Baharinezhad M. et al.
March 2027
Urban Economics and Planning
Volume 7, Issue 12

Data-driven representation of space syntax research in urban planning: A scientometric and network analysis approach using the Scopus Database (2017–2026)

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Review Article

Received: 2026/06/20
Revised: 2026/07/23
Accepted: 2026/07/28

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HOW TO CITE THIS ARTICLE

Baharinezhad M. Akbari P. Data-driven representation of space syntax research in urban planning: A scientometric and network analysis approach using the Scopus Database (2017–2026). *Urban Economics and Planning* 7(12):180-195.

DOI: 10.22034/uep.2026.587744.1931

Abstract

This study maps the scientific landscape of space syntax research in urban planning using scientometric methods and network analysis, without addressing this domain's theoretical foundations. The research data were extracted from the Scopus database using a systematic review procedure, and after data cleaning and screening, 739 articles were selected for final analysis. The analyses were conducted using VOSviewer, based on indicators such as keyword co-occurrence, total link strength, normalized citation counts, and the country-level co-authorship network. The findings indicate that scientific output in this field has exhibited a continuous upward trend, entering a phase of accelerated growth between 2017 and 2022. Keyword network analysis identified five major thematic clusters: urban planning and spatial analysis, spatial theory and configuration, urban morphology and development, architecture and the built environment, and visibility analysis and spatial tools. The keywords "space syntax" and "spatial analysis" constitute the core of the field's knowledge structure and exhibit the highest total link strength. In addition, the themes of urban planning, urban design, and land use, despite their comparatively lower frequency, show higher scientific impact. At the international level, China and the United Kingdom account for the largest volumes of scientific output, whereas the United States, Italy, and the Netherlands play a more central role within scientific collaboration networks. The results suggest that space syntax has reached scientific maturity and is transitioning from theoretical concepts toward interdisciplinary, data-driven, and problem-oriented applications in urban planning.

Keywords

Bibliometric analysis
network analysis
urban planning
space syntax

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1. Introduction

The contemporary city, understood as a complex system of spatial, social, and functional relationships, requires approaches that can simultaneously analyze the interaction between physical structure and human behavior. In this context, space syntax is regarded as one of the most important analytical approaches in urban planning and architecture, examining the relationship between spatial configuration and human behavior. Developed by Hillier and Hanson, this theory rests on the premise that the spatial organization of the built environment can shape movement patterns, social interactions, and spatial cognition (Hillier & Hanson, 1984). Studies have shown that space syntax indicators such as integration, connectivity, and choice serve as effective tools for analyzing spatial structure and user behavior in urban environments (Mohamed & Yamu, 2024). In recent decades, rapid urbanization and the increasing complexity of urban structures have led to the expanded application of space syntax in fields such as urban design, urban morphology, transportation, urban sustainability, and spatial legibility.

In this context, the relationship between spatial structure, accessibility, land-use patterns, and urban function has gained particular importance because the spatial structure of a city not only influences movement patterns and social interactions, but can also be related to the spatial organization of activities, access to urban opportunities, and the way land uses are distributed. From this perspective, space syntax has, in recent years, evolved from a purely physical framework into a tool for analyzing the relations between spatial configuration, accessibility, land use, and urban development processes. This shift aligns with the growing body of research that examines urban economics, transportation, land use, and spatial structure in relation to one another (Akbari et al., 2023).

Concurrently, the development of data analysis tools and scientometric and network analysis software, such as VOSviewer and CiteSpace, has enabled the examination of knowledge structures, research trends, and scientific collaboration networks. Recent studies indicate that scientometric analyses can play an important role in identifying developmental trends in space syntax research and this field's conceptual structure (Meng & Zhang, 2025).

Despite the considerable growth of space syntax research, a comprehensive examination of the field's knowledge structure, thematic trends, and scientific networks within the Scopus database has yet to be presented. Many previous studies have been predominantly descriptive and have made limited use of scientometric and network analysis approaches to examine the knowledge structure (Lee & Ostwald, 2024). Accordingly, a systematic study is still needed to map the scientific landscape and identify key trends in this field. In this light, the present study aims to investigate and analyze the scientific structure of this domain. Through applying scientometric methods and network analysis, it seeks to identify thematic clusters, research trends, and influential authors and sources, thereby providing a comprehensive picture of the state of knowledge in the field of space syntax. Furthermore, the findings can help identify research gaps and outline future research directions in this field. According to Mohamed and Yamu (2024), the entire body of space syntax literature spanning the half-century period from 1976 to 2023 comprises approximately 4,740 documents; by contrast, the urban-focused subset of this field alone, within the shorter period of 2017–2026, has reached 739 articles, indicating a considerable acceleration of this sub-domain over the past decade and underscoring the need for an independent representation of its knowledge structure.

The study by Mohamed and van der Laag Yamu (2024) also provides a comprehensive scientometric review of the space syntax field over the period 1976–2023; however, it covers the entire field of space syntax without thematic differentiation, drawing on a combination of four data sources (Scopus, the Space Syntax Network database, and archival records). In contrast, the present study focuses specifically on the intersection of space syntax with urban planning and the built environment, relies on a single database (Scopus) to enhance accuracy and replicability, and centers its analysis on the field's recent, rapidly growing period (2017–2026). Accordingly, the novelty of the present study lies not in introducing scientometric methods to this field, but in providing a more precise and up-to-date mapping of the knowledge structure of the applied sub-domain of "space syntax in urban planning."

In this regard, VOSviewer software was used as the principal tool for network analysis and scientific mapping. This software enables keyword co-occurrence, co-citation, and co-authorship analyses, through which the thematic clusters, conceptual structures, and developmental trends of research in this field can be identified by addressing the following questions.

1. What has been the growth trajectory of scientific output related to space syntax in urban planning within the Scopus database?
2. How many thematic clusters comprise the scientific records indexed in the field of space syntax in urban planning, what keywords does each cluster include, and how are the density and thematic concentration of these clusters distributed?
3. What is the pattern of thematic concentration and dispersion in space syntax research within urban planning, as indexed in the Scopus database?
4. How has the knowledge structure of the space syntax field been shaped in terms of frequency, link strength, and normalized citation count?
5. What pattern characterizes international scientific collaboration in the field of space syntax in urban planning, and which countries play a central role in the network of scientific output in this field?

