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A Bibliometric Analysis to Examine the Use of Space Syntax on Sustainability Studies

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Abstract

The concept of sustainability has made a significant impact on various disciplines in recent years, standing at the center of scientific research in many different fields. This study used the bibliometric analysis method to shed light on the relationship between the space syntax method used in urban planning, urban design, and architecture and the concept of sustainability. Bibliometric analysis was conducted on bibliometric information obtained from publications using the search terms "sustain" and "space syntax" in the Scopus and Web of Science Core Collection databases. Based on the findings obtained from the analysis of publications discussing both the concepts of space syntax and sustainability, influential authors in this field, citation information and general information about the concepts discussed together with these fields are provided. In the last 10 years, there has been an increase in interest in publications exploring the relationship between space syntax and sustainability. It is expected that this field will provide increasing research potential in the future alongside different branches of academic study.*

Keywords: *Sustainability, Space syntax, Bibliometric analysis.*

Sürdürülebilirlik Çalışmalarında Mekân Dizim Kullanımını İrdeleyen Bibliyometrik Bir Analiz

Öz

Sürdürülebilirlik kavramı son yıllarda çeşitli disiplinler üzerinde önemli bir etki yaratmış, birçok farklı alanda bilimsel araştırmaların merkezinde yer almıştır. Bu çalışmada bibliyometrik analiz yöntemi kullanılarak şehir planlama, kentsel tasarım ve mimarlıkta kullanılan mekân dizimi yöntemi ile sürdürülebilirlik kavramı arasındaki ilişkiye ışık tutulmaya çalışılmıştır. Bibliyometrik analiz, Scopus ve Web of Science Core Collection veri tabanlarında "sustain" ve "space syntax" arama terimleri kullanılarak yapılan yayınlardan elde edilen bibliyometrik bilgiler üzerinde gerçekleştirilmiştir. Hem space syntax hem de sürdürülebilirlik kavramlarını birlikte ele alan yayınların analizinden elde edilen bulgulara dayanarak bu alanda etkili olan yazarlar, atıf bilgileri ve bu alanla birlikte çalışılan kavramlar hakkında genel bir bilgi sağlanmıştır. Son 10 yılda, mekân dizimi ve sürdürülebilirlik arasındaki ilişkiyi araştıran yayınlara olan ilgi artmıştır. Bu alanın gelecekte farklı akademik çalışma dallarıyla birlikte artan bir araştırma potansiyeli sunması beklenmektedir.*

Anahtar kelimeler: *Sürdürülebilirlik, Mekân dizimi, Bibliyometrik analiz.*

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1. Introduction

Urbanization, the growing global population, technological developments, and an increase in living standards have all led to a rise in the need for energy consumption. Therefore, the sustainability of buildings and the environment has become a more common topic of discussion among both academics and policymakers (Hawkes, 2001). The roots of the concept of sustainability date back to the 1960s and 1970s, when environmental movements and economic development models were arising. In those years, the book *Silent Spring* by Rachel Carson (1962) raised particularly significant awareness of environmental consciousness by focusing on environmental problems. A declaration published in 1972 after the International Stockholm Conference addressed certain fundamental principles that would later be included in environmental law to protect and improve environments inhabited by humans. The International Union for Conservation of Nature (IUCN) adopted the World Charter for Nature in 1982. This document has been accepted as a significant text that highlights sustainable development and the principles of nature protection. The charter encourages lifestyles compatible with nature and has drawn attention to the environmental aspects of sustainability (Pallemaerts, 1997). Furthermore, a report titled "Our Common Future," published by the United Nations World Commission on Environment and Development (Brundtland Commission) in 1987, defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" and made the international recognition of the concept of sustainability possible (WCED, 1987).

Sustainability was previously defined to possess ecological, social, and economic dimensions (Santos et al., 2023; Soretz, Nodehi & Taghvaee, 2023), but it is now being reconsidered to include a dimension of cultural sustainability as well (Macagnan & Seibert, 2023; Haripriya, 2023; Schoor et al., 2023; Hariram, Mekha, Suganthan & Sudhakar, 2023). An understanding of the relationships between sustainability and urbanization or architecture requires a combination of various theories and spatial analyses with an integrated approach that aims for balanced and sustainable development in the environmental, economic, cultural, and social dimensions. The spatial orders applied by individuals and communities and the evaluations of their various aspects of meaning with the support of new theories and analyses are of significant importance in predicting how spatial interventions can promote sustainable cities and communities (van Nes & Yamu, 2020). Therefore, planning and designing cities and buildings in a sustainable way is highly significant in efforts to create healthy and balanced living spaces for future generations.

