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GREEN OPEN SPACE RESEARCH IN SUPPORTING SUSTAINABLE URBAN PLANNING EFFORTS: FOCUSED LITERATURE REVIEW

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Abstract
Green open spaces (GOS) are vital infrastructure for promoting ecological balance, improving urban livability, and enhancing climate resilience. Although their global importance is increasing, scientific advancements in GOS in landscape architecture remain fragmented and unevenly distributed. This study offers a thorough bibliometric analysis of GOS research to chart its global development, key themes and emerging areas. Data were sourced from the Scopus database (1968–2026) and examined using VOSviewer and Biblioshiny to identify the publication trends, collaboration networks, and thematic clusters. The findings indicate a significant increase in research output post-2015, influenced by global sustainability frameworks such as the Paris Agreement and Sustainable Development Goals. China, the United States, and the United Kingdom have emerged as leading contributors, whereas Indonesia and other Southeast Asian nations have shown increased involvement, especially in tropical urban settings. Keyword network analysis highlighted a conceptual shift from aesthetic and recreational views to transdisciplinary themes connecting nature-based solutions, ecosystem services, public health and urban resilience. These results emphasize the growing integration of landscape architecture with environmental science and policy-driven sustainability. Future research should focus on context-specific frameworks, digital and geospatial modeling, and equitable access to green spaces, particularly in regions vulnerable to climate change effects. This study reaffirms the role of landscape architecture in advancing GOS as adaptive, regenerative, and inclusive infrastructure for sustainable urban development.
Keywords*: Green open space; Landscape architecture; Urban resilience; Climate adaptation; Bibliometric analysis; Sustainable cities*

INTRODUCTION

Urbanization has rapidly altered the spatial and ecological makeup of cities worldwide, frequently resulting in the deterioration of natural habitats, heightened surface temperatures, and reduced public well-being[1]. Currently, over 55% of the world's population lives in urban areas, and this figure is expected to rise to 68% by 2050. This urban growth places significant strain on land resources and contributes to environmental challenges, such as urban heat islands, air pollution, flooding, and biodiversity loss[2]. In this scenario, green open spaces (GOS), which include parks, urban forests, green corridors, and ecological parks, have become vital infrastructures that support urban ecological functions and bolster climate resilience[3].

Green open spaces offer various ecosystem services, including microclimate regulation, carbon sequestration, biodiversity support, and mental and physical health enhancement [4]. Recently, the idea of GOS has expanded

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from merely recreational areas to becoming a strategic tool for urban climate adaptation and mitigation[5]. Cities such as Singapore, Copenhagen, and Melbourne have demonstrated how well-planned GOS networks can enhance climate resilience by managing stormwater, regulating temperatures, and promoting green mobility systems [6], [7]. Despite these advancements, developing nations, particularly in tropical areas, still encounter difficulties in planning, maintaining, and assessing the effectiveness of GOS as an adaptive infrastructure [8]. From a landscape architecture perspective, planning and designing GOS requires a transdisciplinary approach that integrates ecological science, spatial design, and social inclusivity [9]. However, scientific exploration in this area remains limited[10]. Previous research has mainly concentrated on urban greening strategies, sustainability indicators, and nature-based solutions, but has seldom synthesized the knowledge structure, thematic evolution, and research collaboration networks that form the foundation of GOS studies[6], [11]. Consequently, the lack of a comprehensive review that integrates these aspects limits the understanding of how GOS research contributes to urban climate resilience and sustainable development goals (SDGs)[12].

Bibliometric analysis has become a significant tool for evaluating scientific progress across various fields by identifying publication patterns, key contributors, and new research areas[13]. By employing bibliometric mapping, one can visualize the development of knowledge within a discipline, uncovering international collaborations and research gaps that require further investigation[14]. Utilizing this method in GOS studies offers a chance to elucidate the advancement, interaction, and future directions of research at the crossroads of urban ecology, climate resilience, and landscape architecture [15].

This study aims to perform an extensive bibliometric analysis of the global literature on green open spaces, emphasizing their function as infrastructure for urban climate resilience. The study's objectives are to (i) uncover temporal patterns and geographical distribution in GOS research; (ii) identify the leading countries, institutions, and authors in this domain; (iii) investigate thematic development through keyword co-occurrence and clustering; and (iv) suggest future research paths to better integrate GOS into resilient-landscape planning strategies. The findings are anticipated to aid policymakers, planners, and researchers in maximizing the role of GOS as a cornerstone of sustainable and climate-resilient urban settings.

MATERIALS AND METHODS

This study utilized a structured approach through bibliometric analysis to investigate the evolution and patterns of green open spaces across three distinct stages (Fig. 1). Initially, the process involved data mining by delving into the literature specific to the subject. The subsequent stage comprised an extensive bibliometric analysis that included various parameters, and the final stage was dedicated to presenting the findings of the study. The literature review was limited to relevant references identified using keywords derived from the bibliometric analysis. The methodological approach for each stage is detailed in the following section, with slight modifications from previous methods.

