

# A Systematic Literature Review on Streetscape Environment: Bibliometric and Visualization Insights

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**Abstract:** Streetscape environment (SE), integral to public spaces, has become increasingly significant due to its direct impact on urban life, particularly in the context of rapid urbanization and globalization. The paper aims to investigate the current research situation and progress related to SE research through bibliometrics research on the existing literature. In this study, VOSviewer and Scimago Graphica software were used to visually analyze 257 articles about SE on the Web of Science(WoS) from January 2014 to May 2024. This paper presents the basic characteristics of SE research for the first time, including publication productivity, citation rates, research categories, Web of Science index, and identifies the most cited publications, journals, countries/regions, organizations, and authors. It also maps the network of cooperation among countries/regions, organizations, and authors, identifying their cooperative relationships. Furthermore, the researchers investigate the evolution of SE research hotspots by means of keyword co-occurrence analysis and co-citation reference analysis. The study suggests that while SE research is advancing, there is a critical need for strengthened inter-organizational and author collaboration to facilitate a more profound investigation of SE-human relationship, SE design, and other emerging topics.

**Keywords:** Streetscape environment(SE), Bibliometric analysis, Web of Science (WoS), VOSviewer, Scimago Graphica.

## 1. Introduction

Streets are widely regarded as public spaces that are intimately connected to urban residents. They play an important role in defining the visual identity of cities(Carmona, 2021). In general, streets serve as public thoroughfares in urban, suburban, or rural areas, designed to organize and connect environmental elements such as buildings, plants, and street furniture on either side (Riggs, 2022).

As a branch of public space studies, research on SE started relatively later and is comparatively less extensive than research on public spaces as a whole. Some urban theorists and researchers have investigated the theories in the field of SE research. The majority of research on SE focuses on its conception, constituent elements, methodology, quality evaluation, and associated variables(Furchtlehner et al., 2022; El-Darwish, 2019; Harvey et al., 2015; Abass and Tucker, 2021). In details, Kevin Lynch identified five city elements: landmarks, streets, nodes, edges, and districts, highlighting streetscapes as the most significant among them in 1960. Jane Jacobs (1961) emphasized the critical role of streets in the city's structure. Cullen (1971) described streetscape as outdoor rooms encountered when stepping out the door, crossing the roadside, or

turning a corner. Whyte (1980) suggested that the physical characteristics of streetcape environment plays an important role in providing an enjoyable pedestrian experience by observing people's behavior directly. Gehl (1987) argued the difference between streetscapes and plaza for people. Moreover, Jacobs(1993) proposed the theme of SE quality. To be more precise, Ewing et al. (2009) further operationalized this by identifying twenty streetscape characteristics representing five key qualities. In summary, the SE study is originally proposed in the urban design field. There is a lack of work to systematically analyze and summarize the research status of SE. Therefore, it is helpful for scholars to understand the research profile thus far by conducting a quantitative overview of previous SE publications.

In order to progressively enhance and expand SE research, researchers have examined the current status, development and future research directions related to SE. This study employed bibliometric analysis, which is an effective and mature method that avoids the potential for subjective bias inherent in expert reviews. Consequently, the paper aims to present a systematic literature review in the field of SE research by addressing the research questions as follows: (1) What is the basic statistics of publications? (2) what are the cooperation networks ? (3) what are the principal themes? (4) what could be the possible research directions in the future?

This paper utilizes VOSviewer and Scimago Graphica software to analyze the basic statistics, cooperation relationships, keyword cooccurrence, and co-citations references of SE publications in Web of Science (WoS), aiming to help academics gain a clearer understanding of the SE research knowledge map and identify emerging frontiers. The structure of this research is organized as follows: Part 2 introduces the methods and data source, Part 3 presents the findings from the knowledge map analysis, and Part 4 concludes the results and proposes research limitations.

## **2. Methods and Data Source**

### **2.1 Methods**

The bibliometric analysis of data using graphical tools enables the identification of connections between fundamental knowledge(Moral-Muñoz et al., 2020; Li, 2023; Huang et al., 2022). In details, the application of bibliometrics enables the investigation of research themes and trends, as well as the identification of key authors, institutions, research directions, and academic collaborations within a given field(Cui et al., 2022; Shahidan et al., 2021; Işık et al., 2022). The study employs bibliometric and visualisation analysis using VOSviewer and Scimago Graphica as the methods. VOSviewer is a mature and effective tool for the construction and visualisation of bibliometric networks(Van et al., 2010; Bukar et al., 2023; Ding et al., 2022). VOSviewer has been selected for this research due to its intuitive interface and clear output. Scimago Graphica is used for creating geographic visualization images and keyword cloud maps(Huang et al., 2024; Hassan-Montero et al., 2022; Onoda et al., 2023).

### **2.2 Data Collection and Pre-processing**

This study employed the WoS as the source of literature data because it is a highly authoritative and widely utilized database(Wu et al., 2021; Singh et al., 2021).The strategy for data collection is as follows: topic research = "streetscape" AND "environment"; timespan = 2014-2024; document types = article and proceeding paper; language = English; database =WoS. Documentation was obtained on 17 May 2024 and a total of 257 publications were found.The collected data were pre-processed through two stages to ensure accuracy and validity. Firstly, the researchers checked for duplicate data in Excel (Pan et al., 2023). No duplicates were found. Then the data were cleaned and summarized based on VOSviewer.

### **2.3 Data Analysis**

Based on the bibliometric theory and collected literature data, this study employs two analytical procedures to examine the characteristics of streetscape environment publications: Firstly, it investigates the basic statistical characteristics, such as annual productivity and citations, the

Web of Science index, and top publication sources. Secondly, scientific mapping analyses were carried out to uncover the thematic hotspots and research trends of publications, including co-citation references, co-authorship analysis, and co-occurrence analysis based on VOSviewer and Scimago Graphica software. The methodological framework of this investigation is illustrated in Figure 1.

