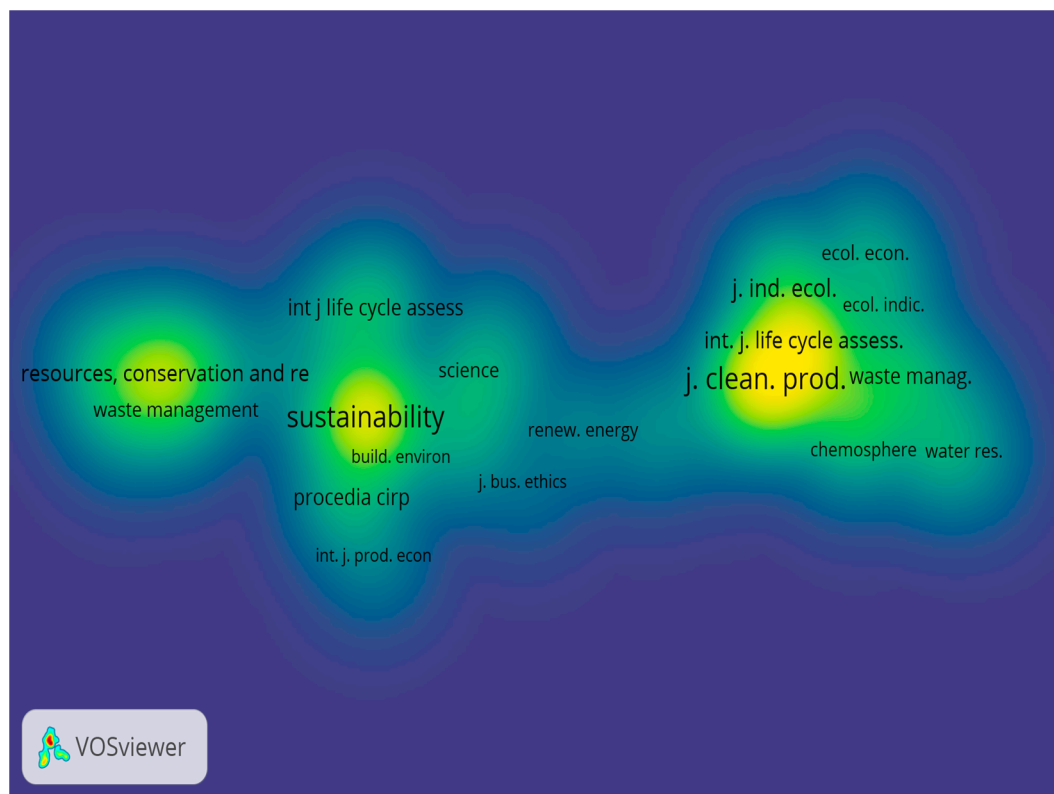
Journal Name	Documents	[%]	Citations	Cite Score 2024	Impact Factor 2024	Rank
<i>Journal of Cleaner Production</i>	20	13	1610	20.7	10.0	1
<i>Sustainability</i>	54	36	1578	7.7	3.3	2
<i>Resources, Conservation and Recycling</i>	18	12	807	24.7	10.9	3
<i>Science of the Total Environment</i>	12	8	788	16.4	8.0	4
<i>Journal of Industrial Ecology</i>	11	7	398	12	5.4	5
<i>Waste Management</i>	9	6	148	15.1	7.1	6
<i>International Journal of Life Cycle Assessment</i>	7	5	114	10.4	5.4	7
<i>Procedia CIRP</i>	7	5	102	3.7	2.28	8
<i>Journal of Environment Management</i>	7	5	312	14.4	8.4	9
<i>Sustainable Production and Consumption</i>	6	4	143	22.5	9.6	10

The visualisation density in Figure 5 shows the distribution of the most productive research sources within the network of journal outlets. They can be identified according to clustering together in the three yellow colours. Journals in the same colour cluster signifies that they are frequently co-cited together by other publications. This indicates that they share a common knowledge base and are part of the same scholarly field or sub-discipline. The core areas of the network among the journal outlets are centred around the *Journal of Cleaner Production*, *Sustainability* [Switzerland], and *Resources, Conservation and Recycling*.