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Literature search strategy

On October 11, 2025, a document search was conducted in Scopus to obtain this information. Scopus was selected for its extensive range and accessibility to research publications in various disciplines. Bibliographic data mining concentrated on green open spaces (ARTICLE TITLE, ABSTRACT, KEY WORDS (green open space AND landscape architecture)) within Scopus. The search yielded 1516 documents, which included 1050 articles, 13 books, 103 book chapters, 17 conference proceedings, and other types of documents. The collected data included article titles, abstracts, and keywords.

Bibliometric analysis

The bibliometric analysis concepts and procedures of this study are based on Anshori et al. [40], with a focus on Biblioshiny and VOSviewer. The analysis employed three methods: general data analysis, global topic development, and keyword-based topic development. VOSviewer (Leiden University, Leiden, Netherlands) and RStudio (version 2024.09.1-394, R Studio Inc., Boston, MA, USA) are utilized to access bibliometric packages, each offering distinct functions for conducting bibliometric analysis.

VOSviewer is a widely used tool in bibliometric studies. It primarily focuses on handling document data and interconnected knowledge elements to construct a scientific knowledge map that illustrates the relationships within the literature on a specific topic.

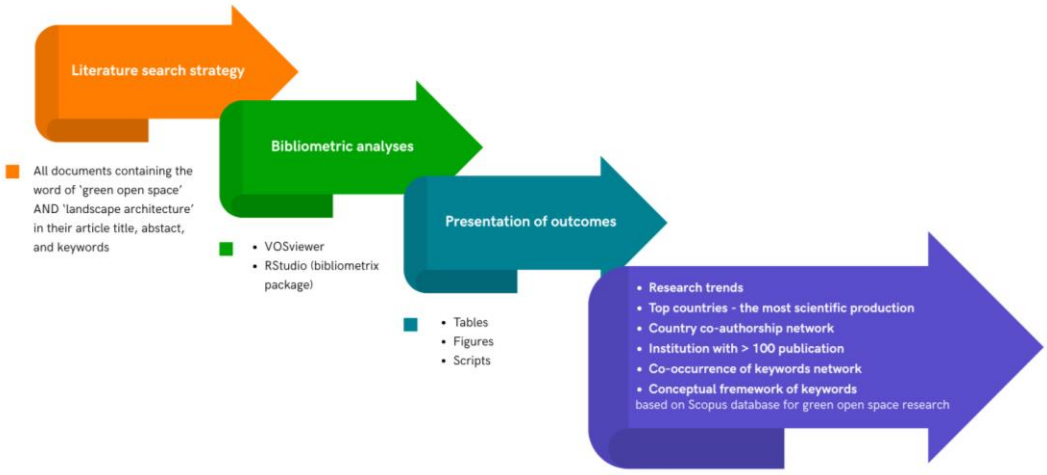

Fig. 1. Flow chart of the bibliometric review process

VOSviewer offers comprehensive graphical displays and can accommodate various database formats. This software detects clusters of interactions, international collaborations, keyword associations, and citation links among publishers. Items are represented by labels and circles, where the size of the circle denotes the frequency of the item. Certain items were excluded from the analysis to avoid overlap. The colors in the network visualization or text map signify groups of similar items, as determined by the program. The proximity of items indicates the strength of their relationships.

RStudio, when used alongside the bibliometric package, offers support for bibliometric concepts at a negligible cost. This software can tap into various data

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mining sources, enhance reference accuracy using string-based algorithms, conduct direct and tri-citation analyses, and employ a hybrid method that merges bibliometric and semantic techniques. We utilized Biblioshiny to generate informative visuals and summary tables.

RESULT

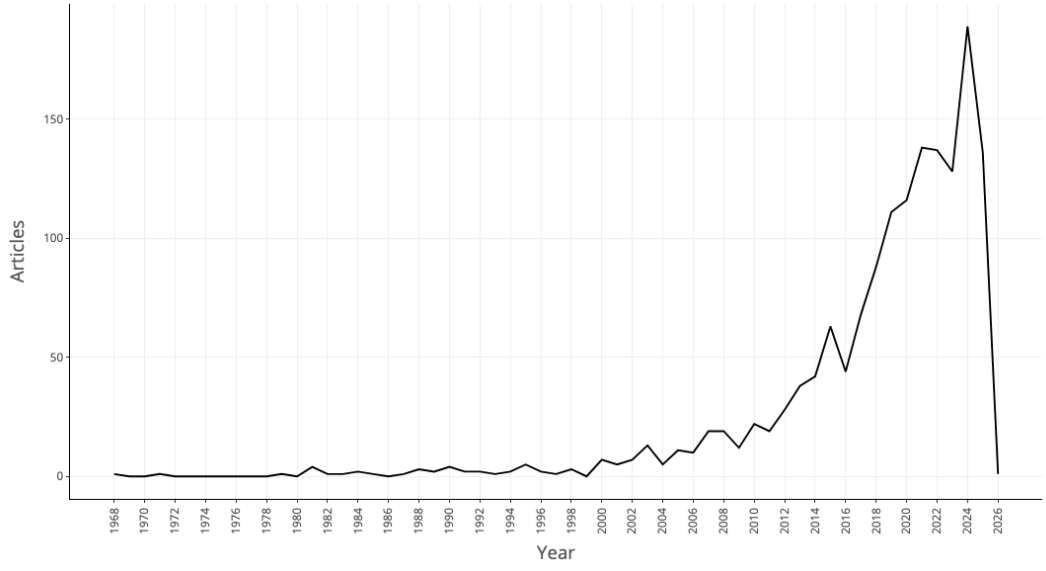
General trends in green open space–related documents in Scopus