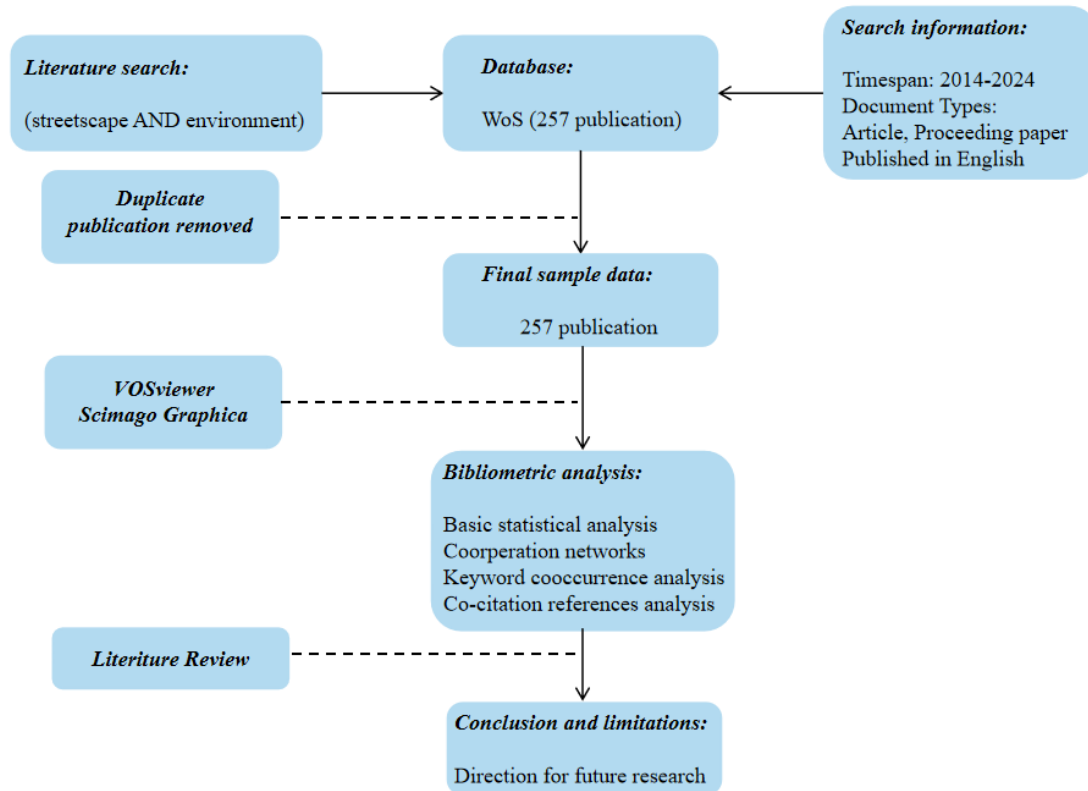


Fig. 1 The methodological framework of this study

### 3. Results

The bibliometric analysis results for publications related to the streetscape environment are divided into three sections based on the methods and data sources described in Section 2. The first section explores basic statistics of publications. The second section examines the cooperation networks among all streetscape environment research terms.

#### 3.1 Basic Statistics

##### 3.1.1 Annual indicators

Figure 2 presents the annual distribution of publications and citations for the period spanning 2014 to May, 2024. The overall trend in both metrics demonstrates robust and positive growth over time. These findings indicate that streetscape environment research has garnered significant attention in recent years. Specifically, the number of publications exhibited a gradual increase from 2014 to 2018, followed by a slight decline from 2019 to 2020, possibly due to the COVID-19 pandemic. A rapid growth was observed from 2021, peaking in 2022 with more than 50 articles published. This trend reveals that research on the streetscape environment has entered a period of increasing prosperity despite a slight dip in 2023. Unlike the publication trends, the number of citations has consistently exhibited an upward trajectory, peaking in 2023 at approximately 1,300. In details, the increase in citations was modest until 2018. However, from 2019 to 2023, citations rose rapidly. This trend may be attributed to recent publications making more significant contributions and attracting greater scholarly attention compared to earlier works.

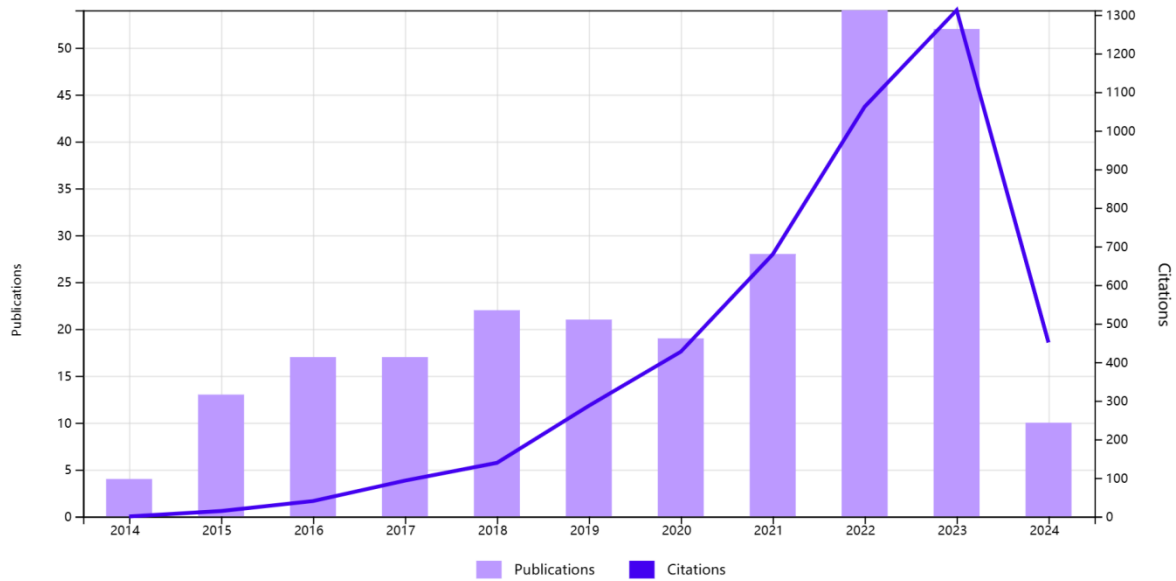


Figure 2: The number of publications and citations related to SE research from 2014 to May,2024

### 3.1.2 Research categories

Figure 3 illustrates the ten most prevalent research categories among the 257 publications. The categories are ranked by the number of publications, with Environmental Studies leading at 62 publications. This is followed by Urban Studies with 54 publications and Public Environmental Occupational Health with 51 publications. Geography and Environmental Sciences account for 44 and 43 publications, respectively. Other notable categories include Transportation with 35 publications, Regional Urban Planning with 33, and Green Sustainable Science Technology with 22. Geography Physical and Ecology have the fewest publications in the top 10, with 19 and 17, respectively. This distribution highlights the interdisciplinary nature of SE research, with substantial contributions from environmental, urban, and public health studies.