#### 4.3.2. Top Articles on Sustainable Public Procurement and Circular Economy

The top 10 most cited articles are presented in Table 5. The most cited publications were identified and selected based on the times cited from highest to lowest. The analysis of results shows that the most cited research publication on circular procurement assessment methods, "Measuring circular economy strategies through index methods: A circular analysis," received 661 citations. In this work, the authors argue that the state-of-the-art research on circular economy shows that deep research on circular economy assessment and indicators is still lacking, particularly on the micro level. To fill the gap, the authors proposed a reference framework for the monitoring phase of the CE strategy through index methods, highlighting the need for better measurement indicators at the micro level. The second most cited paper is "Life cycle environmental impacts of chemical recycling via pyrolysis of mixed plastic waste in comparison with mechanical recycling and energy recovery", with 361 citations. The authors examined the use of life cycle assessment [LCA] in managing mixed plastic waste through chemical recycling. They found that LCA significantly impacted climate change compared to other established waste management alternatives. The presented methods play a critical role in evaluating circular procurement

by providing a framework for decision-making and impact assessment. This ensures that products and services support circular economy principles.



**Figure 5.** Visualisation density of citations by prominent sources in circular economy assessment methods.

**Table 5.** Top 10 most cited papers on circular procurement and circular economy in 2004–2025.

Article	Citations	References	Journal	Keywords
“Measuring circular economy strategies through index methods: A critical analysis”	661	[17]	Cleaner Production	Assessment; Circular economy; Environmental impact; Index methods; Micro-level
“Life cycle environmental impacts of chemical recycling via pyrolysis of mixed plastic waste in comparison with mechanical recycling and energy recovery”	361	[63]	Science of the Total Environment	Circular economy; Life cycle assessment; Low-density polyethylene; Plastic waste; Pyrolysis; Recycling
“Do circular economy business models capture intended environmental value propositions?”	356	[64]	Cleaner Production	Business model; Circular economy; Environmental impact; Environmental value proposition; Value creation
“Carbon emission reduction in prefabrication construction during materialisation stage: A BIM-based life cycle assessment approach”	215	[11]	Science of the Total Environment	BIM; Carbon emissions; Life cycle assessment; Materialization stage; Prefabrication

Table 5. Cont.

Article	Citations	References	Journal	Keywords
“Coupling material circularity indicators and life cycle-based indicators: A proposal to advance the assessment of circular economy strategies at the product level”	193	[20]	Resource, Conservation and Recycling	Circular economy; Circular indicators; Life cycle assessment; Multi-criteria decision analysis; Packaging; TOPSIS
“Circular economy strategies in eight historic port cities: Criteria and indicators towards a circular city assessment framework”	158	[13]	Sustainability	Built environment; Circular city; Circular economy; Evaluation; Historical cities; Indicators; Port cities; Urban circular economy; Urban metabolisms
“Nutrients recovery from anaerobic digestate of agro-waste: Techno-economic assessment of full-scale applications”	154	[65]	Environmental Management	Anaerobic digestion; Circular economy; Drying; Manure; Membranes; Nutrients; Stripping
“Assessing enablers of e-waste management in circular economy using DEMATEL method: An Indian perspective”	150	[66]	Environmental Science and Pollution Research	Circular economy [CE]; Developing countries; E-waste management [e-WM]; End-of-life [EoL]; MCDM
“Integrating material stock dynamics into economy-wide material flowing accounting: Concepts, modelling and global application for 1900–2050”	148	[21]	Ecological Economics	Circular economy; Dynamic material flow analysis; Economy-wide material flow accounting; Monte-Carlo simulations; Socio-economic metabolism; Uncertainty
“Circular economy research: A bibliometric analysis (2000–2019) and future research insights”	134	[67]	Cleaner Production	Bibliometric metric; Circular economy; Conceptual framework; Literature review; Sustainability

From the research publications in Table 5, three articles discussed circular economy strategies. One assessed the circular economy model in capturing environmental value propositions. The other two discussed the life cycle environmental impacts of recycling, including carbon emission reduction in prefabrication construction. Further, one research publication assessed the enablers of e-waste management in a circular economy. Among the ten articles, only one used a bibliometric analysis. Analysis of results shows that circular procurement assessment methods research uses the life cycle assessment approach. The results in Table 5 show that all the top-cited research publications under review are co-authored. This demonstrates the collaborative efforts occurring among researchers in the field of circular procurement and assessment methods.