Various concepts pertaining to sustainability are intended to make the natural environment and social and economic systems sustainable while considering human needs and values. The sustainability approaches utilized in architecture and urban planning focus on various actionable strategies that aim to reach different goals. These approaches entail a great variety of methods that can be applied to encourage sustainable applications in the design and improvement of buildings and cities. While topics related to environmental sustainability, such as green spaces, the protection of ecosystems, and energy and water management, are discussed in the framework of urban planning (Grimm et al., 2008; Kaur & Garg, 2023; Wolch, Byrne & Newell, 2014), topics such as energy savings and environmental harmony are addressed in the context of architectural design (De Santoli, Fraticelli, Fornari & Calice, 2014; Taleb & Sharples, 2011; Kadaei, Sadeghian, Majidi, Asaee & Mehr, 2021; Emekci, 2022). Goodland (1995) defined environmental sustainability as the sustainable management and protection of natural resources and underlined the fact that, despite being a separate topic of discussion, environmental sustainability is closely related to social and economic sustainability. While topics of mixed-use designs, urban density, transportation, and infrastructure are addressed on an urban scale, questions related to materials and efficient construction processes are generally discussed on an architectural scale within the framework of economic sustainability. Since all concepts of sustainability affect or are affected by humans in environments where the subject is human, the concepts are accordingly shaped around the subject itself, and all of these concepts, with their differences and similarities, serve as intermediaries to protect and improve human resources and opportunities.

Based on the definitions of culture as an interdisciplinary concept at the level of human-nature interactions, the importance of analytically and systematically bringing together relationships of sustainability within culture and of culture within sustainability has been emphasized (Soini & Dessein, 2016). In the cultural context, the protection of urban structures is critically important in terms of society's participation and the general development of cities. While the protection of cultural heritage accordingly protects cities' identities and their histories, the participation of society in this process enables more inclusivity and democratic decisions (Cotter & Karsono, 2023; Tweed & Sutherland, 2007; Foster, 2020). Inclusive approaches such as these can make cities sustainable, livable, and culturally rich. The consideration of cultural aspects throughout urban planning processes contributes to the creation of healthier and more balanced living spaces for the generations of today and those of the future (Askarizad, Safari & Pourimanparast, 2017). Culture shapes the interactions that individuals and communities have with their environments and with one another; therefore, cultural sustainability is also a fundamental element of social and environmental sustainability (Abusafieh, 2019). Social sustainability, which is intertwined with culture, is considered to be of great importance in many works of architecture and urban planning for its provision of peace and continuity in societies (Daugelaite, 2022; Goh, Ting, & Bajracharya, 2023; Itma & Monna, 2022; Huang, 2019; Zeng et al., 2020). Overall, in studies of humans and their environments, social sustainability includes elements such as social equality, accessibility, participation, and the strengthening of social bonds.

Space syntax theory, introduced by Hillier & Hanson (1984), is used extensively as an approach for evaluating various aspects of urban structures, which include spatial configurations, human movements, land use, and social, cultural, perceptual, and psychological effects. Space syntax theory makes it possible to explore the interactions of these elements in different models (Hillier, 2016). Since its introduction in 1984, this theory has been used to model and analyze urban spaces for an understanding of the social meanings behind cities and how streets are related to one another or how the structuring of streets is related to human movements, activities, and behaviours. Space syntax theory has a significant place in modern urban design and planning approaches, contributing to the modern understanding of how cities and buildings can be more functional, livable, and sustainable (Zhang, Yuan & Kim, 2022; Zaleckis et al., 2022; Huang, 2019). The convenience it provides in terms of its wide range of use in architecture and urban planning disciplines and its adaptability to different studies with an interdisciplinary approach has further expanded the fields of the use of space syntax.

The present study utilizes bibliometric analysis to shed light on the relationship between the concepts of sustainability and space syntax and to identify trends among the studies conducted in this field to date as well as relevant topics that have not yet been sufficiently studied. Publications indexed in the Scopus and Web of Science Core Collection databases were used for the analysis. Scopus and the Web of Science Core Collection are two of the largest and most frequently used databases for academic literature reviews and bibliometric analyses. Both are known as extensive and multidisciplinary databases. Scopus, in addition to being a database that includes extensive multidisciplinary abstracts and citations within various academic disciplines, also indexes a large portion of relevant journal articles (Aksnes & Sivertsen, 2019). The Web of Science Core Collection, on the other hand, has a larger historical scope and more selective indexing criteria. Scanning these two extensive databases helps identify gaps in the current literature on a topic together with subjects yet to be studied or subjects that are currently drawing more attention and may provide potential fields for new research. VOSviewer software was used to create graphs, tables, and visuals by compiling the data obtained from the Scopus and Web of Science Core Collection databases. VOSviewer was specially developed for the analysis and visual representation of large datasets used in bibliometric analyses in the academic literature (van Eck & Waltman, 2009). Bibliometric mapping involves the visualization of bibliometric data to represent relationships between elements such as the authors, journals, or keywords in a scientific field.