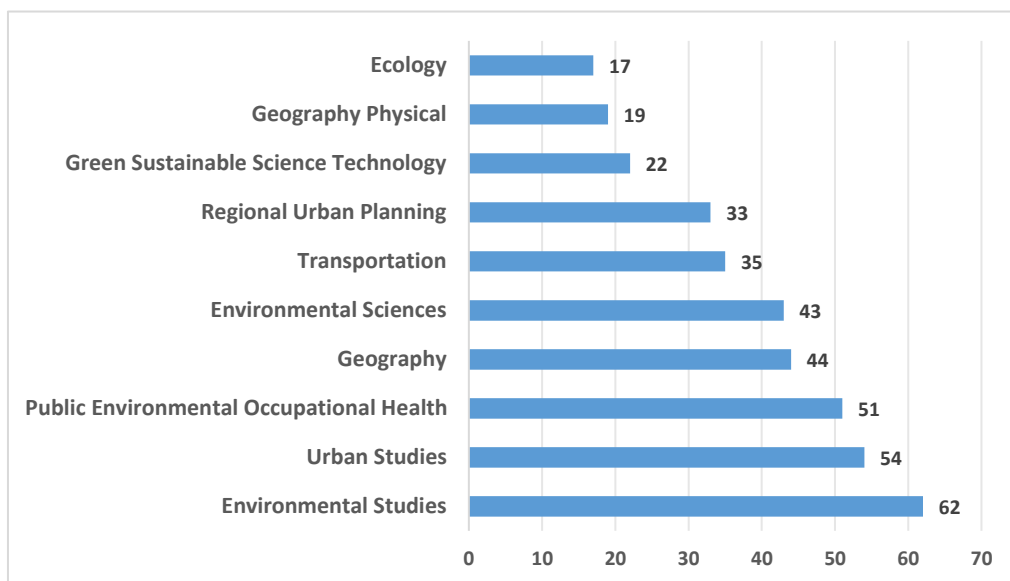


Fig. 3 The top 10 research categories of publications related to SE research

### 3.1.3 Web of science index

Table 1. Web of science index.

Rank	Web of Science Index	Count	%
1	Social Sciences Citation Index (SSCI)	168	65.37
2	Science Citation Index Expanded (SCI-EXPANDED)	128	49.805
3	Emerging Sources Citation Index (ESCI)	29	11.284
4	Conference Proceedings Citation Index – Science (CPCI-S)	23	8.949
5	Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH)	10	3.891
6	Arts & Humanities Citation Index (A&HCI)	9	3.502

Table 1 lists the WoS indexes for 257 SE publications. The data indicates that the Social Sciences Citation Index (SSCI) comprises the highest proportion at 65.37% (168 articles), followed by the Science Citation Index Expanded (SCIE) at 49.805% (128 articles). The remaining indices show significantly lower representation, with the Arts & Humanities Citation Index (A&HCI) exhibiting the lowest representation at 3.502% (9 articles). In conclusion, this distribution demonstrates the multidisciplinary interest and diverse academic engagement in SE research.

### 3.1.4 Citation analysis

Table 2. Top 10 most highly cited journals

Rank	Journals	NC	NP	AC
1	Environment International	347	3	115.67
2	International Journal of Environmental Research and Public Health	293	13	22.54
3	Journal of Transport Health	276	8	34.50
4	Cities	248	8	31.00
5	Landscape and Urban Planning	235	12	19.58
6	Urban Forestry Urban Greening	230	9	25.56
7	Journal of Transport Geography	129	8	16.13
8	Computers Environment and Urban Systems	121	6	20.17
9	BMC Public Health	108	5	21.60
10	Sustainability	53	10	5.30

The number of citations (NC) effectively reflects the impact of source, countries/regions, organizations, and authors. Table 2 summarises an overview of the top ten most highly cited journals related to SE research. It details the total number of publications (NP), the total NC, and the average number of citations (AC) for each journal. The journals are ordered according to their NC ranking as follows: Environment International (347), International Journal of Environmental Research and Public Health (293), Journal of Transport Health (276), Cities(248), Landscape and Urban Planning(235), Urban Forestry Urban Greening(230), Journal of Transport Geography(129), Computers Environment and Urban Systems(121), BMC Public Health (108 ), and Sustainability(53).

It is worth noting that Environment International exhibits significantly higher NC (347) and AC (115.67) compared to other journals, despite having the lowest NP (3) among them. This suggests that Environment International holds substantial potential in SE research. In addition, The journal Sustainability, with the third highest NP (10), has the lowest NC (53) and AC (5.3). This discrepancy indicates that the quality of articles published in Sustainability may be lower compared to those in journals with higher AC values.

Table 3. Top 10 most highly cited countries/regions, organizations, and authors.

