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Sustainable Cities and Communities: Bibliometric Analysis of Research Trends and Scholarly Networks

Cornelia Ayu Purwandari[1,2], Edi Purwanto[1], Cynthia Sari Dewi[1,2], and Syifa Hanifa Salsabil[1,2]
[1] Deparment of Management, Universitas Pembangunan Jaya, 15413 South Tangerang, Indonesia
[2] Center for Urban Studies, Universitas Pembangunan Jaya, 15413 South Tangerang, Indonesia
cornelia.purwandari@gmail.com

ABSTRACT
This study presents a comprehensive bibliometric analysis of research trends, collaboration networks, and thematic developments within *Sustainable Cities and Communities*, aligning with Sustainable Development Goal 11 (SDG 11). Using the Scopus database, 107 relevant documents published between 1998 and 2024 were analyzed to identify patterns in scholarly output, publication types, influential sources, and international co-authorship. VOSviewer software was employed to generate visualizations, including co-authorship by country, keyword co-occurrence networks, temporal evolution, and density mapping of research focus areas. The findings reveal a significant increase in publication activity post-2015, following the global adoption of the 2030 Agenda. The United Kingdom, Netherlands, and Italy emerged as key contributors to international research collaborations. Thematic clusters primarily revolve around urban planning, sustainability frameworks, climate change, and SDG monitoring. Recent trends show a growing emphasis on climate adaptation and community engagement in urban sustainability. This study provides a structured overview of the intellectual landscape in sustainable urban development and highlights emerging research priorities. The insights can support scholars, policymakers, and practitioners in understanding the field's evolution and identify future directions for interdisciplinary and policy-relevant research.

Keywords:
Bibliometric Analysis, Research Trends, Sustainable Cities and Communities

INTRODUCTION

The concept of sustainable urban development has gained substantial global attention in recent decades as cities face increasing challenges related to rapid urbanization, climate change, and social inequality. According to the United Nations, more than 56% of the world's population currently resides in urban areas, and this proportion is expected to rise to nearly 70% by 2050 (United Nations, 2018). In response to these trends, the United Nations adopted the 2030 Agenda for Sustainable Development, with Sustainable Development Goal 11 (SDG 11) specifically aimed at making cities and human settlements inclusive, safe, resilient, and sustainable (United Nations, 2015). The growing relevance of SDG 11 has sparked a surge in scholarly research across multiple disciplines, including urban planning, environmental science, public policy, and community development.

This interdisciplinary growth has created a diverse and complex body of literature, making it increasingly necessary to analyze the evolving structure of knowledge production in this domain. Bibliometric analysis offers a powerful method for systematically mapping research trends, identifying influential publications, and visualizing scholarly collaboration and thematic focus areas (Donthu et al., 2021). By utilizing bibliometric tools such as VOSviewer, scholars can explore the dynamics of co-authorship networks, keyword co-occurrence, and citation patterns, enabling a more comprehensive understanding of how the field develops over time (van Eck &

Waltman, 2010). Despite the importance of sustainable cities as a global priority, a consolidated bibliometric overview of this research area remains limited.

This study addresses this gap by conducting a bibliometric analysis of the scholarly literature on "Sustainable Cities and Communities," focusing on publication trends, document types, research hotspots, and international collaborations. Using data from the Scopus database between 1998 and 2024, this research maps the intellectual landscape of SDG 11-related studies. The findings are expected to inform future research directions, enhance policy formulation, and strengthen interdisciplinary dialogue around urban sustainability.

METHOD

This study adopts a bibliometric approach to examine scholarly trends, research focus areas, and collaboration patterns related to the theme *of Sustainable Cities and Communities*. The analysis followed a structured six-step framework (Figure 1), beginning with the definition of the core keyword—"Sustainable Cities and Communities"—which aligns with the United Nations' Sustainable Development Goal 11 (SDG 11). The Scopus database was selected as the primary source for data collection due to its comprehensive indexing of peer-reviewed literature. A total of 111 documents were initially retrieved, covering the period from 1998 to 2024. After applying inclusion criteria and refining the dataset, 107 relevant documents were selected for further analysis.

Bibliometric indicators such as publication year, document type, source title, subject area, author affiliation, and country were examined to identify trends and patterns (Purwanto & Irawan, 2023). VOSviewer software (version 1.6.19) was used to generate visualizations, including co-authorship networks, keyword co-occurrence maps, and temporal overlays. These visual tools enabled a deeper exploration of scholarly interconnections and thematic evolution in the field. The combination of quantitative metrics and visual mapping provides a robust methodology for understanding the structure and dynamics of research on sustainable urban development.

Table 1. Documents by Type

Documents	Type
Article	36
Book Chapter	27
Conference Paper	25
Review	3
Book	9
Conference Review	71
Editorial	56

Table 1 provides a detailed breakdown of the types of documents retrieved from the Scopus database as part of the bibliometric analysis on "Sustainable Cities and Communities." The distribution highlights the diversity of publication formats contributing to the scholarly discourse in this domain. The most prevalent document type is conference review, with 71 documents in total, reflecting the strong presence of conference-based knowledge dissemination within this field. This suggests that sustainable cities research is frequently presented at academic and professional gatherings, allowing for the real-time exchange of ideas and emerging practices. Editorials are the second most common type, totaling 56 documents. Their

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prominence indicates an active editorial engagement with sustainability topics, potentially offering expert opinions, thematic introductions, and policy-oriented commentary within journals. Articles constitute 36 documents, representing the core body of peer-reviewed empirical and theoretical research. These are essential for advancing academic knowledge and are often the most cited and rigorously evaluated contributions. Following this, book chapters (27) and conference papers (25) comprise a significant portion of the literature. Book chapters often provide in-depth, conceptual insights or case studies, while conference papers reflect ongoing research developments that may later evolve into full journal articles. A smaller proportion of the dataset includes books (9), reviews (3), and other materials. Books offer comprehensive treatment of sustainability themes, while reviews synthesize existing knowledge and identify research gaps—though their lower count suggests room for more integrative studies in this field.