2. Literature review

To clarify the position of the present study within the existing body of knowledge, prior studies were reviewed in two categories: international and domestic literature. This review has shown that research on space syntax has, in recent years, moved beyond purely physical analyses toward data-driven, network-based, and interdisciplinary approaches.

At the international level, Jiang and Liu (2008) contributed to the development of computational methods for analyzing the spatial structure of cities by proposing an algorithm for automatically generating axial lines. Zhang and Chiaradia (2020) extended space syntax to three-dimensional environments by using Isovist analysis, emphasizing the role of spatial complexity in predicting user movement in urban environments. Wu et al. (2022), using bibliometric methods and co-citation analysis, examined the knowledge structure and growth trends of spatial social network studies and demonstrated an increasing interaction among different research fields. Subsequently, Karimi (2023), in clarifying the position of space syntax within evidence-based design, emphasized the evolution of this approach from a descriptive tool into an analytical and predictive framework. Zhang et al. (2023) also demonstrated, by integrating space syntax, network science, and spatial data, a meaningful relationship between spatial structure and patterns of human movement. Likewise, Mohamed and van der Laag Yamu (2023), through a scientometric analysis of Scopus data, identified the evolutionary trajectory of space syntax research, its scientific collaboration networks, and the thematic clusters within this field. More recently, Ratnaningrum et al. (2025) used VOSviewer to analyze research clusters in space syntax, while Afrianto et al. (2026), by integrating space syntax, fractal analysis, and spatial clustering, demonstrated the capacity of hybrid approaches to explain the dynamics of urban density.

The domestic literature review for this study was conducted through a purposeful and systematic search of Persian-language scientific databases, including SID, ISC, and Magiran, using keywords related to the research topic. The studies were then selected following a screening process based on their thematic relevance. This review indicates that the application of space syntax in Iran has primarily focused on issues of social interaction, security, and urban regeneration. Sajjadzadeh et al. (2017), in a study of informal settlements in the city of Hamadan, demonstrated a significant relationship between spatial configuration characteristics and environmental security, emphasizing the role of accessibility and spatial integration in improving environmental quality. In another study, the same researchers explained the role of spatial configuration analysis in regenerating impoverished neighborhoods and in identifying the structural weaknesses of these areas. Ali-Tajer et al. (2018), examining the Hesar and Dizaj neighborhoods of Hamadan, demonstrated the impact of spatial configuration characteristics on the sociability of informal settlements. In a further study, Ali-Tajer et al. (2019), by combining cognitive mapping with spatial configuration analysis, emphasized the need to use complementary methods alongside computational space syntax models for analyzing social concepts. Rajabi et al. (2022) similarly demonstrated, by integrating cognitive mapping techniques and space syntax analysis in the Ekbatan township of Tehran, that this approach can provide a more precise understanding of sociability patterns and the quality of collective spaces. Likewise, Hanaei et al. (2022), in a study of the central core of Mashhad, confirmed the effect of integration and connectivity indicators on the cohesion of urban structure.

The review of prior studies indicates that, although numerous studies have applied space syntax to analyze urban issues, they have predominantly focused on physical, behavioral, and social dimensions. Furthermore, at the international level, while some studies have employed scientometric approaches to examine the developmental trajectory of the space syntax field, no study has yet been identified within

the Iranian research literature that employs a scientometric and network analysis approach to provide a data-driven representation of space syntax research in urban planning based on Scopus database data. The present study therefore seeks to fill this research gap.

The review of prior studies further indicates that the scientometric approach has been applied to space syntax in three distinct forms: 1) comprehensive, multi-source reviews at the scale of the entire field, such as Mohamed and Yamu (2023), which drew on 4,740 documents from four databases; 2) thematically focused studies on specific sub-domains, such as Wu et al. (2022) on spatial social networks; and 3) applied-descriptive studies with more limited data volumes, such as Ratnaningrum et al. (2025). The present study falls into the second category. However, unlike Wu et al., whose focus is on social networks, the present study centers on the intersection of space syntax with urban planning and design. This thematic distinction, rather than a merely temporal one, constitutes the principal point of differentiation between the present study and the prior literature.