Rank	Country/Region	NC	Organizations	NC	Author	NC
1	China	1898	China University of Geosciences	470	Lu, Yi	458
2	USA	1848	City University of Hong Kong	458	Li, Xiaojiang	439
3	Canada	552	University of California San Di-ego	422	Cain, Kelli L.	412
4	England	463	University of British Columbia	411	Conway, Terry L.	412
5	Australia	463	Wuhan University	399	Frank, Lawrence	402
6	Netherlands	425	University of Washington	359	Wang, Ruoyu	390
7	Spain	290	University Pennsylvania	353	Geremia, Carrie	365
8	Japan	228	University Utrecht	346	Glanz, Karen	353
9	Belgium	133	Massachusetts Institute of Technology Mit	343	Saelens, Brian	353
10	New Zealand	127	Sun Yat Sen University	328	Sallis, James	353

The top ten countries/regions, organizations, and authors with the highest NC related to SE research are shown in Table 3. With regard to countries/regions, China leads with 1,898 citations, followed closely by the USA with 1,848 citations. Canada (552), England (463), and Australia (463) also rank highly. The remaining five countries/regions are the Netherlands (425), Spain (290), Japan (228), Belgium (133), and New Zealand (127). Regarding organizations, the China University of Geosciences ranks first with 470 citations, followed by the City University of Hong Kong in China (458), University of California San Diego in the USA (422), University of British Columbia in Canada (411), and Wuhan University in China (399). China and the USA each have four organizations, while Canada and Netherlands each have one. In terms of authors, Lu, Yi from China is the most influential author in the field of SE, with 458 citations. Li Xiaojiang from China follows with 439 citations, while Cain Kelli L. (412), Conway Terry L. (412) from the USA, and Frank Lawrence from Canada (402) are also prominent. Notably, these three authors collaborated on a highly cited publication as shown in Table 4, further enhancing their impact in the SE domain. Moreover, Wang Ruoyu from China, with 390 citations, contributed to the highest-cited article and another highly cited publication alongside Lu Yi.

Table 4 presents a comprehensive overview of the top ten most highly cited publications, highlighting key metrics such as the NC, AC, source, years, number of authors (AN), number of organizations (ON), and number of countries/regions (CN) involved in each publication. The result shows that the most influential publication is by Helbich et al. (2019), which has garnered 299 citations. Notably, All of the top ten most frequently cited articles were the result of multi-author collaborations, with five articles coming from different organizations in the same country, while the other five involved international cooperation. The findings suggest that collaboration between authors, organizations, and countries/regions contributes significantly in enhancing the quality of publications. Moreover, most of the highly cited works were published after 2018. This suggests that there has been a recent surge in interest and research outputs in the SE field, possibly driven by the need for sustainable urban planning.

Table 4 The top 10 most highly cited publications

Rank	Title	Source	Year	NC	AC	AN	ON	CN
1	Using deep learning to examine street view green and blue spaces and their associations with geriatric depression in Beijing, China.(M, Helbich; Y, Yao; Y, Liu; J, Zhang; P, Liu; R, Wang 2019)	Environment International	2019	299	49.83	6	4	2
2	To walk or not to walk? Examining non-linear effects of streetscape greenery on walking propensity of older adults. (L, Yang; Y, Ao; J, Ke; Y, Lu; Y, Liang 2021)	Journal of Transport Geogr- aphy	2021	204	51	5	5	1

3	Mapping sky, tree, and building view factors of street canyons in a high-density urban environment. (Gong et al. 2018)	Building and Environment	2018	173	24.71	6	7	2
4	Contribution of streetscape audits to explanation of physical activity in four age groups based on the Microscale Audit of Pedestrian Streetscapes (MAPS). (Cain et al. 2014)	Social Science & Medicine	2014	143	13	12	8	2
5	Social inequalities in neighborhood visual walkability: Using street view imagery and deep learning technologies to facilitate healthy city planning. (Zhou et al. 2019)	Sustainable Cities and Society	2019	137	22.83	5	5	1
6	Social sensing from street-level imagery: A case study in learning spatio-temporal urban mobility patterns. (Zhang et al. 2019)	Isprs Journal of Photogrammetry and Remote Sensing	2019	110	18.33	4	2	2
7	Natural outdoor environment, neighbourhood social cohesion and mental health: Using multilevel structural equation modelling, streetscape and remote-sensing metrics. (Y, Liu; R, Wang; Y, Lu; Z, Li; H, Chen; M, Cao; Y, Zhang; Y, Song 2020)	Urban Forestry & Urban Greening	2020	90	18	8	10	2
8	Objective scoring of streetscape walkability related to leisure walking: Statistical modeling approach with semantic segmentation of Google Street View images. (Nagata et al. 2020)	Health & Place	2020	88	17.6	6	2	1
9	Measuring human perceptions of streetscapes to better inform urban renewal: A perspective of scene semantic parsing. (Ma et al. 2021)	Cities	2021	86	21.5	8	6	1
10	Effects of skeletal streetscape design on perceived safety. (Harvey et al. 2015)	Landscape and Urban Planning	2015	84	8.4	4	4	1

### 3.2 Cooperation networks

The 257 publications on the SE study involved 42 countries, 401 organisations and 925 authors, so it was necessary to analyse their collaborative relationships. This section examines cooperation networks from three perspectives: international partnerships, inter-organizational collaboration, and co-author relationships, using the software tools VOSviewer and Scimago Graphica.

#### 3.2.1 The international cooperation networks

To study the cooperation between countries/regions in the field of SE from a macroscopic perspective, Scimago Graphica software was employed to examine their distribution and interactions. The results are shown in Figure 4. Firstly, the size of each circle represents a country's output. Larger circles indicate higher output. Among the 42 countries/regions, China and the United States dominate, with 82 and 77 publications, respectively. Moreover, it is evident that publications related to SE are predominantly concentrated in Asia, North America, and Europe. Secondly, the lines in Figure 4 represent the co-operation between the countries/regions, with the thickness of the lines indicating the strength of the collaborations. These countries/regions are grouped into six clusters. Two of the most productive countries demonstrate strong collaborative relationships with others, as evidenced by the thicker lines. The result suggests that international cooperation enhances both the quantity and quality of research output.



Fig. 4 Country collaboration map

Table 5 The top 10 active and productive countries/regions

Rank	Country/regions	NL	NC	Country/regions	NP	NC
1	USA	70	1848	China	82	1898
2	China	62	1898	USA	77	1848
3	Australia	36	463	England	26	463
4	England	26	463	Australia	25	463
5	Spain	26	290	Japan	23	228
6	Brazil	22	105	Canada	20	552
7	Belgium	21	133	Netherlands	13	425
8	Japan	21	228	Spain	12	290
9	Canada	18	552	Germany	10	37
10	Netherlands	18	425	Belgium	9	133

Moreover, the top ten countries/regions are shown in Table 5 ranked by NP and the number of links (NL). Through the analysis presented in Figure 4 and Table 5, we find that the USA has the highest NL (70), followed by China (62) and Australia (36). Notably, the rankings based on NL differ from those determined by NP and NC. For example, the NL of China is slightly lower than that of the USA, although its NP and NC are all the highest. This result may be due to a lack of collaboration with countries/regions such as Malaysia, Russia, Italy, and France.