The bibliometric analyses of the present study, conducted at the intersection of space syntax and sustainability, aimed to provide data on the following topics: (1) the fields and numbers of relevant publications, or the activity status of these fields; (2) how often these publications are cited, and which authors have studied the fields of space syntax and sustainability together in effective ways; (3) the

subjects that are studied together and their focal points and relationships, based on an examination of the subjects and keywords appearing in the literature; (4) the types of publications and research performance according to the publishing countries; (5) cooperation among authors who study space syntax and sustainability; (6) and possible areas of research on the intersection of space syntax and sustainability that have received limited attention in the literature to date.

2. Material and Method

Bibliometric analysis, which constitutes the methodology of the present study, is used to quantitatively evaluate and measure certain indicators in the literature and then create information maps for a specific field using extensive databases (Ellegaard & Wallin, 2015). This type of analysis enables us to evaluate various elements of academic research, such as scientific publications, citations, authors, journals, and institutions, and to understand the dynamics and tendencies of a certain field of study (Donthu, Kumar & Pattnaik, 2020; Lazarides, Lazaridou & Papanas, 2023; Merigó & Yang, 2017; Zeng & Chini, 2017). According to Donthu et al. (2021), bibliometric analysis is an analysis method that can serve as a guide in identifying the shortcomings in a field of academic literature and in generating new ideas for researchers based on information from scientific databases on the subject of interest. After scanning for certain parameters, a pool of scientific information is obtained, providing specific to general information design (Donthu et al., 2021). This method entails the statistical analysis of journal articles, books, and other publications to measure the studies conducted by individuals, groups, institutions, and countries; in this way, it defines national and international cooperation trends and maps the developments in various scientific fields (Arévalo & García, 2023). This type of analysis, which serves as a powerful method for understanding the performance and interactions of academic literature, provides significant information allowing researchers to use resources more effectively and evaluate scientific contributions more accurately.

For this study, the Scopus and Web of Science Core Collection databases for the concepts of sustainability and space syntax were scanned. A search was performed of all resources accessible using the “Article title, Abstract, Keywords” criteria without any time restrictions in the Scopus database, where “sustain*” and “space syntax” were used as the search terminology (Table 1). As a result of that search, data for 373 publications indexed by the Scopus database were accessed. In the Web of Science Core Collection database search, the “Topic” search criterion (with the fields of Title, Abstract, Keywords Plus, and Author) was applied for all available resources without any time restrictions. The terms “sustain*” and “space syntax” were used and obtained for 262 publications in line with the search criteria. Thus, a total of 635 publications that addressed space syntax and sustainability together were identified. The scans were conducted on May 26, 2024, and results for the Scopus database were downloaded as .cvs files while those for the Web of Science Core Collection database were downloaded as .txt files. The downloaded files were then imported into VOSviewer software and analyzed.

Table 1. Scopus and Web of Science Core Collection search results. Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

	Scopus	**Web of Science Core Collection**
Search Term	Criteria: TITLE-ABS-KEY (sustain*, "space syntax")	Criteria: TOPIC (sustain*, "space syntax")
Search Results	373 Documents (2002-2024)	262 Documents (2005-2024)
Total 635 Documents (2002-2024)		

3. Findings and Discussion

The findings of this study obtained from bibliometric analysis using VOSviewer software consist of graphs, tables, and visual mappings created with the data obtained from Scopus and the Web of Science Core Collection. Mappings were created based on the link strength between data points. For

any given item, the links and the total link strength indicate the number of links an item has with other items and the total strength of that item's links with other items, respectively (van Eck & Waltman, 2023).

Figure 1 shows the distribution of studies addressing both the concept of sustainability and space syntax according to years. The first study in Scopus to explore space syntax and sustainability together was an article by Moirongo published in *Urban Design International* in 2002. The first such study in the Web of Science Core Collection database, on the other hand, was titled "Social and geometrical centrality of Chinese courtyard house" by Haofeng and Min, included in the 5th International Space Syntax Symposium in 2005. From this Figure 1, it is seen that the intersection of space syntax and sustainability has become an increasingly popular field of research and has been developing steadily between 2002 and 2024. The upward trend of research in this field is especially evident after 2016.

Figure 1. Number of publications in Scopus and Web of Science Core Collection database by years. (Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