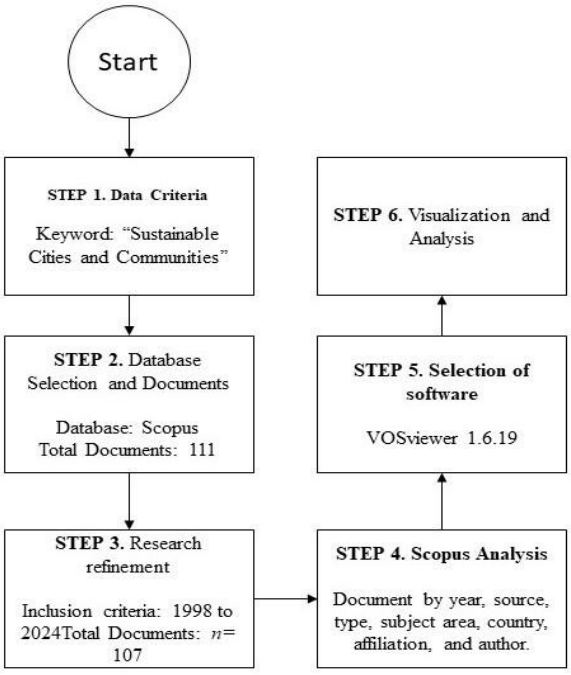

Figure 1. Methodological Framework for Bibliometric Analysis on Sustainable Cities and Communities

Figure 1 presents a step-by-step methodological framework for conducting a bibliometric analysis using "Sustainable Cities and Communities" as the central research focus. This structured approach ensures rigor and reproducibility, guiding the study from data identification to analytical interpretation. The figure encapsulates six sequential steps, each contributing to a comprehensive and systematic literature mapping.

Step 1: Data Criteria. The process begins with defining the core keyword—"Sustainable Cities and Communities"—which anchors the entire bibliometric search. This term directly corresponds to Sustainable Development Goal 11 (SDG 11), reflecting the global emphasis on creating inclusive, safe, resilient, and sustainable urban spaces. Choosing a specific and policy-relevant keyword ensures the thematic

consistency of the retrieved literature and aligns the study with internationally recognized research priorities (Pitaloka et al., 2024).

Step 2: Database Selection and Document Retrieval. The Scopus database was selected as the source of bibliographic data, yielding a total of 111 documents. Scopus is one of the most comprehensive and widely used scientific databases, offering reliable metadata across diverse disciplines (Purwanto et al., 2025). The choice of Scopus guarantees high data quality, facilitates advanced filtering, and supports standardized bibliometric analysis (Purwanto, Uddin, et al., 2024).

Step 3: Research Refinement. To ensure relevance and accuracy, the documents underwent a refinement process based on inclusion criteria (Suyoto et al., 2024). The analysis included publications from 1998 to 2024, ultimately narrowing the dataset to 107 documents. This filtering phase likely excluded duplicates, irrelevant articles, or those not meeting predefined criteria (e.g., language, accessibility, or thematic alignment), enhancing the robustness of the dataset (Dwianika et al., 2024).

Step 4: Scopus Analysis. In this step, the refined dataset was systematically analyzed based on multiple bibliometric parameters: publication year, source title, document type, subject area, author affiliations, and country of origin (Purwanto, Nugraha, et al., 2024). This multidimensional analysis enables the identification of trends, patterns, and gaps in the scholarly landscape. It also lays the foundation for more advanced mapping, such as co-authorship networks, keyword co-occurrence, and citation analysis (Purwanto, Iskandar, et al., 2024).

Step 5: Software Selection. The software VOSviewer (version 1.6.19) was selected for visualization and network analysis. VOSviewer is a powerful tool for constructing and exploring bibliometric maps based on co-authorship, co-citation, and keyword co-occurrence data. Its ability to generate visually intuitive network graphs enhances the interpretability of complex bibliometric relationships (Purwanto, Tafridj, et al., 2024).

Step 6: Visualization and Analysis. The final step involves visualizing and interpreting the bibliometric data. The analysis reveals thematic concentrations, research trends, collaboration patterns, and emerging areas of interest through network maps, density visualizations, and temporal overlays. These visual insights support evidence-based conclusions and inform future research directions within sustainable urban development (Purwanto et al., 2025).

So, Figure 1 provides a clear and methodologically sound bibliometric study roadmap. Integrating keyword-based search, refined data collection, multidimensional analysis, and advanced visualization tools ensures a holistic understanding of the research landscape surrounding “Sustainable Cities and Communities.” This framework enhances transparency and replicability and is a practical guide for scholars conducting similar studies in sustainability and urban development.

RESULTS AND DISCUSSION

1. Publication Trends in Sustainable Cities and Communities

Figure 2 illustrates the temporal distribution of publications related to “Sustainable Cities and Communities” from 1998 to 2024, based on Scopus-indexed documents. The chart reveals a striking evolution in scholarly attention to this theme, highlighting a relatively dormant period followed by exponential growth in recent years.

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From 1998 to approximately 2014, the number of publications remained consistently low, generally between 0 and 2 documents per year. This trend suggests that the topic had limited visibility or was still emerging within academic discourse during this period. The lack of significant growth could be attributed to the absence of a unified global policy framework such as the United Nations' Sustainable Development Goals (SDGs), which were not adopted until 2015. A modest uptick begins around 2015–2016, which coincides directly with the launch of the 2030 Agenda for Sustainable Development by the United Nations and the formal introduction of SDG 11: "Sustainable Cities and Communities." This policy milestone likely catalyzed increased scholarly interest, funding availability, and international collaboration on urban sustainability issues.