#### 4.3.3. Co-Occurring Analysis of Keywords

Keyword co-occurrence analysis was conducted to construct and map knowledge in circular procurement assessment methods. Keyword analysis provides a high degree of revelation into the main research direction in any field. Table 6 presents the top ten keywords from the retrieved documents used by authors in their publication titles, abstracts, and keywords. Circular economy emerges as the prominent authors’ keyword, occurring 199 times. Life cycle assessment occurred in 187 and is ranked second, demonstrating that the research is closely related to these two themes. Notably, “Sustainable development”

[ $n = 148$ ] and “Assessment methods” [ $n = 141$ ] ranked third and fourth, respectively. Analysis of results in Table 6 shows the highest total link strength of the top ten keywords. Life cycle assessment has the highest total link strength of 1451. The circular economy follows this [ $n = 1037$ ]. The occurrence of the top five keywords underscores the attention given to circular procurement assessment concepts in the circular economy context. Notably, keywords such as circular economy, life cycle assessment, sustainable development, and assessment methods have high occurrence and total link strength. It shows the attention these keywords have received in the circular procurement assessment methods research domain. Furthermore, the occurrence figures suggest the targeted assessment approaches in circular procurement to achieve a circular economy.

**Table 6.** Most co-occurrence keywords.

Rank	Keyword	Occurrences	Total Link Strength
1	Circular economy	199	1037
2	Life cycle assessment	187	1451
3	Sustainable development	148	964
4	Assessment method	141	745
5	Environmental impact assessment	99	793
6	Recycling	63	451
7	Waste management	63	479
8	Economic aspect	57	434
9	Climate change	31	247
10	Construction industry	21	128

Figure 6 depicts the network of keyword co-occurrence analysis. The keyword network shows a range of areas researched in the domain and how they are connected. The labels and circles represent the items in the network. The large circles within the diagram denote the more frequent occurrences of the keywords [43]. The connections between nodes illustrate the co-occurrence relationship, highlighting how often specific keywords appear together within the literature [68]. The colours of the circles show the clustering results of related topics, and the circles with the same colours belong to the same cluster [43]. As shown in Figure 6, circular economy assessment methods (green) and life cycle assessment (red) were the keywords that were predominantly used from 2009 to 2025 in the circular procurement assessment methods research domain. Other major visualisation keywords include construction industry and decision-making (yellow), environmental performance and impact assessment (red), and global warming (blue).

#### 4.4. Circularity Assessment Methods for Circular Economy

To manage and achieve circularity, it must be measured [69]. Ref. [70] posit that achieving circularity in the built environment requires a comprehensive and multidimensional approach. Though most approaches to measuring circularity focus on the environmental cycle, more attention to address economic and social approaches is necessary [35]. In decision-making, an index method can facilitate clear communication of circularity performance [17] to procurement policymakers, stakeholders, consumers, investors, and policymakers [71]. Thus, it is unsurprising that the circular economy has received legislative attention mainly in Europe, particularly in the United Kingdom, the Netherlands, and Italy, where CE indicators account for materials without taking the Life Cycle Thinking approach [LCT] [72]. Similarly, a specific set of indicators has been adopted in China to measure the CE strategy, though existing policies focus on broader areas like climate change [73], green economies, and waste management [59]. In contrast, policy approaches for accelerating circular procurement in sub-Saharan Africa are in their infancy. This is despite the potential



perspective [84]. LCA effectively supports environmentally informed decisions in policy-making, product development, and procurement [70]. In addition, life cycle assessments can be applied within supply chain management to provide a clear advantage from an environmental point of view [85]. Though there is no one way of conducting an LCA, it has been used as a single tool or in combination with others. For instance, ref. [76] combined real estate appraisal, economic evaluation of a project's environmental design, LCA, and LCC for developing a decision-making tool to support designers in the construction industry [28].

#### 4.4.2. Circular Procurement Hierarchy

Circular procurement hierarchy is a framework that prioritises waste reduction and resource optimisation in purchasing decisions based on the waste hierarchy [reduce, reuse, recycle, and recover] [15]. It offers a more explicit priority through hierarchy by reducing material input into the economy and the material output or waste, which is key to achieving a sustainable circular economy [86]. Circular procurement hierarchy also helps assess suppliers' capabilities to contribute to a circular economy [32]. However, it is criticised for lacking incentives for following the order of treatment of resources in the waste hierarchy [87], which can lead to less preferred options like energy recovery or disposal being prioritised over more sustainable choices like prevention, reuse, or recycling [86].