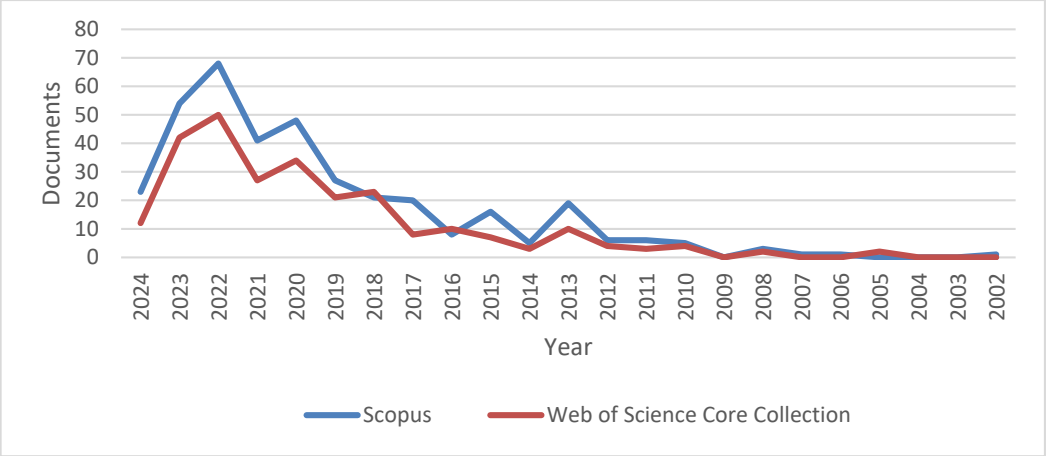

Table 2 shows the research fields in which space syntax and sustainability have been studied together and the publication numbers for each of those fields in Scopus and the Web of Science Core Collection. According to the research field classification used by Scopus, the fields of "Social Sciences," "Environmental Science," and "Engineering" are particularly active in exploring the intersection of space syntax and sustainability. The Web of Science Core Collection uses a different field classification; accordingly, it was found that "Environmental Sciences Ecology," "Science Technology - Other Topics," "Urban Studies," and "Architecture" are the fields with the most publications exploring the two concepts.

Table 2. The most common research areas and the number of publications in Scopus and Web of Science Core Collection database. Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Scopus	**Web of Science Core Collection**
Social Sciences (172)	Environmental Sciences Ecology (107)
Environmental Science (130)	Science Technology Other Topics (83)
Engineering (123)	Urban Studies (47)
Earth and Planetary Sciences (95)	Architecture (39)
Computer Science (79)	Engineering (38)
Energy (62)	Public Administration (31)
Arts and Humanities (31)	Computer Science (27)
Mathematics (19)	Construction Building Technology (23)
Business, Management and Accounting (10)	Geography (20)
Agricultural and Biological Sciences (7)	Transportation (12)

Table 3 lists publication numbers of the top 10 authors with the highest numbers of relevant publications in the Scopus and Web of Science Core Collection databases. Yamu is the author with the highest numbers of publications in both databases, and van Nes, Askarizad, Cutini, Griffiths, and Marcus follow in terms of the highest numbers of publications in both databases.

Table 3. Authors with the most publications in Scopus and Web of Science Core Collection database and number of publications. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/).

Scopus	Web of Science Core Collection
Yamu, C. (13)	Yamu, C. (9)
van Nes, A. (9)	Askarizad, R. (7)
Annunziata, A. (7)	van Nes, A. (7)
Cutini, V. (7)	Cutini, V. (5)
Tan, W. (7)	Fonseca, F. (5)
Askarizad, R. (6)	Griffiths, S. (5)
Garau, C. (6)	Bonifacius, N. (4)
Griffiths, S. (6)	He, J.L. (4)
Marcus, L. (6)	Marcus, L. (4)
Murgante, B. (6)	Ramos, R. (4)

Table 4 lists the countries or regions from which the publications in Scopus and the Web of Science Core Collection were published and the number of publications. Based on countries or regions, China stands out with the highest number of publications jointly addressing the concepts of space syntax and sustainability. In both databases, the other countries with the highest numbers of publications in both databases are the United Kingdom, Italy, Türkiye, the Netherlands, Norway, Sweden, and South Korea.

Table 4. Countries/regions with the highest number of publications in Scopus and Web of Science Core Collection database and number of publications. Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/).

Scopus	Web of Science Core Collection
CHINA (77)	CHINA (78)
ENGLAND (44)	ITALY (26)
ITALY (32)	ENGLAND (17)
TURKIYE (22)	NETHERLANDS (17)
UNITED STATES (18)	IRAN (12)
INDONESIA (17)	SWEDEN (11)
NETHERLANDS (17)	TURKIYE (11)
NORWAY (15)	AUSTRALIA (10)
SOUTH KOREA (13)	NORWAY (10)
SWEDEN (13)	SOUTH KOREA (10)

Table 5 shows the distribution of publication types in the considered databases. Scopus contains 223 relevant journal articles, 129 conference paper, 8 book chapters, 7 conference reviews, and 3 review articles. The Web of Science Core Collection contains 218 relevant journal articles, 39 proceeding paper, 6 early access publications, 4 review articles, and 1 book. Both databases have a very high number of journal articles. Scopus contains many more conference paper publications than the Web of Science Core Collection.