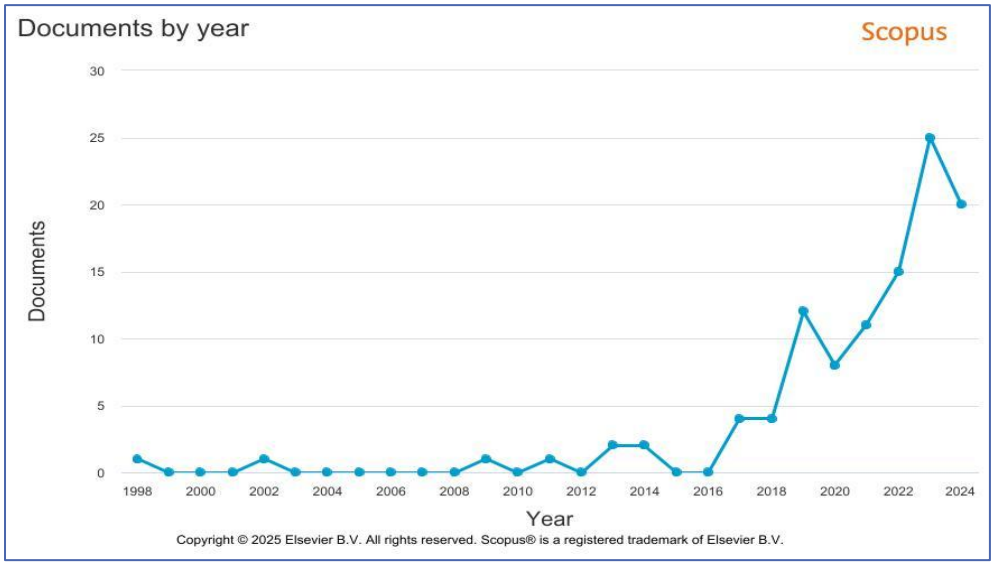

Figure 2. Publication Trends in Sustainable Cities and Communities

The growth becomes markedly pronounced from 2018 onwards, with a sharp and sustained increase in document output. The publication count jumps from fewer than 10 documents in 2017 to over 25 in 2023, indicating more than a fivefold increase within six years. This surge reflects the field's rapid development as an interdisciplinary research area, encompassing urban planning, climate resilience, public policy, environmental science, and community development. The peak observed in 2023 represents the highest level of academic output within the period, likely driven by a combination of factors: increasing climate urgency, urbanization challenges, enhanced global cooperation, and an influx of sustainability-related research funding. While notable, the slight decline in 2024 may be attributed to partial data availability or publication lag, as not all documents for that year may have been indexed at the time of analysis.

This trend line highlights sustainable urban development's growing academic and policy relevance. It mirrors the concept's evolution from a niche research interest to a mainstream, multidisciplinary priority with global significance. The sustained upward trajectory also points to a maturing research ecosystem where new methodologies, technologies, and cross-sectoral insights continuously shape the knowledge base. Figure 2 demonstrates that scholarly attention to sustainable cities and communities

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has expanded dramatically since 2015, with notable acceleration in the post-2020 period. This reflects the field's alignment with global sustainability goals, increasing urbanization pressures, and the academic community's recognition of cities as critical sites for transformative environmental and social change. The trend also indicates a fertile landscape for future research, policy innovation, and interdisciplinary collaboration.

2. Bibliographic Coupling Network of the Sustainable Cities and Communities

Figure 3 presents the annual publication trends from 2018 to 2024 across six Scopus-indexed sources related to sustainable cities and communities. These sources include journals and conference proceedings on environmental science, urban sustainability, and energy transitions. The data reveal a dynamic and evolving research landscape, with variations in document output reflecting broader shifts in scholarly interest, publication venues, and global sustainability agendas.

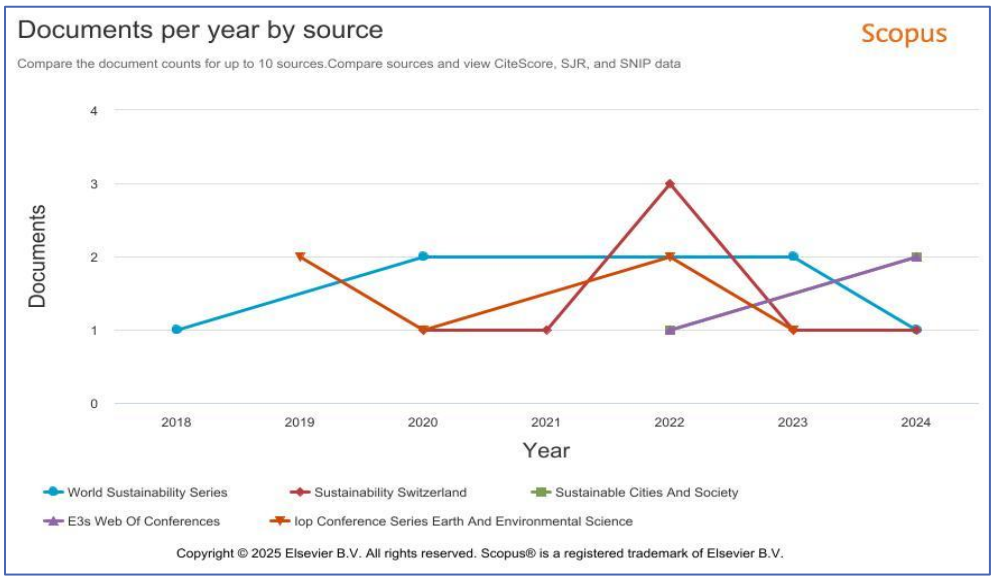

Figure 3. Bibliographic Coupling Network of the Sustainable Cities and Communities Research Journals

The *World Sustainability Series* shows a steady growth pattern, beginning with one publication in 2018 and maintaining a consistent output of two documents annually from 2020 to 2023. This trend indicates a sustained scholarly interest in broad sustainability themes within this series. In contrast, *Sustainability Switzerland* exhibits a more volatile trajectory. It reached a notable peak of three publications in 2022—the highest single-source contribution within the figure—before experiencing a significant decline to just one document in 2023 and 2024. This fluctuation may be attributed to changes in editorial focus, author preferences, or competition from alternative publication venues.