#### 4.4.3. Multi-Criteria Decision-Making and Fuzzy Logic

The multi-criteria decision-making [MCDM] approach is applied to evaluate and select the most appropriate options from a set of alternatives within a framework once circularity principles are established [88]. Meanwhile, fuzzy logic is a functional mathematical approach that details imprecise and vague information, such as vulnerability of a system and subjective human language, into precise numerical values, enabling the calculation of risk analysis and a better description of consequences [89]. For instance, imprecision, incomplete data, and reliance on expert opinions with biases to improve decision-making when precise numerical data is unavailable increase risk by hindering accurate risk assessment and leading to flawed decision-making [90].

MCDM and fuzzy methods have often been employed with other approaches to measure circular performances from environmental and economic perspectives. Together, they offer a robust, valuable framework for decision-making problems with uncertain or subjective information [79]. In circular procurement, the MCDM and fuzzy logic combination provides a structured and systematic approach for evaluating multiple conflicting criteria [91], which is essential for making informed choices aligned with sustainability and the circular economy. The framework helps to handle the complexities of circular economy assessments and decision-making, where quantifying the circularity of products or processes can be challenging [16].

#### 4.4.4. Material Circularity Indicator and Material Flow Analysis

According to [32], the material circular indicator [MCI] is a prime example of a tool to gauge circularity [92]. The MCI, developed by the Ellen MacArthur Foundation and Franta Design, indicates how much material a product circulates. It can measure linear and restorative flows, though it does not fully explain the product's sustainability [28]. While material flow analysis [MFA] is described as a mass balance approach that tracks and quantifies the movement of materials within a system [93], it provides complete and consistent information about movements, depletion, and remaining energy reserves and material resources within the relevant system [94]. In addition, MFA can facilitate early recognition of problems such as environmental load and resource depletion [72]. Similarly, by analysing resource flows, the material circular indicator helps identify inefficiencies and areas for improvement, leading to more sustainable practices [95].

## 5. Conclusions

The study examined circular procurement assessment methods to achieve a circular economy in the built environment. The study addresses this by presenting a scientometric analysis of circular procurement assessment methods in research. The findings show that the first article, co-authored by Shao-Iun Zeng, Hong Hu, and Wei Wang, who are all affiliated with Sichuan University of Science and Engineering, China, was published in 2009. The analysis revealed that Ulgiat Sergio of Beijing Normal University, China, is the most productive author. Sergio has seven publications. However, Azapagic Adisa of the University of Manchester received the highest citations [ $n = 401$ ]. Regarding top institutions publishing on circular procurement assessment methods, Delft University of Technology from the Netherlands is the most productive institution with the most citations [ $n = 896$ ]. Italy leads with three of the top ten institutions producing works on circular procurement assessment methods. The *Journal of Cleaner Production* is the most cited article on circular procurement assessment methods, as revealed by the research findings.

Circular procurement assessment methods research is advancing in the global north and, partly, in the global south, with China as the lead. However, Africa, particularly sub-Saharan Africa, is lagging. The study established that no author, institution, or country in the global south, except for China, contributed to the publications under review. Further, the results show no collaboration between the researchers in the global north and the global south on circular procurement assessment methods research, particularly in sub-Saharan Africa, despite the benefits of circular economy assessment methods research for policy and practice. After analysing the assessment methods employed to measure circularity and achieve a circular economy, the study established the various assessment methods employed to measure circularity and achieve a circular economy. The study established that most published research focuses on agriculture, manufacturing, food, and textile industries. This demonstrates the need for more integrated assessment methods for circular procurement in the built environment to capture the full scope of circularity and guide decision-making for sustainable construction.

Finally, the results reveal that several assessment tools are used to measure circularity. The findings show that life cycle assessment is the most used single tool, and it is placed in combination with other methods to evaluate the environmental impact of a product, process, or system. The results show that assessment methods help decision-makers prioritise resource use in the built environment to minimise environmental impact through the project life cycle. The study established that different assessment methods are employed to assess circularity and that a review of the literature shows that previous authors have proposed frameworks for specific areas of assessment and evaluations. However, no agreed assessment methods framework is designed to help decision-making in circular procurement in the built environment. The study findings are useful to guide further research on a framework for assessment methods to be employed in decision-making for circular procurement in the built environment, particularly for the growing economies of the global south and African countries.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su17219409/s1>, Table S1: PRISMA 2020 Checklist. Reference [96] is cited in the Supplementary Material.

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