Through data mining in Scopus, 503 journals were identified as contributors to green open space research, showing an annual growth rate of 0%. The analysis revealed 3867 authors, with an average of 6.38 co-authors per paper and an international collaboration rate of 18.27%. Each document had an average citation rate of 25.33 citations. These findings provide essential data for evaluating research progress in the field of green open spaces.

Research publications on green open spaces, as recorded in the Scopus database, began in 1968 and extend through 2026 (Fig. 2). The most significant rise was observed in 2024, with nearly 200 articles, a 25% increase from the previous year. This was followed by a slight drop in 2025 and a more pronounced decline at the start of 2026, attributed to data being available only until October. Additionally, there were several peaks in the average citations per year, with the highest in 2004 and another notable peak in 2016. However, after 2022, the annual number of published articles decreased sharply in 2024 and 2025.

Country trends in green open space-related documents in Scopus

According to trends in green open space research, China and Indonesia lead in scientific publications, with 777 and 412 papers, respectively, significantly outpacing the United States, which ranks third with just 323 publications (Table 1).



(a)

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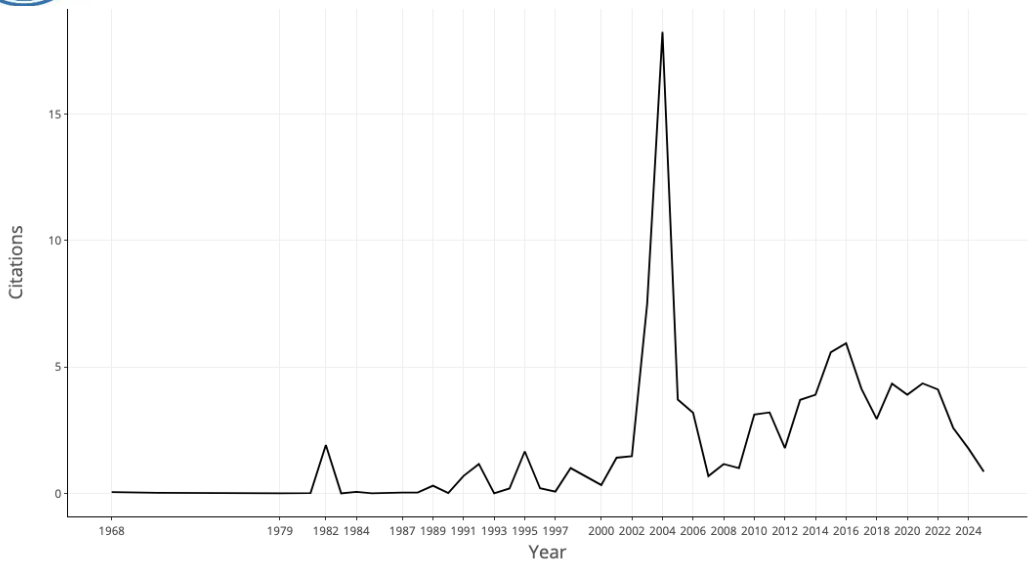

(b)

Fig. 2. (a) Annual publication rate and (b) average citation per year based on the Scopus database (1968–2026) for green open space-related research.

The influence of the institution was crucial in determining the outcomes of this study. Among the ten institutions with the most pertinent publications, eight were based in China, with the Department of Landscape Architecture leading in publication volume on this subject (Table 2). Conversely, Singapore is represented by only one institution, the National Parks Board (NParks), which is dedicated to researching green open space topics and ranks tenth.

Table 1 Top 10 countries with the highest scientific production based on the Scopus database (1968–2026) for green open space-related research.

Country	Total Publication
China	777
Indonesia	412
USA	323
Germany	300
Australia	221
Italy	206
UK	186
Spain	175
Turkey	157
India	156

Table 2 Institutions with 29 or more publications on green open space-related research based on the Scopus database (1968–2026).