Table 5. Distribution and number of types of publications in Scopus and Web of Science Core Collection database. Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Scopus	Web of Science Core Collection
Article (223)	Article (218)
Conference Paper (129)	Proceeding Paper (39)
Book Chapter (8)	Early Access (6)
Conference Review (7)	Review Article (4)
Review (3)	Book (1)

The biometric maps provided in this section were obtained by submitting data from the Scopus and Web of Science Core Collection databases to VOSviewer software after determining certain parameters. The first map obtained from VOSviewer illustrates the co-authorship analysis of the authors. Co-authorship data analysis is valuable for visualizing the cooperation networks of different research fields (Manickam & Rozan, 2023). The cluster analysis used in mapping is a technique for grouping similar objects into clusters according to their shared features, and it helps to understand complex data structures, identify tendencies in research, and obtain information based on data from various fields (Aström, 2002).

Table 6 shows the most cited authors and their citation numbers in both databases. According to both databases, Yamu was cited most often among the authors with publications addressing the concepts of space syntax and sustainability together. Subsequently, van Nes, Garau, Marcus, Chiou, Huang, and Li stand out as other authors with high numbers of citations in both databases.

Table 6. Most cited authors and several citations in Scopus and Web of Science Core Collection databases. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Scopus	Web of Science Core Collection
Yamu, C. (542)	Yamu, C. (366)
Dembski, F. (251)	van Nes, A. (174)
van Nes, A. (240)	Marcus, L. (146)
Garau, C. (182)	Hijazi, I.H. (118)
Marcus, L. (158)	Li, X. (118)
Hidayati, I. (111)	Garau, C. (106)
Chiou, S. (107)	Colding, J. (103)
Huang, B. (107)	Chiou, S. (90)
Li, W. (107)	Huang, B. (90)
Tan, W. (95)	Li, W. (107)

The data from the 262 sources obtained from the Web of Science Core Collection database were imported into VOSviewer and a total of 698 authors were found in the process of co-authorship analysis. Upon setting the minimum number of publications by an author as 2 and the minimum number of citations by an author as 0, 82 authors who met our criteria were found. All 82 authors were selected for mapping, and in the final stage, the program suggested the 9 most interlinked authors, with the caveat that not all of these authors were related to each other. After that suggestion was accepted, a co-authorship map was created with the 9 authors with the highest link strength (Figure 2). After the mapping process, 3 co-authorship clusters were recognized: Cluster 1 (Annunziata A., Fortunato G., Murgante B., and Scorza F.), Cluster 2 (Garau C., van Nes A., and Yamu C.), and Cluster 3 (Hidayati I. and Tan W.).

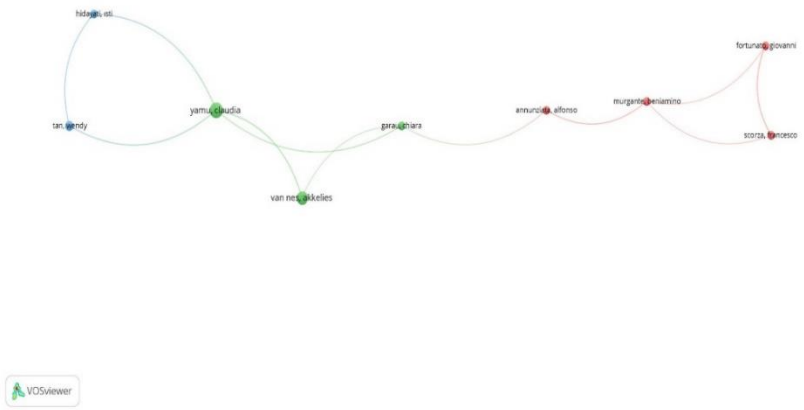

Figure 2. Co-authorship analysis of authors in the Web of Science Core Collection database. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

After the data obtained from the Scopus database for 373 publications were imported into VOSviewer, a total of 899 authors were found for co-authorship analysis. Subsequently, 110 authors who met the criteria of ≥2 publications and ≥0 citations per author were identified. All 110 authors were selected and mapped with VOSviewer, and then 13 authors with the strongest links in the mapping process were suggested. That suggestion was accepted, and the mapping process was completed. As a result of the mapping process based on the data obtained from Scopus, 4 clusters were obtained: Cluster 1 (Annunziata A., Garau C., Murgante B., and Valuzzi R.), Cluster 2 (Dembski F., Hidayati I., Tan W., and Yamu C.), Cluster 3 (Ahmer C., de Koning R. E., and van Nes A.), and Cluster 4 (Fortunato G. and Scorza F.) (Figure 3).