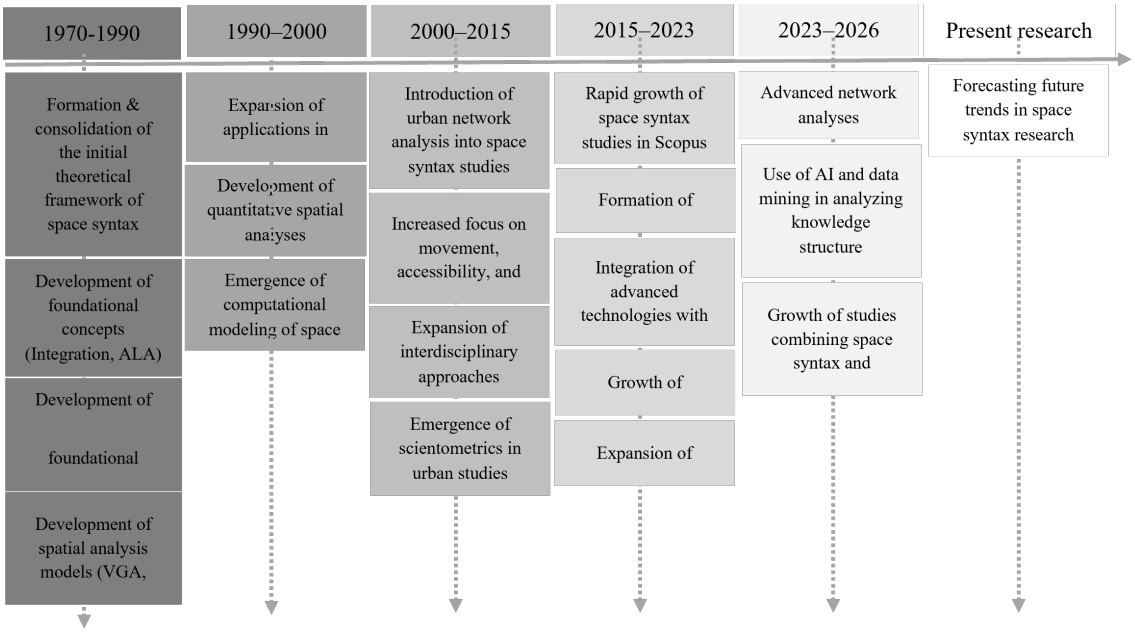

Figure 1. The evolution of space syntax and scientometric concepts

3. Theoretical foundations

3.1. Space syntax and the analysis of physical configuration

Space syntax, as an analytical approach within architecture and urban planning, examines the relationship between spatial structure and human behavior patterns. This approach rests on the premise that the spatial organization of built environments plays a determining role in shaping movement, social interaction, and spatial cognition. Early studies show that spatial structure can be analyzed quantitatively through indicators such as integration, depth, and connectivity. These indicators make it possible to convert space into a measurable and comparable system (Hillier, 1996). In more recent research, space syntax has been used as an interdisciplinary tool for urban analysis. It has been integrated with fields such as urban transportation, spatial justice, and movement behavior analysis. This development indicates that space syntax constitutes not merely a physical analytical tool, but also a framework for understanding social interactions within urban space (van Nes & Yamu, 2021).

Table 1. Data screening

Stage	Exclusion criterion	Number of records
Initial search in Scopus	—	3,642
After removal of duplicate records	Duplicate records across title/abstract/keyword fields (904)	2,738
After removal of non-English documents	Documents in a language other than English (158)	2,580
After thematic screening of titles/abstracts	Articles without direct relevance to space syntax in urban planning (1,841)	739

3.2. Scientometrics

The origins of science coincide with the origins of humankind. Early humans, confronting the problems of their existence, began at the most rudimentary stage and, with the aid of certain empirical relationships, gradually came to understand their environment. Science, in this sense, emerged as humans began to seek solutions to the various problems of life. Science is a systematic, logical method for understanding how the constituent elements of the world function; it is a body of knowledge accumulated through discoveries concerning all aspects of the world. Early humans, in addressing their problems and challenges, started at the most basic level and, through certain empirical relationships, gained an increasingly refined understanding of their surrounding environment, thereby becoming aware of the complexities and vicissitudes of existence (Salehsedghpour et al., 2025).

Scientometrics is a branch of information science research concerned with the quantitative analysis of scientific output, publication patterns, and knowledge structures. By drawing on bibliometric data, this field enables the examination of research trends, relationships among authors, and citation networks. In recent years, scientometrics has become a key tool for analyzing complex scientific domains, particularly those characterized by very large volumes of scientific data (Zupic & Čater, 2015).

3.3. Network analysis and science mapping in scientometrics

Network analysis and science mapping are regarded as among the most important scientometric approaches for understanding the knowledge structure of complex scientific domains. Using bibliometric data, these methods model relationships among scientific elements such as authors, articles, keywords, and cited sources, revealing hidden knowledge structures. In recent years, science mapping has been widely used as an analytical tool for examining the evolution of scientific fields. This approach enables simultaneous analysis of citation relationships, keyword co-occurrence, and co-authorship, thereby rendering the conceptual and social structure of science observable (Donthu et al., 2021).

4. Research methodology

The present study used a scientometric approach and scientific network analysis within a systematic review framework. The study population comprises all articles related to the field of "space syntax in urban planning," indexed in the Scopus citation database between 2017 and 2026. To collect the data, we conducted a systematic search across the title, abstract, and keyword fields (TITLE-ABS-KEY) to ensure comprehensive retrieval of relevant records. We developed the search strategy using specialized keywords related to space syntax, as presented in Table 2. The search string was as follows:

TITLE-ABS-KEY (("space syntax" OR "spatial configuration" OR "spatial integration" OR syntactics) AND ("urban design" OR "urban planning" OR architecture OR "built environment") AND (Isovist OR visibility OR accessibility OR GIS OR "justified graph" OR integration OR connectivity OR choice))

In the initial search stage, 3,642 scientific records were retrieved. The extracted data, including bibliographic information, authors, keywords, citations, and participating countries, were then organized and prepared in Excel. During the data-cleaning stage, 904 duplicate records were first removed. Subsequently, 158 non-English documents and 1,841 articles unrelated to the research topic were excluded. Ultimately, 739 articles were deemed eligible and selected for analysis. To address the research questions, we employed standard scientometric and network analysis indicators. The growth trend of scientific output was analyzed by examining the temporal distribution of article publication. In addition, to identify the field's conceptual structure, we performed keyword co-occurrence analysis and

thematic clustering, and evaluated indicators such as keyword occurrence frequency and total link strength. We also examined the field's knowledge structure based on indicators such as citation count, link strength, and normalized citations. To analyze patterns of international scientific collaboration, we examined the country co-authorship network using indicators such as weighted degree, betweenness centrality, and network clustering. We performed all scientometric analyses and network visualizations using VOSviewer. VOSviewer, employing the VOS mapping technique, represents the distance between two items (e.g., two keywords) in two-dimensional space in proportion to the strength of their link; the more frequently two keywords co-occur, the shorter the distance between them on the map. The VOS clustering technique then partitions items into thematic clusters by simultaneously maximizing within-cluster link strength and minimizing between-cluster link strength; the resolution parameter controls the level of granularity of this clustering.

Keyword co-occurrence analysis was performed in VOSviewer version 1.6.20 using the full counting method, with a minimum occurrence threshold of five repetitions per keyword; of the 2,738 keywords identified, 739 keywords met this criterion. The Resolution parameter for VOS clustering was set to 1.1 so that the resulting five-cluster level of granularity would align with the thematic interpretability of the results; the attraction and repulsion parameters were left at the software's default values (2 and 1, respectively).