The journal *Sustainable Cities and Society* maintains a relatively stable contribution throughout the period, consistently publishing between one and two documents annually. This pattern underscores its ongoing relevance to urban sustainability research and its alignment with Sustainable Development Goal (SDG) 11, which advocates for inclusive, safe, resilient, and sustainable cities. The *E3S Web of Conferences* displays an intermittent publication pattern, with peaks in 2019 and 2021

but limited output in other years. As a conference-based outlet, its variability reflects relevant events' timing and thematic focus.

Interestingly, the *IOP Conference Series: Earth and Environmental Science* shows a marked increase in publications in 2023 and 2024. This upward trend signals its emerging importance as a platform for disseminating interdisciplinary research findings, particularly those addressing the practical challenges of environmental sustainability in urban contexts. Similarly, the *Top Conference Series: Earth and Environmental Science* appears only from 2021 onward, suggesting it is a relatively new or newly indexed venue gradually gaining traction.

A comparative view of the data highlights 2022 as a particularly active year, driven primarily by the surge in publications from *Sustainability Switzerland*. This may reflect heightened global interest in sustainability following the COVID-19 pandemic and major international policy events such as COP26. The period from 2023 to 2024 demonstrates a shift in publication patterns, with an increasing proportion of contributions emerging from conference proceedings rather than traditional journals. This suggests a growing preference for venues that offer more immediate dissemination and engagement with applied research topics.

The figure illustrates a diverse and decentralized scholarly ecosystem where no single source dominates throughout the observed period. This diversity underscores the interdisciplinary nature of sustainable cities research and points to a need for strategic publishing approaches. While high-impact journals like *Sustainability Switzerland* remain influential, venues such as *Sustainable Cities and Society* offer a more stable and consistent platform for long-term engagement. Meanwhile, the rise of conference series as key outlets highlights the importance of timely, policy-relevant discussions in shaping the research agenda. The evolving distribution of publications across these sources reflects the field's maturity and dynamism.

3. Citation Map of Influential Authors and Publications

Table 2 presents the most cited publications in agricultural technology and rural development, sourced from Scopus. The table ranks the top 10 publications based on their citation counts, reflecting their influence and contribution to the academic discourse in this field. The citations range from 128 to 25, highlighting the varying degrees of impact these studies have had on subsequent research.

Table 2 Top 10 publications on Agricultural Technology and Rural Development with the highest citations in Scopus

No	Author/ References	Year	Citations
1	(Macke et al., 2019) (Macke et al., 2019)	2019	128
2	(Wątróbski et al., 2022) (Wątróbski et al., 2022)	2022	98
3	(Anthony, 2024) (Anthony, 2024)	2024	62
4	(Pittman et al., 2019) (Pittman et al., 2019)	2019	50
5	(Ismagiloiva et al., 2019) (Ismagiloiva et al., 2019)	2019	50
6	(Beilin & Hunter, 2011) (Beilin & Hunter, 2011)	2011	49
7	(Beck et al., 2023) (Beck et al., 2023)	2023	37
8	(MacDonald et al., 2020) (MacDonald et al., 2020)	2020	30
9	(Stratigea et al., 2017) (Stratigea et al., 2017)	2017	27
10	(Devisscher et al., 2019) (Devisscher et al., 2019)		25

Source: Scopus Analyze

The high-impact publications, particularly those at the top of the list, demonstrate their strong academic influence. Macke et al. (Macke et al., 2019) lead with 128 citations, making it the most influential work in this category. The high citation count suggests that this study provides foundational knowledge or presents a widely applicable framework within agricultural technology and sustainable rural development. The second most-cited publication, Wątróbski et al. (Wątróbski et al., 2022), has 98 citations. Given its recent publication year, its relatively high citation count indicates its rapid academic adoption, likely due to its relevance to current technological advancements or policy implications. The third-ranked paper, authored by Anthony (Anthony, 2024), has 62 citations, which is impressive given that it was published in the current year. This suggests an exceptional early impact, possibly due to addressing an emerging trend or filling a significant research gap in agricultural technology.

The middle-ranking publications in positions four through seven maintain a moderate citation impact. Pittman et al. (Pittman et al., 2019) and Ismagiloiva et al. (Ismagiloiva et al., 2019) received 50 citations, indicating their comparable influence in the domain. Beilin & Hunter (Beilin & Hunter, 2011), with 49 citations, represents an older but still relevant contribution, possibly serving as an early theoretical or conceptual framework for subsequent research. Beck et al. (Beck et al., 2023), with 37 citations, indicates growing recognition within the academic community, likely focusing on more contemporary or emerging areas of agricultural technology.

The publications ranking between eighth and tenth place exhibit lower citation counts, ranging from 30 to 25. The studies by MacDonald et al. (MacDonald et al., 2020), Stratigea et al. (Stratigea et al., 2017), and Devisscher et al. (Devisscher et al., 2019) represent research that is either more specialized or has been recently gaining traction. The lower citation count does not necessarily imply lower quality. Still, he may indicate that these papers target niche aspects of agricultural technology that have not yet reached widespread adoption in research.

A key insight from the data is the dominance of recent publications (2019-2024), suggesting that agricultural technology and rural development is an evolving field with increasing academic interest. Older studies (e.g., 2011 and 2017) highlight foundational works that continue to shape contemporary research. Additionally, the wide citation range (128 to 25) reflects diverse research focuses, with some papers gaining broader attention due to policy implications, technological advancements, or methodological innovations.