### 3.2.2 The co-organization network

A total of 401 organizations have contributed to SE research publications. To analyze the co-organization network, we use VOSviewer software, setting a threshold of a minimum of 3 publications per organization, which 63 organization meet. As shown in Fig. 5, only 50 organizations are displayed because some of the 63 organizations lack connections with others. In this figure, nodes symbolize organizations, with node colors indicating 6 distinct clusters. The link thickness reflects the strength of cooperative relationships between organizations. Additionally, Table 6 lists the most productive organizations, ranked by NP and NL. According to it, University of California San Diego is the leading organization in terms of activity and productivity, while the rankings of other organizations vary.

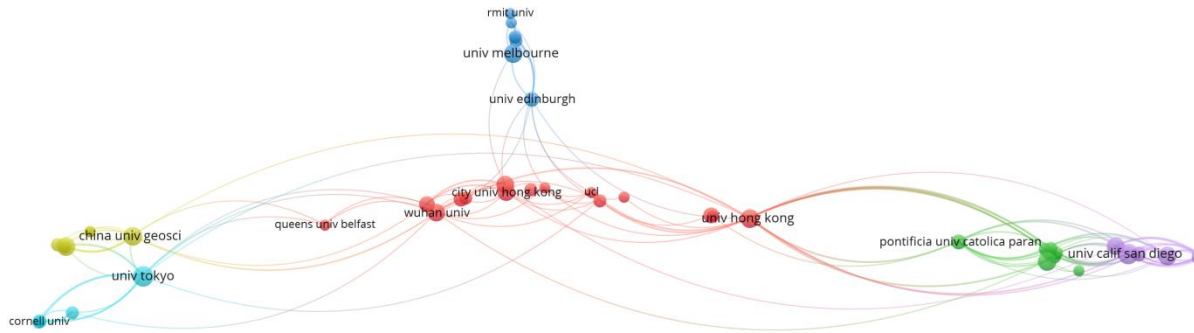


Fig. 5 The co-organization network

Figure 5 and Table 6 reveal strong cooperation among 50 organizations, with the University of California San Diego, the University of British Columbia, and the University of Hong Kong serving as central hubs due to their high NL and NP. However, the broader network of 401 organizations engaged in SE research demonstrates a notable lack of cooperation and collaboration. Institutions with higher publication outputs, such as the University Melbourne, University Utrecht, Wuhan University, Tongji University, and City University of Hong Kong, should enhance their cooperative efforts with other organizations to improve the quality of their research.

Table 6 The top active and productive institutions

Rank	Organizations	NL	NC	Organizations	NP	NC
1	University of California San Diego	71	422	University of California San Diego	10	422
2	University of British Columbia	46	411	University Tokyo	10	116
3	University of Hong Kong	43	300	University of British Columbia	8	411
4	University of Washington	41	359	University of Hong Kong	8	300
5	University Ghent	39	129	China University of Geosciences	8	470
6	Urban Design 4 Hlth Inc	39	284	University Ghent	8	129
7	Australian Catholic University	36	59	University Utrecht	8	346
8	University Tokyo	36	116	University Melbourne	8	193
9	China University of Geosciences	32	470	University of Washington	7	359
10	Deakin University	32	77	Wuhan University	7	399
10	University Pennsylvania	32	353	Tongji University	7	282
10				City University of Hong Kong	7	458

3.2.3 The co-author network

The co-author network was generated based on VOSviewer to explore the cooperation of 925 authors. Notably, only 109 out of the 925 authors formed a connected network. Figure 6 presents the visualization results of 109 authors, with each node representing an author and the node colors indicating 10 distinct clusters. To gain a clearer understanding of the cooperative relationships among authors, Table 7 provides a ranking of authors according to NP and NL.