Institution	Total publications	Country
Department of Landscape Architecture	80	China
Sveriges Lantbruksuniversitet	46	Sweden
Northwest Aandf University	45	China
Universitas Indonesia	36	Indonesia
The University of Hong Kong	33	Hong Kong
Technische Universität München	31	Germany

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Slovak University of Agriculture In Nitra	30	Slovakia
Technische Universität Berlin	30	Germany
Boku University	29	Austria
National University of Singapore	29	Singapore

The visualization of the co-authorship network (Fig. 3A) depicts the global collaboration framework among countries contributing to publications on green open spaces (GOS) and urban climate resilience. In this network, each node signifies a country, with its size indicating the number of publications and the thickness of the connecting lines representing the strength of collaboration. The analysis highlights China, the United States, and the United Kingdom as the most prominent and influential nodes, serving as central hubs within the network. China, the largest node, shows strong research connections with several Asian countries, notably Indonesia, Malaysia, and Japan, underscoring its leadership in urban ecological and climate adaptation research. The United States and the United Kingdom also have extensive collaborations across Europe, Asia, and Latin America, focusing on sustainability assessment, park accessibility, and ecosystem service valuation. European countries, such as Germany, the Netherlands, Spain, and Italy, form a tightly interconnected cluster, reflecting a well-established collaborative culture in ecosystem-based urban planning and green infrastructure research. Indonesia is emerging as a regional player, actively engaging with Malaysia, Japan, and China. Although its publication volume is still lower than that of the major contributors, Indonesia's increasing centrality in the network indicates its growing prominence and integration into the global research community on climate-resilient landscapes.

The overlay visualization is depicted in (Fig. 3B) offers a chronological view of this collaborative network, with node colors indicating the average publication year. Dark blue nodes mark earlier research efforts, primarily located in Western nations such as the United Kingdom, the United States, and Japan, which have been exploring GOS and urban sustainability since before 2016. As time progressed, the research focus shifted eastward, as shown by the transition to green and yellow nodes, highlighting the increased activity in countries such as China, Indonesia, Malaysia, and Bangladesh between 2020 and 2023. This temporal shift illustrates a change in research leadership from the Global North to the Global South, spurred by the pressing need for climate adaptation in rapidly urbanizing tropical regions. The bright yellow hues around Indonesia and Malaysia indicate a significant rise in publication activity following the COVID-19 pandemic, aligning with the growing academic interest in green space accessibility, human well-being, and environmental resilience. Overall, these trends demonstrate that research on green open spaces has developed into a globally interconnected field marked by expanding collaboration, thematic diversification, and increasing contributions from developing countries, which are reshaping landscape architecture with a focus on tropical and climate-responsive approaches.

Green open space thematic research area

The keyword co-occurrence network depicted in Fig. 4A illustrates the conceptual framework of global research on green open spaces (GOS) and urban climate resilience in the realm of landscape architecture. Each node signifies an author keyword, with the size of the node representing its frequency, and the

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thickness of the links indicates the strength of co-occurrence between terms. Through VOSviewer clustering, four main thematic areas were identified, highlighting the discipline's progression from traditional park and landscape design studies to interdisciplinary research that incorporates climate adaptation, health, and digital technologies.

The initial thematic group (red) focused on urban planning, sustainable development, regional planning, and sustainable cities. This cluster highlights the strategic and policy-driven aspects of GOS research, focusing on how spatial planning incorporates environmental sustainability into larger urban frameworks. Research in this area frequently explores land-use governance, flood management, drainage, and water resource management, emphasizing the role of green infrastructure in enhancing a city's resilience planning. The second group (blue) is characterized by keywords such as green space, cities, urban environment, and climate adaptation. This cluster examines the ecological and infrastructural functions of green open spaces, including carbon sequestration, biodiversity, and temperature regulation. The inclusion of terms such as microclimate, NDVI, and vegetation cover points to the increasing use of remote sensing and GIS-based techniques to evaluate the environmental performance of urban areas. The third cluster (green) pertains to human health, well-being, recreational parks, physical activity, and social environment. This theme adopts a human-centered perspective and analyzes GOS as a factor in public health, mental restoration, and social inclusion. Research in this category gained momentum after 2020, especially during the COVID-19 pandemic, when the significance of accessible urban nature for physical and psychological resilience was acknowledged globally. The fourth cluster (yellow) linked terms such as forestry, heat islands, temperature effects, environmental monitoring, and energy efficiency. It captures the technological and environmental engineering viewpoints, emphasizing how microclimate regulation, thermal comfort analysis, and vegetation dynamics are increasingly incorporated into urban landscape design. The appearance of keywords such as green computing and learning systems also indicates the early integration of digital simulation and artificial intelligence tools in GOS research.

The overlay visualization (Fig. 4B) illustrates the progression of these themes from 2016 to 2022. Earlier research (represented by dark blue nodes) focused on urban planning, forestry, and environmental monitoring. In contrast, more recent studies (green to yellow nodes) have focused on public health, well-being, and sustainable urban development. This chronological shift indicates a conceptual evolution from ecological assessment to incorporating social resilience and human health aspects into the broader sustainability discourse. The emergence of recent key terms such as nature-based solutions, climate adaptation, and green infrastructure networks suggests that GOS is now being viewed as an active urban climate-resilience system rather than merely a static recreational facility.