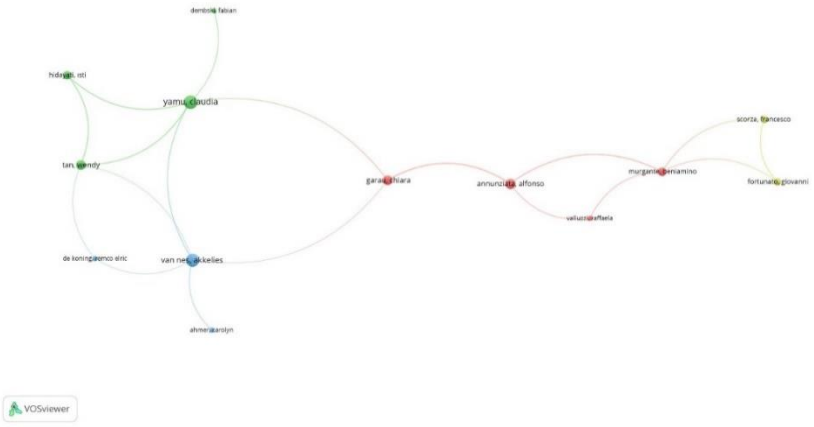

Figure 3. Co-authorship analysis of authors in the Scopus database. (Source: Created by VOSviewer Software, 2024.). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Table 7 provides data on keyword usage obtained from the Scopus and Web of Science Core Collection databases. “Space syntax,” in reference to space syntax theory/method, is the most commonly used keyword among the analyzed publications. It is further seen that the keywords of “sustainability,”

"accessibility," "walkability," "urban morphology," "spatial configuration," "sustainable development", "urban form" and "urban design" are used particularly often in relation to space syntax.

Table 7. The most used keywords and their numbers in publications in Scopus and Web of Science Core Collection databases.(Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024.© Copyright Clarivate 2024. All rights reserved.

Scopus	Web of Science Core Collection
space syntax (223)	space syntax (154)
sustainability (24)	accessibility (23)
accessibility (24)	sustainability (21)
walkability (18)	spatial configuration (16)
urban morphology (15)	walkability (16)
spatial configuration (15)	sustainable development (13)
urban design (12)	spatial analysis (10)
urban form (14)	urban design (9)
sustainable development (13)	urban form (9)
urban planning (12)	connectivity (8)

Examining and interpreting the co-occurrence data based on the keywords used by authors in the VOSviewer program allows for a holistic evaluation encompassing various areas of research. For the analysis of co-citation data according to keywords, a total of 880 keywords were obtained by importing the data from the Web of Science Core Collection database into VOSviewer. This number dropped to 120 after applying the criterion that keywords be used at least twice. The map created with 120 keywords is shown in Figure 4. Circles in the map are located closer to more closely related keywords, and keywords with higher numbers of uses are represented by circles of larger sizes. The linking lines between circles represent the co-occurrence of keywords, and the strength of the link is reflected by the thickness of the link as it appears in the map (Köseoğlu, Katuk, Taşdemir & Genç, 2023). According to this co-occurrence mapping based on keywords, "space syntax," "accessibility" and "sustainability" were frequently used together and had a close relationship, and "sustainable development" and "walkability" stood out as well.

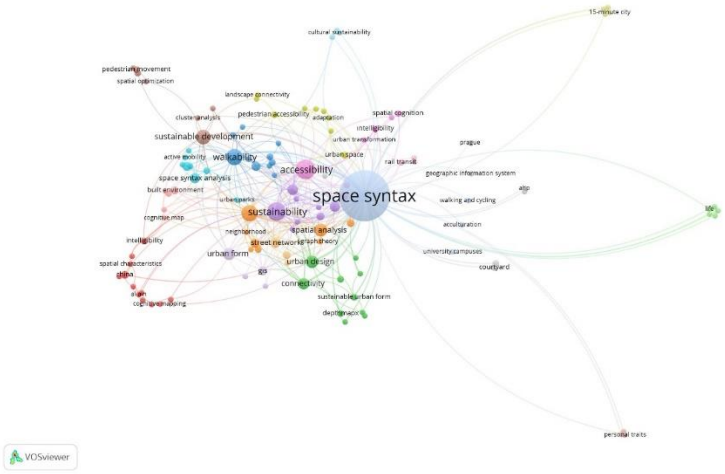

Figure 4. Mapping of keywords used in publications in the Web of Science Core Collection database. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

After the data obtained from the Scopus database were imported into VOSviewer software, a total of 1141 different keywords used in the publications were obtained. After applying the criterion that any given keyword must be used at least twice, this number dropped to 165. Figure 5 shows the resulting map created with 165 keywords. In this mapping, the keywords “space syntax,” “sustainability,” and “accessibility” are located close to one another; in other words, they are interrelated keywords that often occur together.