4.1. Thematic scope of the study

Given that space syntax is employed concurrently in the scientific literature on architecture, built environment studies, and urban planning (van Nes & Yamu, 2021), the thematic scope of this study was defined by simultaneously constraining the search string with urban-domain keywords (urban design, urban planning, built environment, GIS). Accordingly, articles addressing the application of space syntax solely at the scale of a single building or interior space (such as interior design or hospital settings) were excluded from the dataset. Nevertheless, certain keywords from the architecture cluster (such as architectural design) remained in the final network due to their frequent co-occurrence with urban-domain keywords; this co-occurrence confirms the inherent interconnection between architecture and urban planning within the space syntax literature, rather than reflecting a screening error.

Table 2. Search Keywords Used in the Scopus Database

Keyword	Keyword
Transparency	Space syntax
Justified graph	Spatial configuration
Urban Design	Isovist
Built environment	Architecture
Gis	Accessibility
Integration	Visibility
Spatial integration	Local integration

The keywords presented in Table 2 were selected based on the foundational constructs of space syntax theory as formulated by Hillier and Hanson (1984) and Hillier (1996): "integration" and "accessibility" as core indicators of spatial configuration, "Isovist" and "visibility" as tools for analyzing the visual field, and "justified graph" as the classical method for the topological representation of space. The concept of "space syntax" was chosen over alternative urban planning topics because, unlike many urban analysis frameworks, this approach enables the simultaneous integration of physical analysis and social behavior (Hillier, 1996), and has therefore, over the past decade, been increasingly combined with data-driven tools such as GIS and machine learning, which itself motivates the research question of this study.

4.2. Inclusion and exclusion criteria for sources

To enhance the accuracy and reliability of the data used, a source selection and screening process was carried out in several successive stages. The inclusion criteria comprised articles published in English,

indexed in the Scopus database, and directly relevant to the field of urban space syntax. Conversely, the exclusion criteria encompassed the removal of duplicate records, conference papers, documents published in languages other than English, as well as studies that were thematically inconsistent with the objectives of the research. To assess the thematic relevance of each source, the title, abstract, and keywords of every record were examined, and sources lacking a direct connection to the field of urban space syntax were excluded from the analysis process. Accordingly, the process of data collection, screening, and filtering was carried out in a stepwise manner, with its various stages presented schematically in Figure 2.

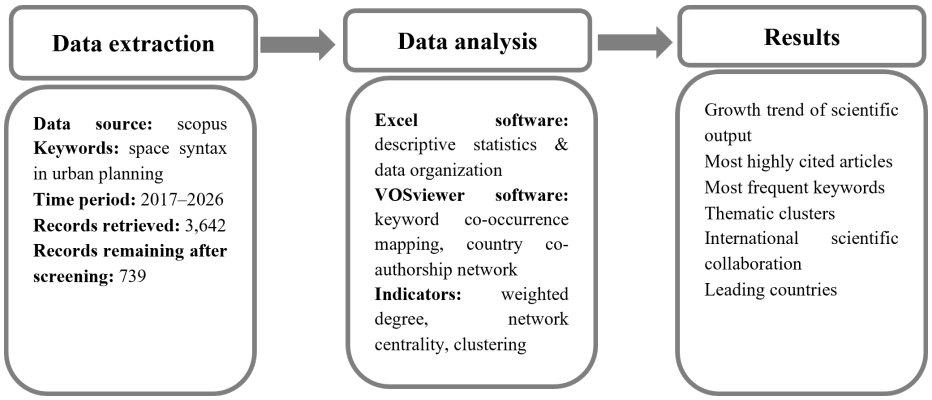

Figure 2. Research method and stages of data collection and screening

Table 3. Research methodology

No.	Research question	Analytical method	Tool/database	Output
1	What has been the growth trajectory of scientific output related to space syntax in urban planning within the Scopus database?	Trend analysis in bibliometrics	Excel/Scopus	Chart
2	How many clusters comprise the scientific records indexed in the field of space syntax in urban planning within the Scopus database, and what keywords does each cluster include?	Keyword co-occurrence analysis and thematic clustering	VOSviewer 1.6.20	Network visualization map + table
3	What is the pattern of thematic concentration and dispersion in space syntax research within urban planning, as indexed in the Scopus database?	Keyword density analysis (density visualization) + total link strength (TLS) analysis of clusters	VOSviewer 1.6.20	Density visualization map + table
4	How has the knowledge structure of the space syntax field been shaped in terms of frequency, link strength, and normalized citation count?	Keyword analysis based on occurrence frequency, total link strength, and average normalized citations	VOSviewer 1.6.20	Table
5	What pattern characterizes international scientific collaboration in the field of space syntax in urban planning, and which countries play a central role in the network of scientific output in this field?	Country co-authorship network analysis	VOSviewer 1.6.20	Network visualization map + table

5. Research findings

The findings are organized according to the responses to the five research questions and the method of achieving them.

Question 1 – What has been the growth trajectory of scientific output related to space syntax in urban planning within the Scopus database?