In conclusion, the thematic framework reveals that current studies on green open spaces are influenced by three overlapping paradigms: (i) urban sustainability and policy integration, (ii) ecological performance and technological evaluation, and (iii) human well-being and social equity. This progression signifies the changing role of landscape architecture, from crafting green spaces to managing adaptive and inclusive urban ecosystems that tackle both environmental and social issues related to climate change.

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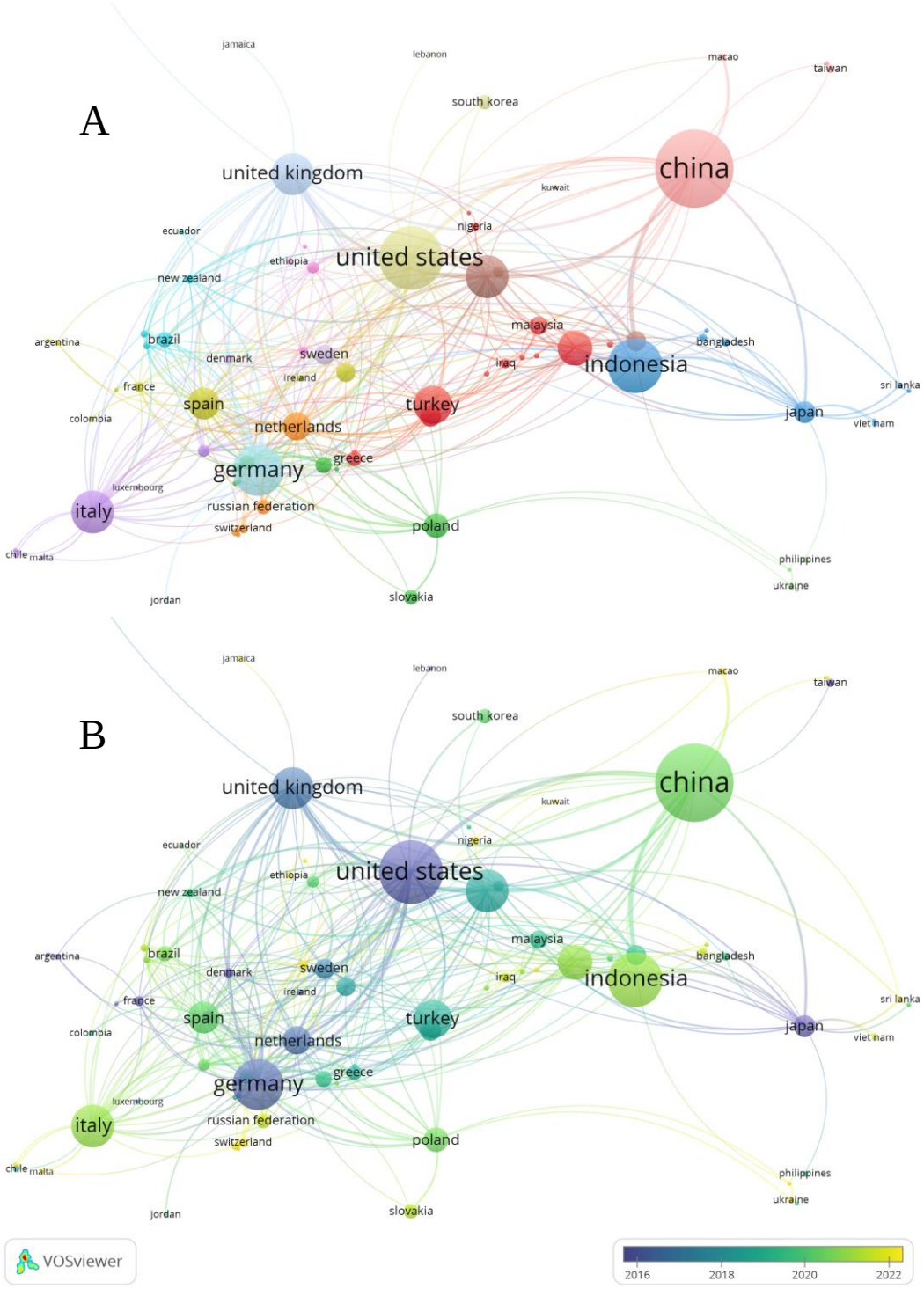

Fig. 3. Country co-authorship network (A) and time frame (B) based on the Scopus database (1968–2026) for green open space-related research.