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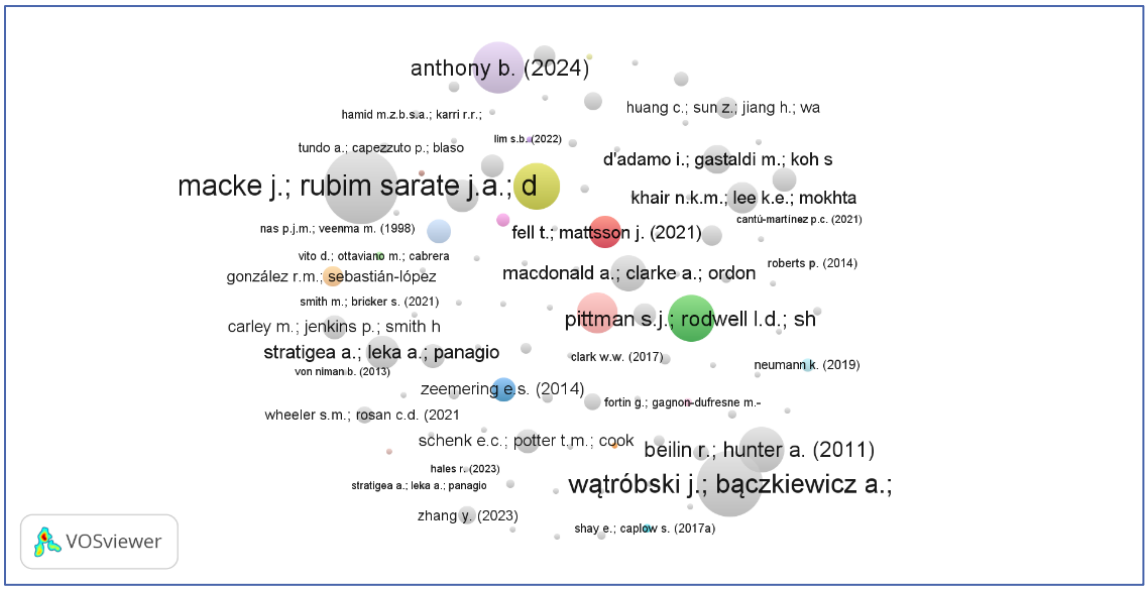

Figure 4. Citation Map of Influential Authors and Publications

Figure 4 visually represents the citation network among key publications and authors in agricultural technology and rural development. It provides a network-based view of how influential studies are interconnected through citations and co-citations. The citation map reveals that specific authors, such as Macke et al. (Macke et al., 2019) and Wątróbski et al. (Wątróbski et al., 2022), appear as significant central nodes, indicating their strong influence in the research landscape. These nodes likely connect to multiple other publications, showing that their work serves as a key reference for subsequent studies.

The map likely groups publications into clusters based on thematic similarities. One cluster may focus on technological advancements in precision farming, smart agriculture, or AI-driven rural development. Another cluster could relate to policy and governance frameworks that impact agricultural sustainability and rural development strategies. A third possible cluster may explore economic aspects, such as financing farm innovation and the role of subsidies in technological adoption.

The density of links between nodes suggests a high degree of interdisciplinary research. Publications at the intersection of multiple clusters indicate cross-disciplinary impact, such as integrating environmental sustainability with digital agriculture. Some nodes are more isolated, which may represent highly specialized studies that, while significant, are not widely cited beyond a specific niche.

A notable trend in the citation network is the emergence of recently published but rapidly cited papers. For example, Anthony (Anthony, 2024) shows strong early influence, suggesting that new research quickly gains attention, possibly due to addressing cutting-edge technological innovations or urgent policy challenges. At the same time, some older, highly cited works still serve as foundational references, showing that while the field rapidly evolves, it continues to build upon established theories and frameworks.

Table 2 provides a quantitative view of the most influential publications in agricultural technology and rural development, illustrating the growth and evolving priorities in the field. Figure 4 offers a network-based perspective, showing how these influential studies interact through citations, co-authorships, and thematic connections.

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Together, these two elements highlight the dynamic and interdisciplinary nature of research in agricultural technology, emphasizing the importance of collaborative knowledge-building, emerging research trends, and foundational academic contributions.

4. Co-authorship Network by Country

Figure 5 illustrates the co-authorship network by country, highlighting the patterns of international collaboration among researchers working on sustainable cities and communities. The visualization presents a clustered network of countries, with each node representing a nation and the connecting lines indicating the presence and strength of co-authorship links. The size of the nodes reflects the number of publications or collaboration frequency, while the colors represent distinct clusters or collaboration groups.

The United Kingdom emerges as the central node in this network, indicating its dominant role in international collaboration within this research domain. It is directly linked with several countries, including the Netherlands, Italy, Canada, and the United States, suggesting that researchers affiliated with institutions in the UK are actively engaged in multi-national projects and frequently co-publish with counterparts abroad. The strong link between the United Kingdom and the Netherlands suggests a high level of bilateral collaboration driven by shared research agendas, funding mechanisms within the European Union framework, or overlapping urban sustainability challenges.

The Netherlands also appears prominently in the network, with fewer outward connections than the UK. Its close ties to the UK reinforce its status as a significant contributor to the field, especially in urban planning, environmental policy, and circular economy research. Similarly, Italy, Canada, and the United States form a secondary hub of collaboration, linking with both the UK and each other. This suggests a transatlantic exchange of knowledge and co-authorships, which likely reflects the global nature of urban sustainability issues and the importance of shared research platforms.