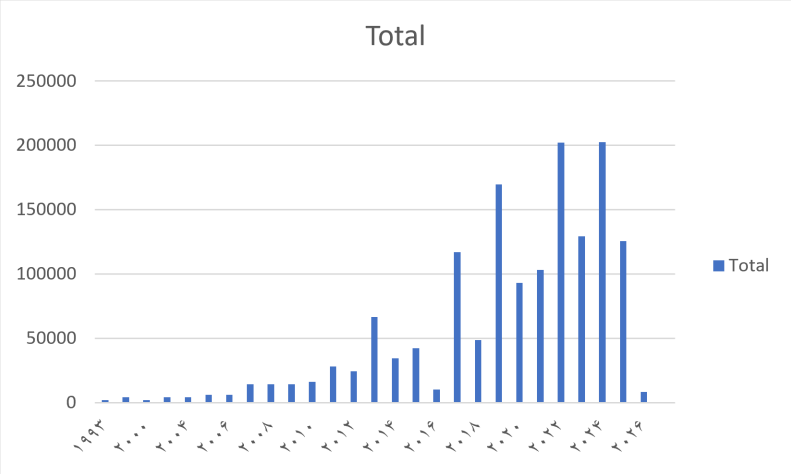

Figure 3. Annual growth of scientific output

To examine the growth trend of scientific output related to space syntax in urban planning, bibliometric data were extracted from the Scopus database. After executing the search strategy and retrieving the bibliographic information, the data were saved in a CSV file and imported into Microsoft Excel. The number of articles published each year was then extracted and aggregated using the Pivot Table tool. Based on the annual frequency of publications, a time-trend chart of scientific output was subsequently constructed. This chart enabled analysis of changes in publication volume, identification of periods of growth and stagnation, and examination of the developmental pattern of research related to space syntax in urban planning. Examination of the temporal trend of scientific output related to space syntax in urban planning within the Scopus database reveals a long-term upward growth pattern, which can be analyzed across four distinct periods. In the first period (1993–2006), the volume of scientific publications was very limited, reflecting the formative stage and initial introduction of the space syntax approach into urban studies. In the second period (2007–2015), the publication rate gradually increased. In the final years of this period, notable growth strengthened this approach's position in urban planning research. The third period (2017–2022) is identified as a phase of accelerated growth, characterized by a marked increase in publications and the highest levels of scientific output. This trend can be explained by the development of spatial analysis technologies, the expanding application of geographic information systems (GIS), improved access to urban data, and the integration of the space syntax approach with novel data analysis methods. Finally, the fourth period (2023–2026) is marked by fluctuations in the number of publications; in particular, the decline observed in 2026 is likely attributable to the incompleteness of data for the current year and delays in the Scopus indexing process, and should not be interpreted as a genuine decline in research activity. Overall, the results indicate that research on space syntax in urban planning has followed a growing trend over the past three decades, evolving from a specialized and limited domain into one of the major streams of urban research. This upward trend reflects expanding applications, researchers' increasing attention, and the consolidation of space syntax's position within contemporary urban planning studies.

Question 2 – How many thematic clusters comprise the scientific records indexed in the field of space syntax in urban planning, what keywords does each cluster include, and how are the density and thematic concentration of these clusters distributed?

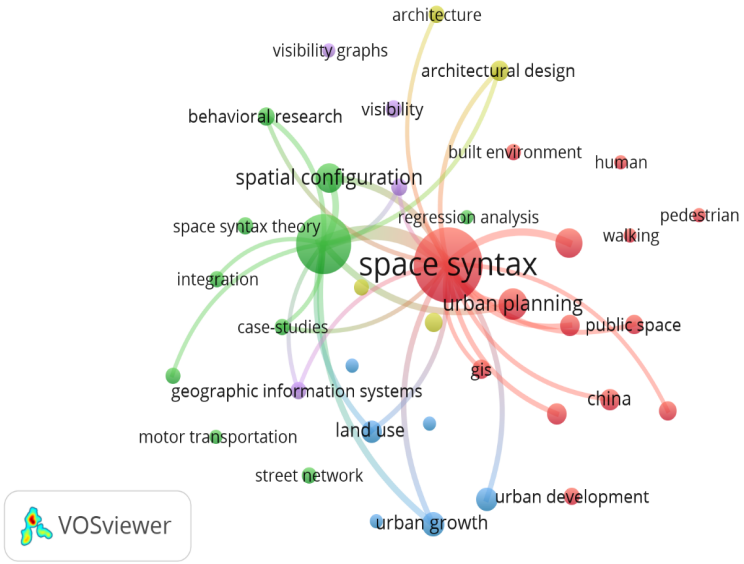

Figure 4. Visual map of the thematic structure of space syntax research in urban planning based on keyword co-occurrence analysis

The present map is the outcome of a keyword co-occurrence analysis. It depicts the conceptual structure and knowledge organization of research related to "space syntax in urban planning." Co-word or keyword co-occurrence analysis is a scientometric method that statistically analyzes published articles and documents based on their keywords (Abbasi et al., 2021). Keyword co-occurrence reflects the degree of association among a set of documents, and comparing the resulting maps across a given time period can reveal the dynamics of science within the field under study (Maditati et al., 2018).

In this map, each node's size represents the keyword frequency, while the thickness of the links between nodes indicates the intensity and strength of the conceptual relationships among them. In addition, differences in node color reflect the formation of distinct thematic clusters within this research field. The results show that the keyword network is organized into five main clusters. Among these, the keyword "space syntax" occupies the center of the network and, owing to its highest frequency and the most extensive connective links, is recognized as the pivotal concept and core of this field of study. Analysis of the network structure indicates that the scientific literature related to space syntax in urban planning is predominantly organized around five thematic axes: "urban planning and analysis," "spatial theory and configuration," "urban morphology and development," "architecture and the built environment," and "visibility analysis." Furthermore, the central position of the keyword "space syntax" and its high degree of connectivity with other concepts indicate the foundational role of this concept in providing cohesion to the knowledge network and in directing the research streams within this field, such that other topics and research concepts have developed in direct or indirect relation to this conceptual core.

Table 4. Thematic clusters of keywords in space syntax research in urban planning based on co-occurrence analysis in VOSviewer

Cluster	Core keywords	Thematic focus
Cluster 1 (red)	Space syntax, urban planning, urban design, spatial analysis, accessibility, GIS, urban area, pedestrian, human, China	Urban planning and spatial analysis; application of space syntax in urban planning, urban design, accessibility analysis, and pedestrian movement behavior
Cluster 2 (green)	Syntactics, spatial configuration, integration, street network, roads and streets, motor transportation, behavioral research, case studies	Space syntax theory and spatial configuration; examination of urban network structure, spatial integration, and the theoretical foundations of space syntax
Cluster 3 (blue)	Urban morphology and development; analysis of the growth and physical evolution of cities, land use patterns, and the spatial structure of the city	Urban morphology and development; analysis of the physical growth and evolution of cities, land-use patterns, and urban spatial structure