DISCUSSION

Trends and insights into green open space research

Over the past fifty years, there has been a noticeable increase in the annual scientific output concerning green open space (GOS) and urban climate resilience,

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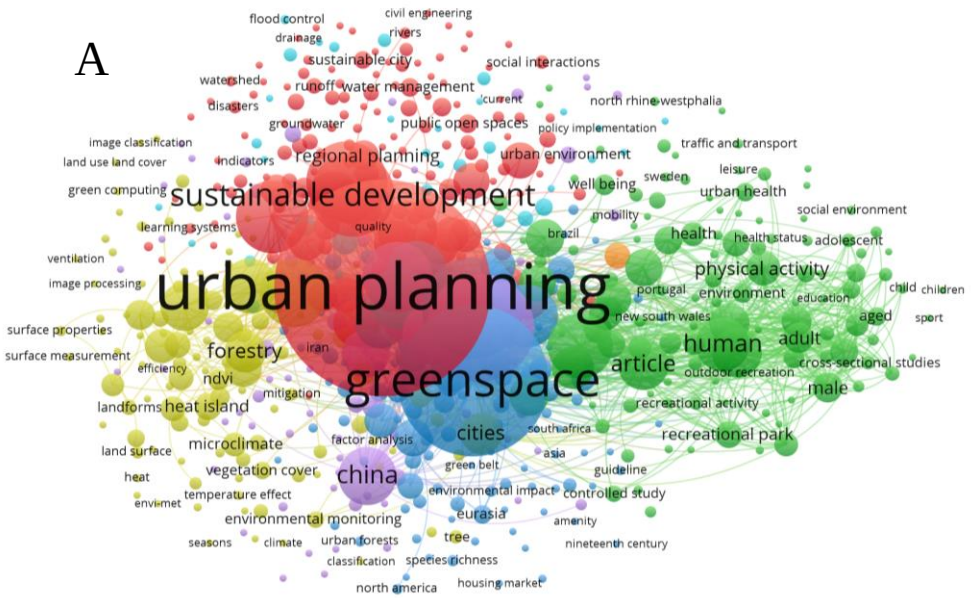
as illustrated in (Fig. 2). From 1968 until the early 2000s, the number of publications remained fairly constant, with fewer than ten articles published annually. During this initial phase, research was largely characterized by descriptive and disciplinary studies that focused on green open spaces from the perspectives of landscape aesthetics and recreation. However, around 2010, a significant turning point occurred, aligning with the global growth of sustainability science and urban ecology as academic disciplines.

Following 2015, there was a notable increase that aligned with the implementation of the Paris Agreement and the United Nations Sustainable Development Goals (SDGs), especially SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). This era signified a fundamental change, where green open spaces started to be viewed as a crucial element of urban infrastructure, with the potential to alleviate climate effects and enhance ecosystem services. The number of publications each year surged dramatically from under 40 in 2015 to over 150 by 2023, indicating a rapid rise in global scientific interest in climate-resilient-landscape planning. The observed decrease in 2025 should not be seen as a reduction in research activity but rather as a result of data limitations, as bibliometric databases such as Scopus often have delays in indexing new publications. Overall, the trend demonstrates a continuous and exponential increase in the scientific focus on studies related to green open spaces.

This trend in publications highlights two significant observations: First, the field has transitioned from a focus on landscape design specific to certain disciplines to a transdisciplinary hub that incorporates urban planning, environmental science, and public health. Second, the increase in publications post-2020 corresponds with heightened awareness of urban green spaces as essential public health infrastructure, especially after the COVID-19 pandemic highlighted the social and psychological benefits of accessible open areas. Collectively, these changes confirm that research on green open spaces has evolved into a global priority at the crossroads of climate resilience, ecological restoration, and human well-being, positioning landscape architecture as a key player in creating sustainable urban futures.



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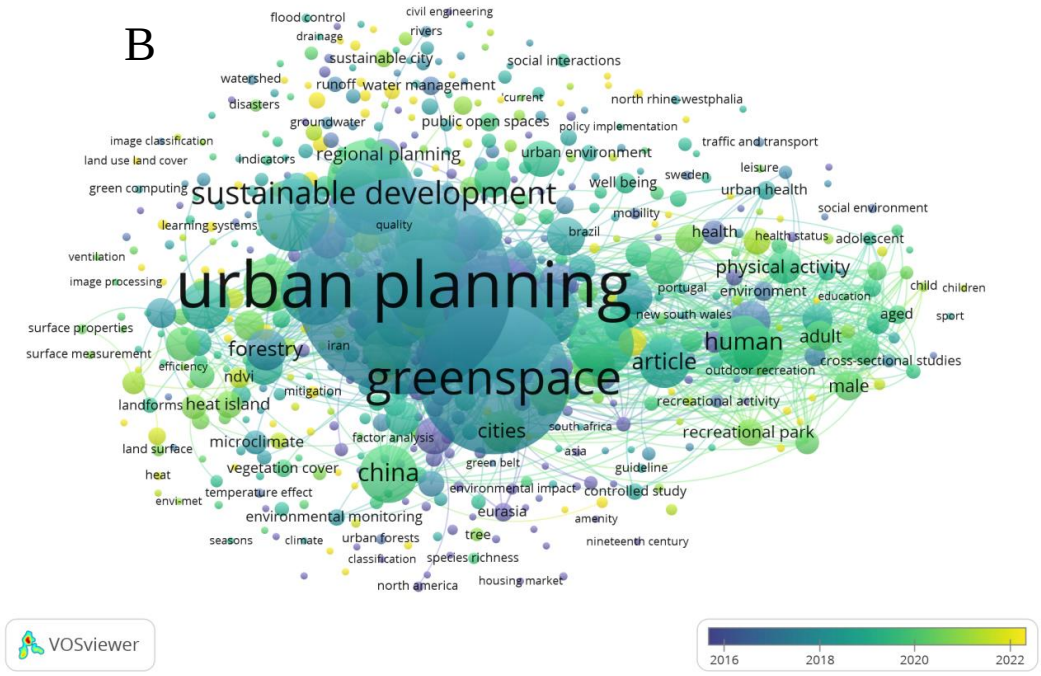