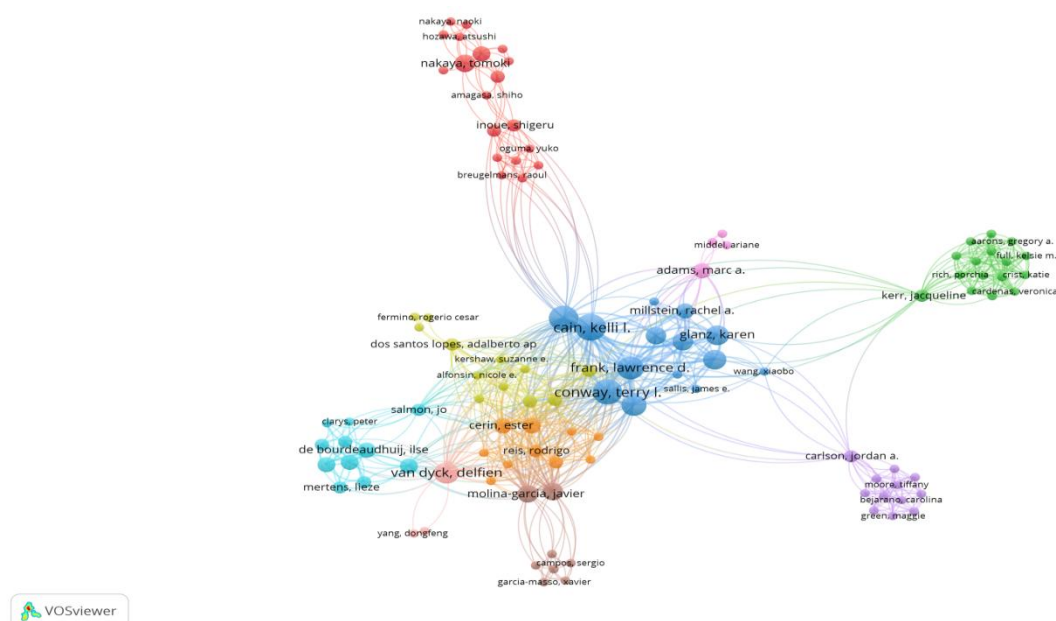


Fig. 6 The co-author network

Table 7 The top active and productive authors

Rank	Authors	NL	NC	Authors	NP	NC
1	Cain, Kelli L.	105	412	Cain, Kelli L.	9	412
2	Conway, Terry L.	96	412	Conway, Terry L.	8	412
3	Sallis, James F.	96	353	Sallis, James F.	8	353
4	Frank, Lawrence D.	82	402	Li, Xiaojiang	8	439
5	Geremia, Carrie M.	69	365	Lu, Yi	8	458
6	Van Dyck, Delfien	64	115	Frank, Lawrence D.	7	402
7	Molina-garcia, Javier	55	96	Geremia, Carrie M.	6	365
8	Queralt, Ana	55	96	Van Dyck, Delfien	6	115
9	Cerin, Ester	48	59	Glanz, Karen	5	353
10	Timperio, Anna	48	59	Saelens, Brian E.	5	353
10	Saelens, Brian E.	48	353	Yao, Yao	5	329
10	Glanz, Karen	48	353	Qiu, Waishan	5	103

Figure 6 and Table 7 reveal that the majority of authors have completed their publications independently. Notably, Cain, Kelli L. from the USA stands out, with the highest NL(105) and NP(9). Moreover, some authors, such as Lu, Yi and Li, Xiaojiang, who have the second highest NP(8), do not exhibit strong NL. In Table 6, it is evident that Cerin, Ester and Timperio, Anna have the same NL(48) and NC(59). A detailed examination of their publications reveals that Cerin, Ester from the University of Hong Kong in China co-authored all her publications with Timperio, Anna from Deakin University in Australia. Similarly, Saelens, Brian E. consistently collaborated with Glanz, Karen. Additionally, Molina-garcia Javier and Queralt Ana, both from the University of Valencia in Spain, have established strong collaborative relationships with Cain, Kelli L.

In conclusion, team collaboration appears to significantly enhance author influence. Therefore, authors who currently lack collaborative efforts should communicate and collaborate more with others, particularly authors with high publication counts. This approach will foster the advancement of SE research.

### 3.3 Keyword analysis

This section utilizes keyword analysis to explore the themes and emerging trends. It involves performing co-occurrence analysis and keyword cloudmap analysis through two software tools: VOSviewer and Scimago Graphica.

### 3.3.1 Co-occurrence analysis

Co-occurrence analysis involves calculating and analyzing the frequency of keyword co-occurrences to reveal the underlying associations and thematic relationships between keywords (Mainali et al., 2022). Thus, the researchers obtain the work of author keywords and keywords plus by employing VOSviewer software as shown in Figure 7. A minimum occurrence threshold of six was set, resulting in 73 out of 1293 keywords meeting this criterion.

Figure 7(a) depicts the findings as follows: (1) Regarding SE research, the five keywords with the most occurrence are "built environment" (99 occurrences, blue), "physical activity" (68 occurrences, red), "walking" (57 occurrences, blue), "walkability" (52 occurrences, red), and "streetscape" (50 occurrences, green). (2) The 73 keywords have been classified into five clusters. The first cluster with red color comprises 23 nodes, emphasizing the impact of SE on activity and health. The primary keyword is "physical activity" (Occurrences=68, Total lines strength=444), followed by "walkability" (Occurrences = 52, Total lines strength = 339) and "health" (Occurrences = 31, Total lines strength = 183). Cluster 2 with green color includes 23 nodes, with the research subject focus on streetscape quality, environmental characteristics, and perception. The leading term is "streetscape" (Occurrences = 50, Total lines strength = 197), followed by "perception" (Occurrences = 35, Total lines strength = 176) and "environment" (Occurrences = 34, Total lines strength = 124). Cluster 3 with blue color includes 17 nodes and centers on the neighborhood environment of street. The most important term is "built environment" (Occurrences = 99, Total lines strength = 535), followed by "walking" (Occurrences = 57, Total lines strength = 349) and "neighborhood" (Occurrences = 27, Total lines strength = 169). The research thematic that land-use of street affect mental-health is identified in Cluster 4 (yellow) with 6 nodes. The key term is "impact" (Occurrences = 11, Total lines strength = 60), "land-use" (Occurrences = 17, Total lines strength = 64), and "exposure" (Occurrences = 9, Total lines strength = 43). Cluster 5 with purple color contains 4 nodes, focusing on space design related to SE research. "Urban design" is the major keyword (Occurrences = 32, Total lines strength = 194). This comprehensive analysis indicates that the topic of place attachment in field of SE research remains underdeveloped. Future research should aim to explore this area more thoroughly to enhance our understanding of its implications.

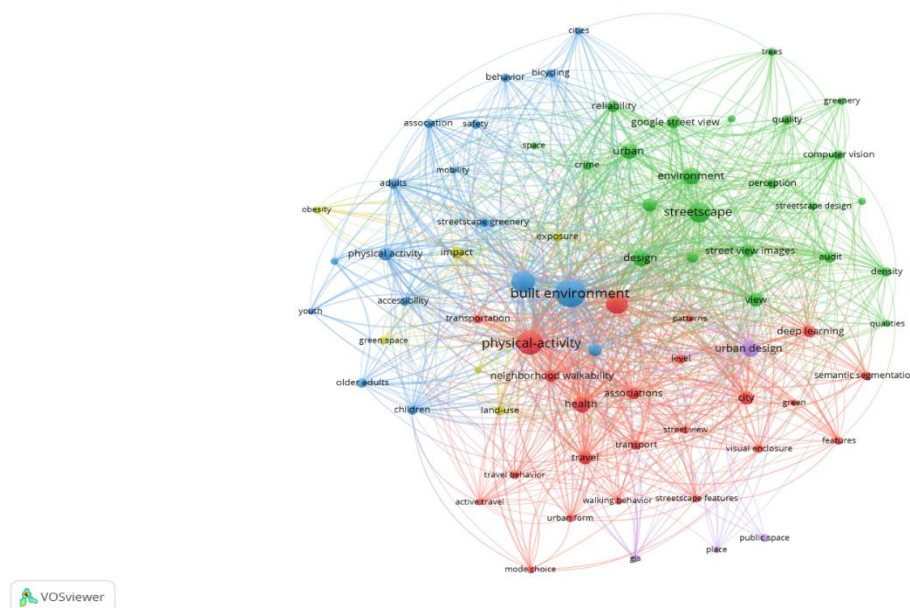


Fig. 7(a) : Co-occurrence network of all keywords of SE study. Online link:<https://tinyurl.com/25cjexzk>.