Cluster	Core keywords	Thematic focus
Cluster 4 (yellow)	Architecture, architectural design, housing, built environment	Architecture and the built environment; application of space syntax in architectural design, housing, and the evaluation of built environments
Cluster 5 (purple)	Visibility, visibility graphs, geographic information systems (GIS)	Visibility analysis and analytical tools; study of the visual field, visibility graphs, and the use of geographic information systems in spatial analysis

Based on the results of the keyword co-occurrence analysis, the scientific literature related to space syntax in urban planning is classified into five main thematic clusters (Table 4). Among these clusters, the "urban planning and spatial analysis" cluster exhibits the highest density and conceptual cohesion. Furthermore, the keyword "space syntax," owing to its highest occurrence frequency and strength of connection with other concepts, occupies the center of the network and functions as the most important knowledge hub and pivotal concept within this research field. This reflects the extensive influence of space syntax theory in shaping and directing studies related to urban planning and the built environment. The centrality of "space syntax" and "spatial configuration" can be attributed to the fact that these two concepts represent the most fundamental theoretical constructs introduced by Hillier and Hanson within the core framework of "the social logic of space," to which every applied study in this field must inevitably refer (Hillier & Hanson, 1984; Hillier, 1996).

Question 3 – What is the pattern of thematic concentration and dispersion in space syntax research within urban planning, as indexed in the Scopus database?

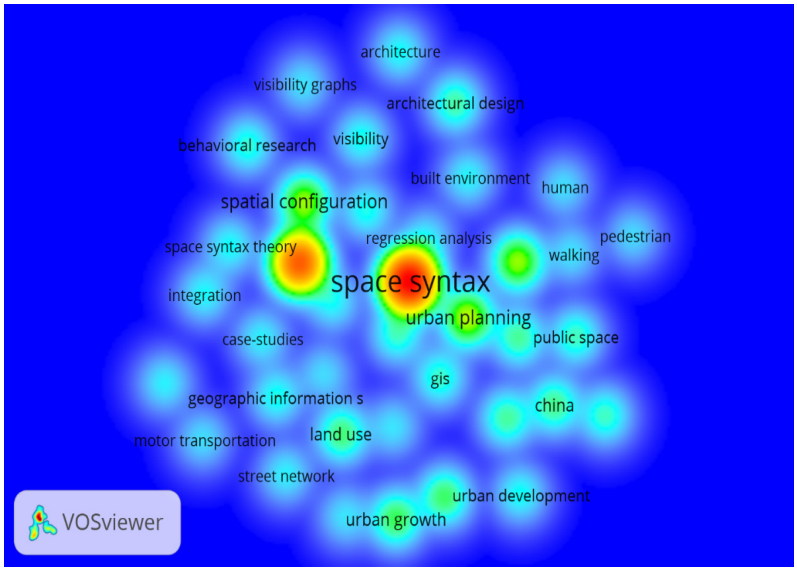

Figure 5. Density map of keyword co-occurrence in space syntax research in urban planning, Scopus database

Density is an indicator used to examine the level of network cohesion. Network density can be defined as the set of relations that connect nodes and prevent the network from becoming fragmented (Faust, 2006, p. 185). The results of the density map[12] (Figure 5) indicate that the most frequent and concentrated topics in research related to space syntax in urban planning include the concepts of space syntax and spatial configuration, the analysis of urban structure and morphology, the movement behavior and accessibility of urban users, and the application of GIS in urban spatial analysis.

Table 5. Network share of thematic clusters based on total link strength (TLS)

Cluster	Total link strength	Network share (%)
Space syntax / spatial analysis	2,763	49.8
Urban design & planning	1,104	18.7
Mobility & accessibility	498	9.3
Context / case studies	511	9.5
Socio-economic & behavioral	440	8.1
GIS & spatial data	271	3.6
Total	5587	100

The network share is calculated based on the total link strength (TLS) of each cluster. First, the TLS values of all keywords within a given cluster are summed; this sum is then divided by the total TLS across the entire dataset and multiplied by 100 to yield the percentage share of each network. The convergence of the GIS cluster with accessibility and urban morphology can be explained by the expansion of open spatial data and the integration of Isovist analysis with geographic information systems, through which space syntax has evolved from a purely physical tool into a data-driven framework for analyzing movement and land use (Zhang & Chiaradia, 2020; van Nes & Yamu, 2021).

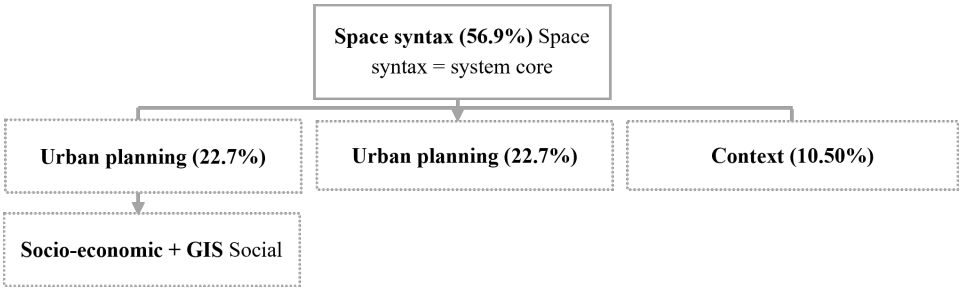

Figure 6. Network structure of thematic clusters based on total link strength (TLS)

Question 4 – How has the knowledge structure of the space syntax field been shaped in terms of frequency, link strength, and normalized citation count?