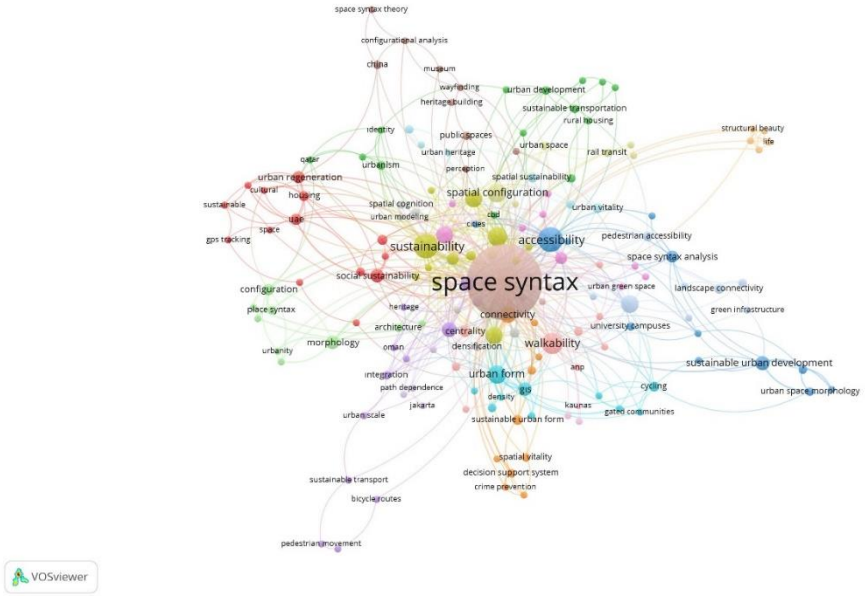

Figure 5. Mapping of keywords used in publications in Scopus database. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Table 7 lists the publications with the highest number of citations in the databases. In utilizing VOSviewer for the analysis of the data, the first author’s name was used as an abbreviation for each publication. The most frequently cited publication in both databases was “Urban Digital Twins for Smart Cities and Citizens: The Case Study of Herrenberg, Germany,” published in 2020 with Dembski (2020) as the first author. Publications with “Edwards (2013)”, “Yamu (2021)”, “Marcus (2014)”, “Mu (2022)”, “Sarkar (2013)” and “Li (2017)” as the respective first authors were the other most cited publications.

Table 8. The most cited publications in Scopus and Web of Science Core Collection databases and the number of citations they received. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Scopus	Web of Science Core Collection
Dembski, 2020 (232)	Dembski, 2020 (157)
Edwards, 2013 (158)	Edwards, 2013 (134)
Yamu, 2021 (139)	Yamu, 2021 (87)
Marcus, 2014 (90)	Su, 2019 (87)
Mu, 2022 (70)	Marcus, 2014 (72)
Sarkar, 2013 (68)	Mu, 2022 (68)
Li, 2017 (63)	Li, 2022 (68)
Hidayati, 2020 (62)	Sarkar, 2013 (61)
Wei, 2018 (50)	Hall, 2019 (55)
Fathi, 2020 (46)	Li, 2017 (50)

In analyzing the citation data of the resources obtained from the Web of Science Core Collection and Scopus databases, the applied criterion held that each considered publication should have received at least 3 citations. Accordingly, the 262 publications obtained from the Web of Science Core Collection database dropped to 140 with the application of that criterion. In the mapping process, the software suggested dropping those 140 publications to the 21 most interrelated publications, and that suggestion was accepted. According to the final mapping, “Tang (2018)”, “Li (2017)”, “Wei (2018)” and “Su (2019)” stood out in terms of their publications, numbers of citations, and link strength (Figure 6).

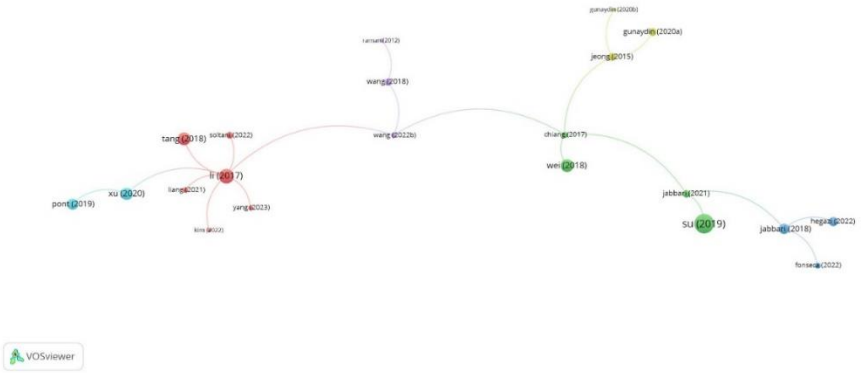

Figure 6. Citation analysis of publications from Web of Science Core Collection database. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

Of the 373 publications obtained from the Scopus database, 184 publications met the criterion of receiving at least 3 citations. In the mapping process, the software suggested dropping those 184 publications to the 17 most interrelated publications, and that suggestion was accepted. As a final result of the mapping process, “Li (2017)” and “Wei (2018)” stood out, represented by larger circles, thanks to the larger numbers of citations that they received (Figure 7).