To investigate the temporal evolution of keyword occurrences, Figure 7(b) presents the overlay co-occurrence network of all the keywords, with color indicating the average year of appearance. Specifically, lighter colors indicate more recent appearances. It is evident that “street view images”, “machine learning”, “perception”, “qualities”, and “behavior” are key areas of focus for scholars in the SE field. This suggests the primary research focus related to SE has shifted from the physical characteristics to the people-place relationship. In addition, Figure 7(c) shows the frequency of co-occurring term clusters related to SE research. It is easy to find that in this cluster “built environment”, “physical-activity”, “streetscape”, “urban design”, “deep learning”, and “travel” are the most prevalent terms. The observations offer significant insights into the primary focus areas within SE research.

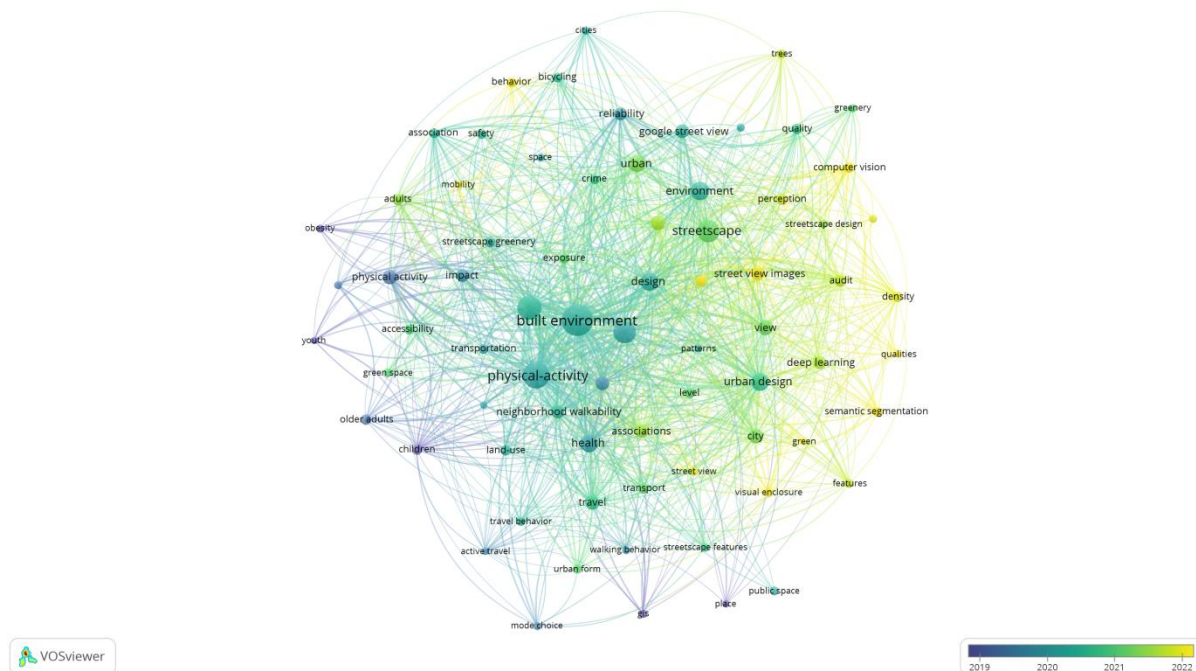


Fig. 7(b): Overlay co-occurrence network of all keywords of SE study. Online link: <https://tinyurl.com/25cjexzk>.

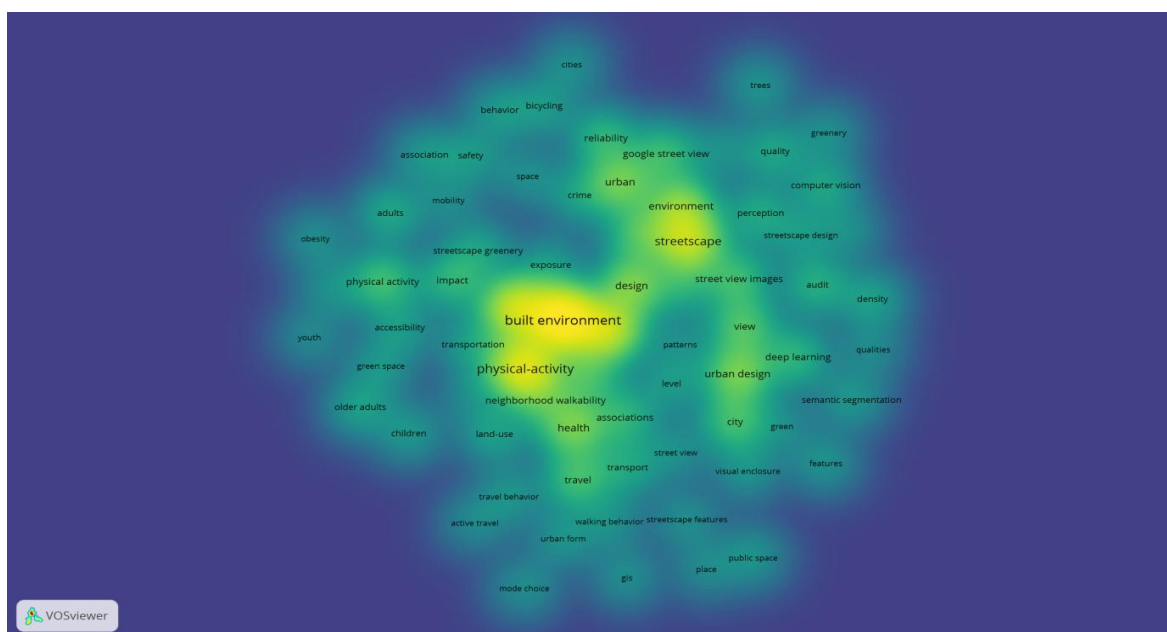


Fig. 7(c): Keywords co-occurrence in cluster density of SE study. Online link: <https://tinyurl.com/25cjexzk>.