Table 6. Analysis of keywords in the field of space syntax based on occurrence, link strength, and clustering

Rank	Keyword	Occurrences	Total link strength	Average citation (normalized)
1	space syntax	493	621	1.26
2	syntactics	312	513	1.64
3	urban planning	87	213	2.45
4	spatial analysis	78	145	1.86
5	spatial configuration	79	157	1.99
6	urban growth	53	142	2.68
7	urban morphology	50	108	2.16
8	land use	47	115	2.45
9	china	43	80	1.86
10	architectural design	39	77	1.97
11	urban design	41	110	2.68
12	accessibility	40	75	1.88

Analysis of the table above indicates that the knowledge structure within the field of urban space syntax exhibits a three-layered organization, differentiated by occurrence frequency, network link strength (TLS), and normalized citation indicators. At the core of the network, the keywords “space syntax” and “syntactics” exhibit the highest occurrence frequency and the strongest link strength, functioning as the dominant theoretical framework. Nevertheless, their scientific impact is lower than that of certain applied concepts, reflecting their well-established and theoretical nature within the research literature. At the intermediate level are keywords such as “spatial analysis,” “spatial configuration,” “urban morphology,” “architectural design,” and “accessibility,” which function as an intermediary layer, linking the theoretical framework to urban applications. This group occupies a balanced position across the various indicators and plays a facilitating role in integrating the network. By contrast, at the outer layer, concepts such as “urban planning,” “urban growth,” “land use,” and “urban design” – despite their lower frequency and link strength – exhibit the highest normalized citation counts. This indicates that, notwithstanding their more limited presence within the network, these keywords carry greater significance in terms of scientific impact and relevance to real-world urban issues. Overall, the results point to a discrepancy among occurrence frequency, connective strength, and scientific impact; space syntax functions as the theoretical axis, the intermediate layer serves as the analytical connector, and urban planning concepts represent the elements of greatest scientific impact within the knowledge structure. The normalized citation score of each document is calculated by dividing the document’s number of citations by the average number of citations of all documents published in the same year within the dataset (van Eck & Waltman, 2011). The normalized citation score of each keyword is, in turn, the average of these scores across all documents in which that keyword appears, rather than the ratio of network link strength to occurrence frequency.

Question 5 – What pattern characterizes international scientific collaboration in the field of space syntax in urban planning, and which countries play a central role in the network of scientific output in this field?

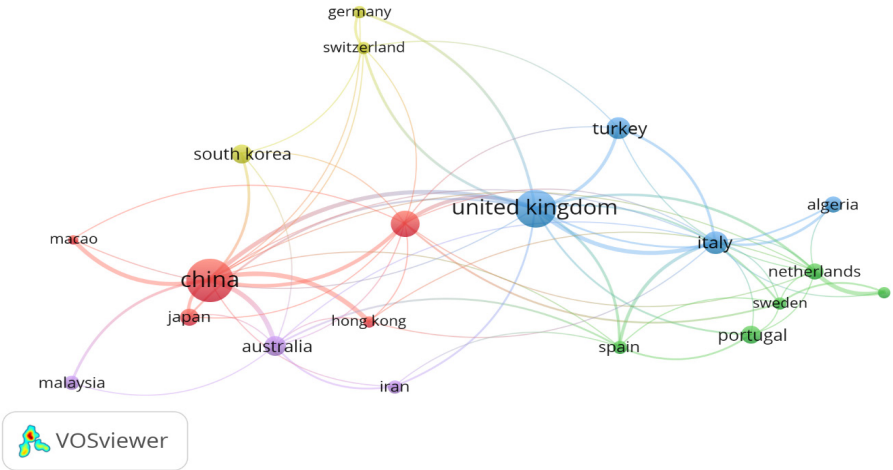

Figure 7. Map of the international scientific collaboration network in the field of space syntax in urban planning, based on the Scopus database

Examination of the network analysis indicators and the co-authorship map reveals that China, with 147 articles (22.2%), and the United Kingdom, with 113 articles (17.1%), account for the largest shares of scientific output in the field of space syntax in urban planning. Nevertheless, despite ranking third in terms of the number of articles, the United States, with the highest betweenness centrality value (0.2533), plays a more prominent role in connecting the different clusters of the network and is recognized as a key intermediary node. Likewise, Italy (0.2183) and the Netherlands (0.1925), despite their comparatively lower volume of scientific output, hold considerable strategic importance owing to their intermediary position within the network structure. The co-authorship network analysis indicates that this network is organized into five main clusters, among which the first cluster, centered on China and the United States,

exhibits the strongest within-cluster links. In contrast, countries such as Malaysia, Germany, and Norway, having recorded a betweenness centrality value of zero, lack an intermediary role within the network and exhibit lower levels of international interaction and collaboration.

Table 7. Indicators of country co-authorship network analysis in the field of space syntax in urban planning, based on the Scopus database

Country	Articles	Percentage	Weighted degree (no. of co-authored articles)	Betweenness centrality
China	147	22.2%	47	0.1918
United Kingdom	113	17.1%	44	0.0154
United States	57	8.6%	21	0.2533
Italy	40	6.1%	24	0.2183
Turkey	37	5.6%	10	0.0059
Australia	33	5.0%	17	0.1532
South Korea	29	4.4%	6	0.0058
Portugal	25	3.8%	7	0.0046
Japan	23	3.5%	8	0.0058
Algeria	22	3.3%	6	0.0012
Netherlands	21	3.2%	17	0.1925
Malaysia	17	2.6%	4	0.0000
Iran	15	2.3%	6	0.0084
Spain	15	2.3%	14	0.0135
Germany	13	2.0%	7	0.0000
Sweden	12	1.8%	10	0.0342
Switzerland	12	1.8%	10	0.0443
Hong Kong	11	1.7%	11	0.0078
Norway	11	1.7%	9	0.0000
Macao	8	1.2%	8	0.0367

With a share of 15 articles (equivalent to 2.3% of total scientific output), Iran ranks thirteenth among the 20 countries examined. Furthermore, with a weighted degree of 6 and a betweenness centrality of 0.0084, Iran exhibits among the lowest levels of influence and impact within the international scientific collaboration network. The results of the network analysis indicate that Iran is positioned within the fifth cluster, alongside countries such as Australia and Malaysia, and that the scope of its scientific collaborations is confined to a limited number of countries, including Australia, Spain, and the United Kingdom. These findings suggest that, despite Iran's considerable scientific and research capacity in urban planning, the country's position within the international collaboration network remains largely peripheral and passive, with no effective connection observed to the leading countries in this field, including China, the United States, Italy, and the Netherlands. Consequently, strengthening cross-border scientific interactions and developing research collaboration networks with leading centers and countries could contribute to enhancing Iran's international standing and increasing its role in the production of knowledge within this field. The high betweenness centrality of the United States, Italy, and the Netherlands, despite their lower scientific output relative to China, can be explained by the fact that these countries host historic centers of space syntax education (such as the European Bartlett schools) and function as connecting bridges among the different schools of thought within this field; a similar pattern has also been reported in the study by Mohamed and

Yamu (2024), which identifies University College London as the principal hub of scientific collaboration.