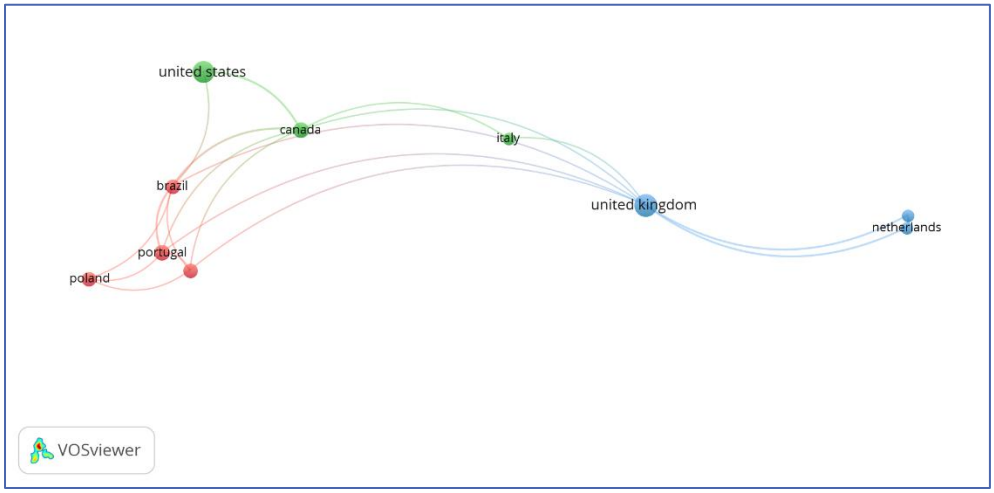

Figure 5. Co-authorship Network by Country

Another distinct cluster is visible among Portugal, Poland, and Brazil, with Portugal bridging Western Europe and Latin America. The co-authorship connections

among these countries reflect strong South-South and South-North academic collaborations. Brazil's involvement in this cluster indicates the country's growing interest and investment in sustainability research, particularly in rapidly urbanizing regions. Meanwhile, Poland and Portugal demonstrate active engagement within the European research space, possibly benefiting from EU-funded collaborative programs such as Horizon Europe.

The United States and Canada are also present in the network, with notable links to European countries and each other, highlighting North America's integral role in contributing to and co-producing knowledge in this field. However, their position in the network's periphery compared to the UK suggests a slightly less central role in cross-national co-authorship, potentially due to a greater focus on domestic research or differences in funding and publication practices.

The color-coded clusters in the visualization reflect natural groupings based on collaborative tendencies. For instance, the red cluster centered around Portugal includes Brazil and Poland, while the green cluster links North American countries with Italy. The blue cluster, featuring the UK and the Netherlands, represents a particularly cohesive and active collaboration region. These clusters reveal geographic proximity, thematic alignment, and shared policy interests.

Figure 5 demonstrates the increasingly international nature of sustainability research and the crucial role of cross-border collaborations in addressing complex urban challenges. The United Kingdom is a pivotal hub in the global co-authorship network, facilitating connections across Europe and beyond. The emergence of collaborative clusters indicates a maturing research ecosystem characterized by regional cooperation, shared goals, and a commitment to addressing global sustainability through interdisciplinary partnerships. Strengthening such international ties will be essential for advancing the agenda of global sustainable cities.

v) Co-occurrence Network of Keywords in Sustainable Cities and Communities Research

Figure 6 presents a network visualization of keyword co-occurrence, offering critical insights into the thematic structure and conceptual linkages within sustainable cities and communities. Each node in the network represents a keyword extracted from the dataset, while the links between nodes indicate the frequency of co-occurrence within the same documents. The size of the nodes reflects the relative frequency of the keyword's appearance, and the colors denote clusters of closely related terms that form thematic groups within the literature.

The term "sustainable cities" appears as the central and most prominent node, signifying its role as the core focus of the research field. It is strongly connected to multiple keywords across different clusters, such as *sustainable development*, *urban planning*, and *sustainable communities*. These linkages suggest that the concept of sustainable cities is deeply embedded in broader sustainability discourse and is often discussed in the context of developmental and urban policy frameworks.

The red cluster primarily revolves around *sustainable cities*, *sustainable development*, *sustainable communities*, *climate change*, and *compact cities*. This grouping focuses on macro-level sustainability issues, emphasizing systemic challenges such as climate adaptation, integrated urban development, and community resilience. The strong connection between *sustainable cities* and *climate change* indicates that urban sustainability research frequently intersects with environmental

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and climate-related concerns, highlighting the importance of cities in global climate mitigation strategies.