Fig. 4. Network visualization of the co-occurrence of keywords (A) and their time frame (B) based on the Scopus database (1968–2026) for green open space-related research.

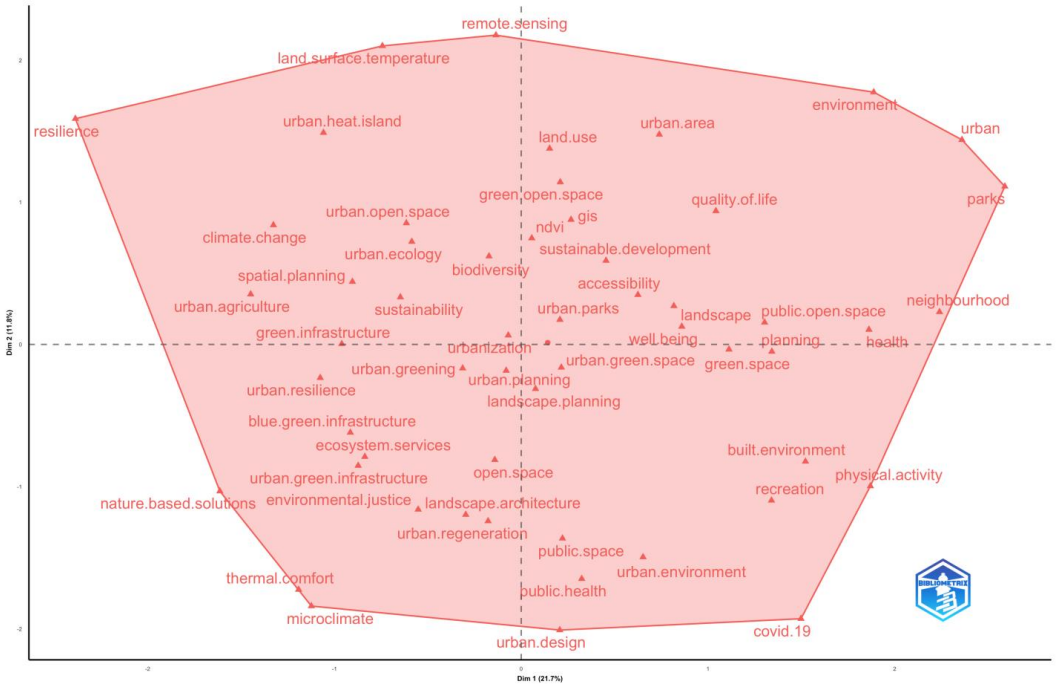

Fig. 5. Factorial map of keywords in the Scopus database (1942–2024) for green open space-related research.

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Table 3 Top 10 most cited scientific publications from the Scopus database (1968–2026) on green open space-related research.

No	Title	Journal	Year	Total citations	Total citation per year
1	The role of urban parks for the sustainable city [OA][a]	Landscape and Urban Planning	2004	1,849	84.05
2	Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom	Science	2013	899	69.15
3	Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes [OA][a]	Landscape and Urban Planning	2015	896	81.45
4	Landscape planning and stress	Urban Forestry & Urban Greening	2003	736	32.00
5	Urban nature in a time of crisis: recreational use of green space increases during the COVID-19 outbreak in Oslo, Norway [OA][a]	Environmental Research Letters	2020	641	106.83
6	Public green spaces and positive mental health – investigating the relationship between access, quantity and types of parks and mental wellbeing [OA][a]	Health & Place	2017	475	52.78
7	A digital twin smart city for citizen feedback [OA][a]	Cities	2021	414	82.80
8	Greening cities – To be socially inclusive? About the alleged paradox of society and ecology in cities [OA][a]	Habitat International	2017	388	43.11

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9	Public open space, physical activity, urban design and public health: Concepts, methods and research agenda	Health & Place	2015	371	33.73
10	A hedonic valuation of urban green areas	Landscape and Urban Planning	2003	365	15.87

[a] [OA] = open access.

Progress in green open space

In the last thirty years, the exploration of green open spaces (GOS) has experienced a notable shift in both concept and methodology. Initially, during the 1970s and the 1980s, research primarily focused on aesthetic, recreational, and horticultural aspects, treating parks and public gardens as passive elements of urban beautification. At that time, the main research focus was descriptive, emphasizing typology, spatial distribution, and design form with minimal consideration of ecological or climatic factors. However, the growing challenges of urbanization, climate change, and biodiversity loss have gradually redefined the GOS as a crucial part of urban environmental infrastructure, steering the research focus towards resilience, sustainability, and social inclusivity.