6. Conclusion

This study aimed to represent the knowledge structure and map the scientific landscape of space syntax research in urban planning. To this end, drawing on a scientometric approach and network analysis, 739 articles indexed in the Scopus database between 2017 and 2026 were examined. The results showed that space syntax research has experienced considerable growth in recent years. This field has moved beyond a relatively limited theoretical framework and has evolved into an interdisciplinary and application-oriented domain within urban studies.

Keyword co-occurrence analysis revealed that the conceptual structure of this field is organized around several main clusters, including spatial configuration, urban morphology, urban design, the built environment, and GIS-based analyses. The findings indicated that, alongside the consolidation of its theoretical foundations, research in this field has progressively shifted toward practical applications and data-driven analyses. In addition, the use of novel technologies within this field is on the rise. Examination of normalized citations further showed that topics related to urban planning, urban design, and land use – despite their lower frequency – exhibit the highest scientific impact.

The results of this study indicate that the knowledge structure of space syntax exhibits a multilayered organization. Foundational concepts such as "space syntax" and "syntactics" constitute the theoretical core of this field. At the intermediate level, concepts such as "spatial analysis," "spatial configuration," "accessibility," "urban morphology," and "architectural design" serve an intermediary function between the theoretical foundations and applied domains. By contrast, topics such as "urban planning," "urban design," "urban growth," and "land use" account for the highest normalized citations. This finding indicates that the scientific impact of a given topic is not necessarily aligned with its frequency in the research literature.

The findings further indicate that the relative maturity of this sub-domain, within the present dataset, is reflected in two numerical indicators: first, the 56.9% network share of the space syntax/spatial analysis cluster (Table 5), which shows that more than half of the network's link strength remains concentrated around foundational concepts rather than diverse applications; second, the gap between the frequency and normalized citation of the foundational keyword "space syntax, "with a frequency of 493 but an average citation of 1.26, compared with the applied keywords "urban growth" and "urban design," which exhibit an average citation of 2.68. This gap illustrates that maturity is reflected not in publication volume but in the shift of scientific impact toward applied domains.

With respect to international scientific collaboration, the results indicate that knowledge production is concentrated within a limited number of countries. China and the United Kingdom account for the largest shares of scientific output in this field and are recognized as the principal hubs of knowledge production. Nevertheless, the analysis of network indicators showed that the strategic role of countries is not determined solely by the volume of their scientific output. Countries such as the United States, Italy, and the Netherlands, owing to their higher betweenness centrality, play a more influential role in knowledge transfer and in establishing connections among scientific clusters.

The findings of this study, which are confined to the specific sub-domain of space syntax in urban planning, indicate that Iran's share of the scientific output indexed in Scopus within this sub-domain is negligible (15 out of 739 articles, equivalent to 2.3%), and that its betweenness centrality (0.0084) is among the lowest of the 20 countries examined. This finding should not be generalized to Iran's entire urban planning output in Scopus; assessing Iran's overall standing in urban planning would require an independent study employing a broader search strategy.

The findings of the present study are consistent with prior research. Ratnaningrum et al. (2025) reported the continuous growth of space syntax research and the formation of distinct thematic clusters, consistent with the results of the present study. Likewise, the findings of the present study align with those of Mohamed and Yamu (2023) regarding the development of scientific collaboration networks and the formation of knowledge structures. Furthermore, the results are consistent with the findings of Wu et al. (2022); both studies emphasize the importance of network analysis and scientometric methods in identifying developmental trends within interdisciplinary fields. This consistency reinforces the validity of the present study's findings.

The distinguishing feature of this study relative to prior

research lies in its specific focus on urban planning and its examination of the 2017–2026 period. Accordingly, it provides an up-to-date picture of thematic trends, conceptual structure, and patterns of scientific collaboration within the field of space syntax.

Based on the findings of this study, the following directions are proposed for future research:

- A systematic comparison of Scopus results with Web of Science to assess the stability of the identified thematic clusters.
- Replication of the analysis incorporating non-English documents (particularly Chinese-language documents) to evaluate the accuracy of China's reported share.
- Conducting qualitative interviews with active researchers in the field to explain the qualitative causes underlying the observed quantitative patterns.
- Disaggregating the analysis by journal quartile (Q1–Q4) to assess the relationship between journal quality and citation impact.
- Extending the time period to encompass the entire history of the field, to compare the urban planning trend with that of the space syntax field as a whole.

For architects and urban planners, the results of this study suggest that applying space syntax–based analyses can enhance environmental legibility, increase sociability, and improve the quality of urban spaces. Therefore, this approach is recommended for use in the urban planning and design process. Likewise, science policymakers can facilitate the expansion of this field by supporting international collaboration, promoting interdisciplinary research, and strengthening data-driven infrastructure.

This study has four main limitations. First, it relies exclusively on the Scopus database, which, despite its extensive coverage of technical and urban fields, does not encompass certain journals indexed solely in Web of Science or in specialized architecture databases (Donthu et al., 2021). Second, excluding non-English documents may present an incomplete picture of the growing space syntax literature in countries such as China, Brazil, and Iran, where research is also published in local languages. Third, the inherent limitation of a keyword-based search string, which depends on the initial selection of terms and may overlook studies associated with alternative terminology (such as "configurational analysis"). Fourth, the lack of differentiation by journal quality (Q1–Q4 quartiles), which may affect the interpretation of scientific impact.

Authors' Contributions

The authors contributed equally to preparing this article.

Acknowledgments

This article received no financial or non-financial support.

Conflict of Interest

The authors declare no conflict of interest.

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