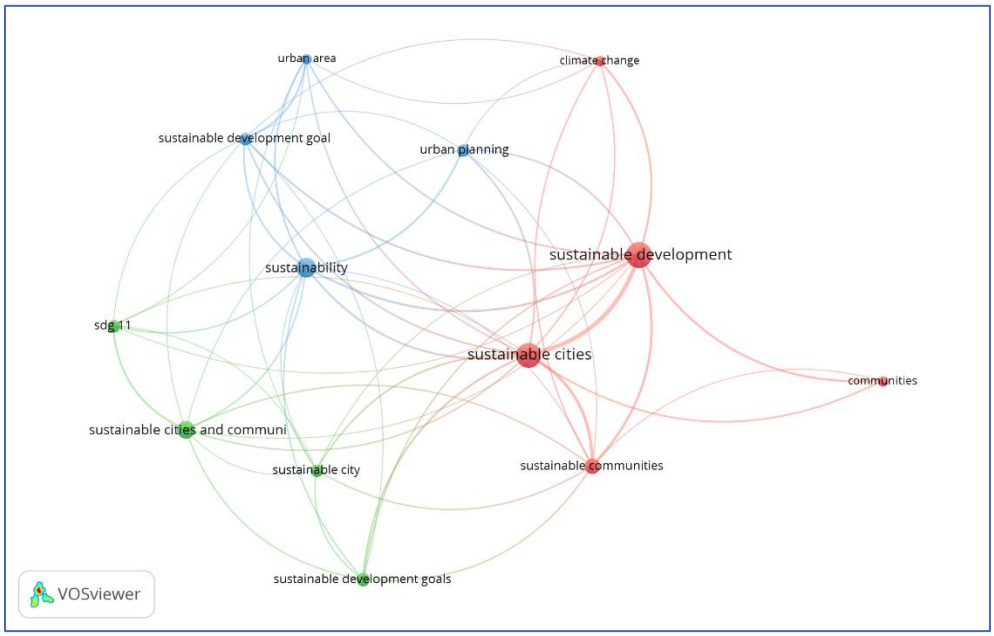

Figure 6. Network Vizualisation Co-occurrence all keyword

The blue cluster includes terms like *urban planning*, *urban area*, *sustainable development goal*, and *urban development*, centering around spatial planning and policy implementation. These keywords point to a sub-theme within the literature that addresses how urban form, governance, and development strategies align with sustainability objectives. The presence of *a sustainable development goal* (in singular) in this cluster links it conceptually to planning efforts directed at achieving specific SDG targets, particularly SDG 11 (Sustainable Cities and Communities).

The green cluster features terms such as *sustainability*, *sustainable city*, *sustainable development goals* (plural), *SDG 11*, and *sustainable cities and communities*. This thematic group focuses more on the normative and goal-oriented aspects of sustainability. The presence of *SDG 11* alongside *sustainability* and *sustainable development goals* suggests that much of the literature emphasizes aligning urban policies and practices with the 2030 Agenda for Sustainable Development. This cluster is more conceptual, reflecting discussions around indicators, frameworks, and progress monitoring.

The interlinkages between the three clusters reveal a well-integrated field where discussions on sustainable development, climate change, urban policy, and SDG alignment are not siloed but interconnected. For instance, the overlap between *sustainable development* (red cluster) and *sustainability* (green cluster) indicates thematic fluidity and shared conceptual foundations across research strands. Similarly, the link between *urban planning* (blue) and *sustainable communities* (red) highlights how social sustainability considerations increasingly inform practical planning approaches.

Figure 7 displays the temporal evolution of keyword co-occurrence within sustainable cities and communities, providing a chronological perspective on the

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thematic development of research from 2021 to 2023. This overlay visualization utilizes a color gradient—ranging from dark blue (older keywords) to bright yellow (recent keywords)—to represent the average publication year associated with each keyword. The network structure and connections remain consistent with the keyword co-occurrence map in Figure 5, but the added temporal dimension reveals shifting research priorities over time.

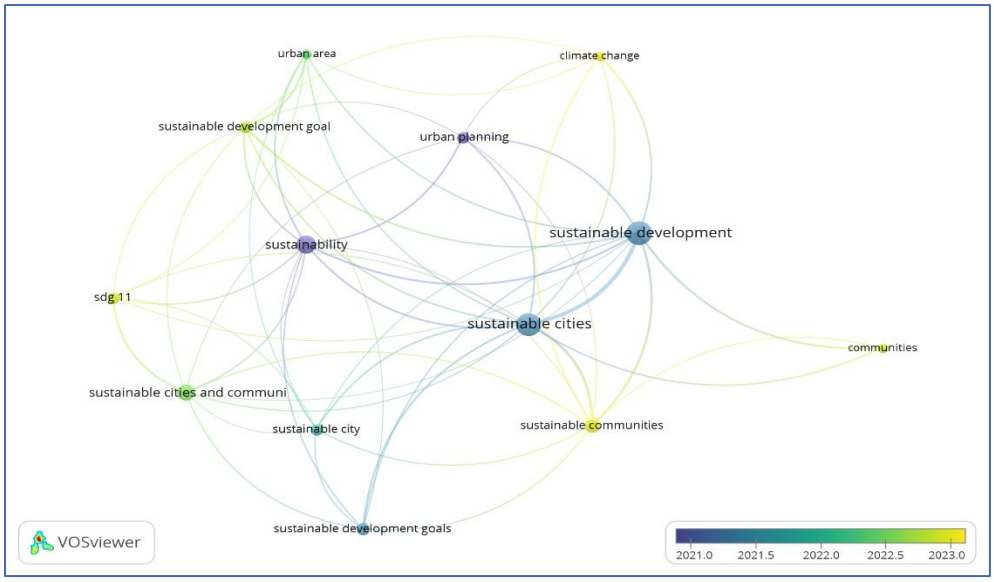

Figure 7. Temporal Evolution of Keyword Co-occurrence

At the center of the map, “sustainable cities” continues to serve as the core term around which the network is organized. It appears in a light green-blue shade, indicating its steady prominence across the examined period, with a particular increase in usage from 2022 onward. Sustainable *development*, *sustainability*, and *urban planning* are closely connected to this core, which also falls within the green spectrum, reflecting their consistent relevance throughout the last few years.

The most recently emerging keywords, shaded in yellow, include *climate change*, *communities*, and *urban areas*. These keywords indicate an increasing research focus on the intersection between urban sustainability and climate adaptation and the growing role of community-level engagement in achieving sustainable development goals. The appearance of *climate change* as a more recent keyword highlights a rising awareness of the urgency to incorporate climate considerations into urban policy and planning. Similarly, *communities* reflect a social turn in the literature, emphasizing participatory approaches, resilience, and inclusion in sustainability strategies.

In contrast, keywords such as *sustainable development goals*, *SDG 11*, and *sustainable city* appear in cooler tones (dark blue to light blue), suggesting that these topics were more prominent in earlier studies, particularly around 2021–2022. This implies a temporal shift in focus from broad, goal-oriented discussions about sustainability frameworks (e.g., the 2030 Agenda and SDGs) toward more applied, localized, and climate-responsive research in the most recent years.