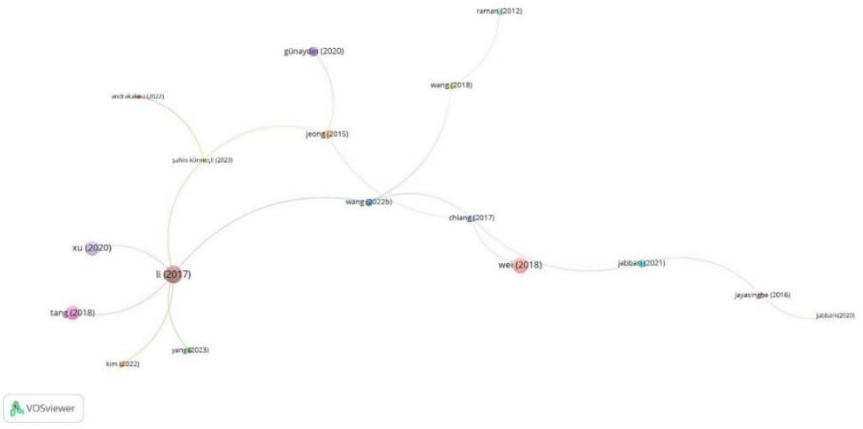

Figure 7. Citation analysis of publications from Scopus Collection database. (Source: Created by VOSviewer Software, 2024). Certain data included herein is derived from Elsevier Scopus (Available at: https://www.scopus.com/) and Clarivate Web of Science (Available at: https://www.webofscience.com/). © Copyright Elsevier 2024. © Copyright Clarivate 2024. All rights reserved.

4. Conclusion

Space syntax is commonly applied in the fields of urban planning, urban design, and architecture. Additionally, scientific research related to sustainability has become crucial and has influenced many

other research fields. It has been seen that space syntax, the scope of which is gradually expanding and which can be used in cooperation with different academic disciplines, has recently been associated with the concept of sustainability. Studies about space syntax and sustainability overlap and can be found among complementary disciplines in the fields of urban planning, urban design, and architecture. Space syntax analyzes the accessibility, walkability, and social interaction potential of cities and buildings, and it contributes to the application of sustainable design principles. The combination of these two concepts can be used as a powerful tool to create accessible and environmentally friendly cities and spaces.

In this study, publications addressing the concepts of both space syntax and sustainability in the academic literature using the Scopus and Web of Science Core Collection databases and a bibliometric analysis method were scanned and evaluated. The terms “sustain*” and “space syntax” were used as the keywords in the scanning process to obtain bibliometric data from the databases. Upon the conclusion of those scans, a total of 635 documents were obtained, including 373 from Scopus and 262 from the Web of Science Core Collection, published between 2002 and 2024. A distribution graph of these publications according to their years was created using the obtained data (Figure 1). That distribution graph showed a large upward trend in the volume of research from 2002 to the present in terms of the numbers of publications discussing both space syntax and sustainability. This finding is significant for reflecting the integration of space syntax into sustainability. Table 2 presents the analysis results for the numbers of authors’ publications, and Yamu clearly stands out as the author with the most publications. Yamu has also received the highest number of citations in this field (Table 5), and this author examines the relationship between sustainability and space syntax from different perspectives and is seen as a pioneer in the field. Another conclusion to be drawn from the number of publications of different authors is that the authors who study space syntax and sustainability continue to contribute to the literature with similar publications. Based on the countries or regions from which publications arise, China, Italy, and the United Kingdom respectively stand out in terms of the intensity of studies. Regarding the distribution of the analyzed publications according to publication types, journal articles are most common, followed by other types of papers (Table 4). For the analyses of co-authorship, keyword co-occurrence, and co-citations conducted with VOSviewer, the obtained maps show the levels and closeness existing among the relationships of these types of data.

The keywords selected by the authors of publications are highly significant in bibliometric analyses. These analyses are helpful in identifying the main themes, trends, and focal points of particular research fields. In particular, the frequency and co-occurrence of keywords indicate the main themes and areas of concentration in a given field of research. Table 6 lists the most common keywords from the publications analyzed in the present study. “Space syntax” ranks first, and the following keywords are concepts that are referred to most often together with space syntax. According to keyword analysis, studies on space syntax and sustainability conducted in the urban context are particularly common. In contrast, building-scale studies in the architectural field addressing space syntax and sustainability are limited in number. As concepts such as cultural sustainability and social sustainability do not stand out among the analysis results, they can be viewed as gaps in the literature or as fields that can be studied more in the future. Considering the most cited publications listed in Table 7, it is seen that publications published in 2013 and later have received the highest number of citations. This reflects the increasing interest in publications addressing space syntax and sustainability in the last 10 years. In conclusion, the bibliometric analysis conducted to evaluate the relationships between space syntax theory and sustainability within a quantitative framework has yielded significant insights regarding this body of literature. The association of these two concepts is continuously growing in the literature and provides potential fields of study open to different approaches in the future.

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The article complies with national and international research and publication ethics, and ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Disclosure Information

All authors contributed equally to the article. There is no conflict of interest.

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