### 3.3.2 Co-citation references analysis

The researchers used VOSviewer software to analyze the co-citation references. A minimum CN threshold for a cited reference was set to be five, identifying a total of 261 publications in this study. Notably, no references among the 261 items are isolated, indicating connectivity within the network. Figure 8 displays the co-citation references network. It can be found that all items are divided into 5 clusters. Ewing(2009) in cluster 3 gains the highest number of co-citation references(51), followed by Xj, Li(2015) in cluster 5 with 35 co-citation references, then Jacobs (1961), also found in Cluster 3, is the third most cited study.

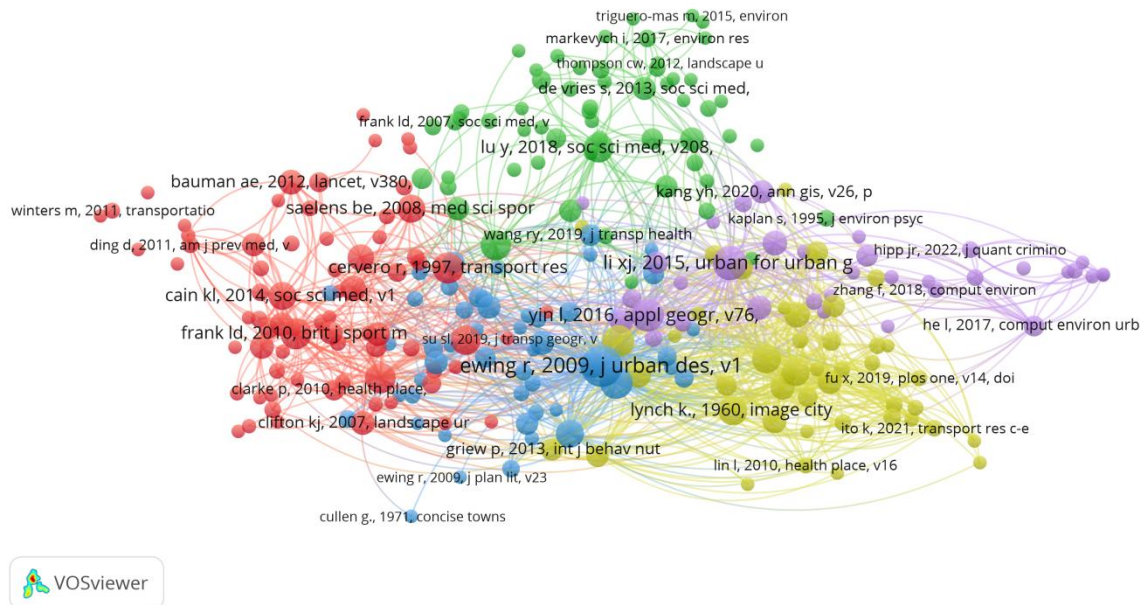


Fig. 8: The co-citation references network related to SE research. Online link:<https://tinyurl.com/29ws73y8>

## 4. Conclusion and limitations

This study employs a bibliometric analysis methodology to provide an objective and comprehensive review of the extant literature in the field of SE research. The selected dataset includes a total of 257 publications from the WoS database. The assessment tools for analysing contains the VOSviewer and SCImago Graphica software. This study covers literature from 2014 to May 2024, providing light on Basic Statistics(annual indicators, research categories, web of science index, citation analysis), cooperation networks (co-country/region, co-organization, co-author), and keyword analysis(co-occurrence, co-citation references). Consequently, five key findings are identified and discussed as follows:

- i. During this period, the overall trend in the annual distribution of publications and citations in SE research is robust and positive growth over time. SE research is interdisciplinary, with significant contributions to environmental, urban, and public health studies. Global statistics suggest that 65.37% of the publications (168 papers) are found in the SSCI, indicating that a significant portion of SE research is recognized within the humanities and social sciences.
- ii. Research interest and publication productivity in the field of SE have increased in recent years. Notably, Environment International is an considerable potential journal for SE research. China and the United States have become relatively influential countries. Lu, Li, and Cain are identified the most influential authors. The leading institution is the China University of Geosciences.
- iii. Cooperation can enhance both the quantity and quality of research output. The publications related to SE are predominantly from Asia, North America, and Europe, with China and the

United States being the most productive countries. However, most organizations engaged in SE research exhibit a lack of cooperation and collaboration. The University of California San Diego is the leading organization in terms of activity and productivity. Cain, Kelli L. from the United States is notable for her high number of publications and total link strength.

iv. The topic of urban design in field of SE research remains underdeveloped. The noteworthy keywords are “built environment”, “physical-activity”, “streetscape”, “urban design”, “deep learning”, and “travel”. Additionally, other recent hotspots include “street view images”, “machine learning”, “perception”, “qualities”, and “behavior”.

v. Ewing (2009) holds significant influence and recognition in the field of SE, evidenced by having the most co-citation references.

In addition, current SE research areas are predominantly focused on the environment, public health, physical activity, urban design, machine learning, and quality evaluation, which has significant limits. With the rapid advancement of urbanization and economic development, the impact scope of SE research will extend to the field of human emotions, for example it will encompass residents’ perceptions, such as place identity, place attachment, and social cohesion, affected by the changes of streetscape environment in the tourism area.

To ensure scientific rigour, a total of 257 publications of this study were retrieved from a single database, namely the Web of Science. However, it is important to recognize that relying solely on a single database may result in biased outcomes. To prevent this study limitation, it is necessary to adopt more sources and different data sets in future research to achieve a more comprehensive and balanced analysis.

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