Interestingly, the keyword *urban planning* retains a central position and appears greenish, reflecting its continuous relevance from early periods to the present. Its sustained prominence underscores the importance of spatial and infrastructural

strategies in advancing urban sustainability. The steady use of *urban development* and *urban area* also suggests that urban form and growth management remain critical topics of scholarly inquiry.

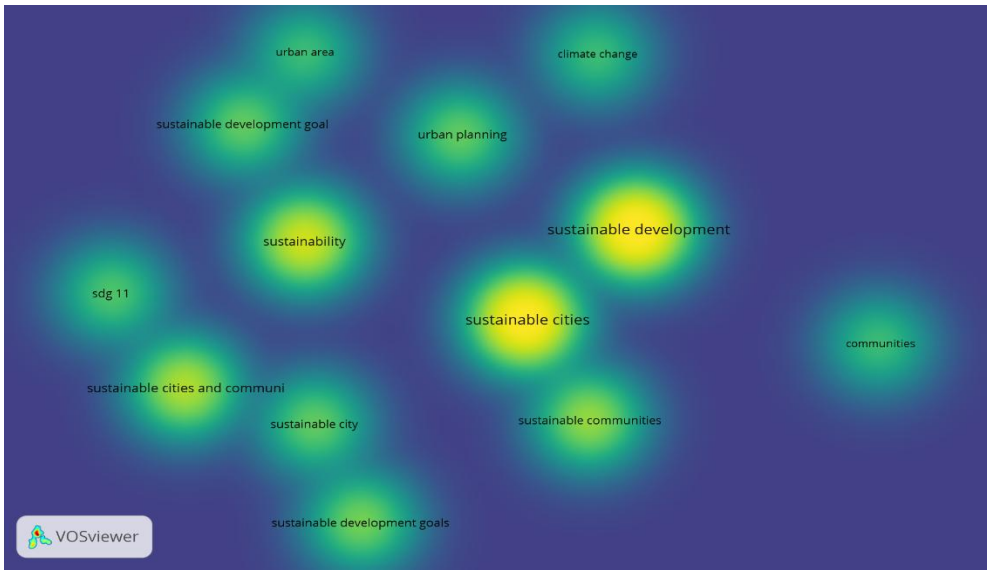

Figure 8. Density Visualization of Research Focus Areas

Figure 8 presents a density visualization of research focus areas within sustainable cities and communities, offering a heatmap-style overview of keyword frequency and thematic intensity. In this visualization, each region's brightness and color intensity represent the density of occurrences and co-occurrences of keywords in the literature. Yellow regions indicate areas of high concentration—denoting frequently studied topics—while green areas show moderately covered themes and blue-to-purple regions signify lower density or emerging areas.

At the center of the heatmap lies the keyword "sustainable cities," which is the most prominent focal point in bright yellow. This centrality reflects its dominant role in the literature and confirms its position as the core theme around which other sustainability-related research clusters are organized. The keyword is tightly surrounded by other high-density terms such as *sustainable development*, *sustainability*, and *sustainable communities*, all appearing in green-yellow hues. This grouping indicates that the conceptual triad of urban sustainability, broader developmental frameworks, and community-level applications are highly interlinked and frequently co-addressed in scholarly work.

The bright cluster surrounding "sustainable development" shows that this concept remains foundational across the research domain, serving as a theoretical anchor in discussions of sustainable urbanization. Its density suggests that it is a highly cited and cross-cutting theme, relevant in studies ranging from policy analysis and planning to implementing and evaluating sustainable practices. Nearby, "sustainability" and "sustainable communities" also display strong density signals, reinforcing their importance in theoretical and applied discussions. The presence of *sustainable cities, cities, communities*, and *sustainable development goals* in the same vicinity indicates that the discourse is heavily shaped by the global policy framework set by the United

Nations' Sustainable Development Goals—particularly SDG 11, which also shows notable density.

Moving outward from the central core, the keywords "urban planning," "urban area," and "climate change" exhibit moderate density, represented in green. These topics are considered necessary, though slightly less central than the core concepts. Their positions suggest that spatial and environmental considerations are integral to the discourse but may be more context- or region-specific in how they are addressed in the literature. Notably, *climate change* appears in a somewhat isolated but dense cluster, indicating growing yet focused scholarly attention to the climate implications of urban sustainability. "Communities" appears farther to the right in a lighter green-yellow hue and relative isolation. This spatial separation and density level suggest that while community-related research is gaining traction, it may still be somewhat peripheral compared to the core of sustainability-centered research. However, its visibility on the map reflects its emerging significance, particularly in social dimensions of sustainability, such as participatory planning, equity, and resilience.

CONCLUSION

This bibliometric study offers a comprehensive overview of the evolving research landscape in *Sustainable Cities and Communities*, in alignment with Sustainable Development Goal 11 (SDG 11). By analyzing 107 documents indexed in Scopus between 1998 and 2024, the study reveals a marked increase in scholarly activity following the global adoption of the 2030 Agenda, with significant growth observed post-2015. Thematic clusters centered around sustainability, urban planning, climate change, and SDG frameworks demonstrate the interdisciplinary nature of this research area.

Visual mapping of keyword co-occurrence, co-authorship networks, and citation patterns highlighted the United Kingdom, Netherlands, and Italy as central contributors to international collaboration. Emerging themes such as climate adaptation and community resilience underscore a growing emphasis on practical and locally grounded sustainability strategies. The density and temporal visualizations further reveal that while foundational concepts remain stable, the field is shifting toward more applied, inclusive, and action-oriented research.

This study enhances understanding of scholarly trends, key contributors, and research priorities in sustainable urban development. Its findings provide valuable insights for academics, policymakers, and urban planners aiming to address complex urban challenges through evidence-based and collaborative approaches. Future research should continue to monitor thematic shifts and expand interdisciplinary integration to support the realization of SDG 11 in diverse urban contexts.

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