From 2000 to 2010, the discipline began integrating ideas from urban ecology and environmental planning, as researchers aimed to measure the ecological benefits of green spaces. The literature has been dominated by studies using indicators such as the Normalized Difference Vegetation Index (NDVI), canopy cover, and microclimate regulation. This period saw the rise of spatially explicit, data-driven methods that utilize remote sensing, GIS, and ecological modeling tools to assess the cooling, hydrological, and carbon-sequestration roles of urban green areas. Advancements in these techniques have enabled researchers to shift from aesthetic evaluations to empirical assessments of green open spaces (GOS) as climate-regulating infrastructure.

The years after 2015 marked a significant turning point in GOS research. The surge in publications, as shown in the bibliometric data, aligns with the emergence of global sustainability initiatives, particularly the Paris Agreement and the 2030 Agenda for Sustainable Development. These pivotal events spurred a transition from isolated case studies to comprehensive research frameworks, highlighting the role of GOS in nature-based solutions (NbS), ecosystem services, and urban resilience strategies. The research focus has shifted from “how to design green spaces” to “how green spaces operate as adaptive systems” that can reduce flooding, enhance air quality, and boost public health.

Thematic analyses show that recent scholarship integrates four major domains of progress.

First, there is the integration of ecological and climatic factors, where green open spaces are viewed as dynamic living infrastructures that interact with water cycles, temperature conditions, and carbon equilibrium. Concepts such as green–blue networks and sponge cities illustrate this ecological development. Second, technological progress is marked by the use of artificial intelligence, machine learning, and geospatial big data in the mapping, monitoring, and

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predictive modeling of green open spaces (GOS). These technologies allow for more accurate assessments of vegetation performance and reduction of urban heat. Third, there is a social and health-focused expansion, where research goes beyond environmental advantages to explore the psychological, cultural, and equity aspects of urban nature. The increase in publications following the COVID-19 pandemic highlights the growing interest in the role of accessible green spaces in encouraging physical activity, mental health, and social unity. Lastly, there has been an evolution in policy and governance, shifting from technical design to governance frameworks that involve multiple stakeholders, including communities, local governments, and the private sector. In many developing countries, such as Indonesia, GOS planning is increasingly integrated with climate adaptation and disaster risk reduction strategies.

In landscape architecture, these advancements signify a growing integration of design expertise with scientific research. The responsibilities of this field have broadened from merely crafting visual and spatial elements to managing intricate socio-ecological networks. This evolution reimagines the landscape not only as a scenic backdrop to urban environments but also as a vital infrastructure crucial for climate adaptation and enhancing human health.

Despite progress, the research landscape remains imbalanced. High-income nations lead global research output, whereas contributions from tropical and archipelagic areas are less visible. In Indonesia and other parts of Southeast Asia, recent developments are encouraging, especially in studies connecting the GOS with urban heat reduction and ecosystem-based adaptation. However, the field still requires better integration of empirical environmental modeling and community-focused design. Future studies in these regions should aim to create metrics and design guidelines tailored to tropical climates and investigate how local vegetation, cultural practices, and spatial layouts can improve adaptive capacity.

Advancements in GOS research signify a distinct shift in understanding, moving from form and function to resilience and regeneration. The integration of ecological science, digital technology, and participatory design has redefined green open spaces as fundamental components of sustainable urban development. This shift not only enhances the importance of landscape architecture in the global sustainability conversation, but also paves the way for transformative urban planning that balances ecological integrity, social justice, and climate resilience.

CONCLUSION AND FUTURE PERSPECTIVES

This research offers an extensive bibliometric analysis of the worldwide progression of green open space (GOS) studies and their crucial contribution to enhancing urban climate resilience. Over the last fifty years, GOS has transformed from being perceived merely as decorative or leisure spaces to becoming essential urban infrastructure that incorporates ecological, social, and technological aspects. The sharp increase in publications since 2015 indicates a significant shift influenced by global sustainability initiatives, such as the Paris Agreement and Sustainable Development Goals. Thematic and network analyses demonstrate that GOS research has moved from isolated case studies to interdisciplinary explorations that include nature-based solutions, ecosystem services and public health. While developed nations such as China, the United States, and the United

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Kingdom continue to be the primary contributors, emerging countries, including Indonesia, are gaining prominence, particularly in tropical and maritime urban settings. This trend highlights the wider democratization of scientific collaboration and the increasing acknowledgment of GOS as dynamic systems that can regulate climate, improve well-being, and support biodiversity in complex urban environments.

In the future, advancing GOS research will necessitate a more robust integration of design innovation, ecological sciences, and digital technology. Future research should aim to create frameworks that are sensitive to the context of tropical and archipelagic cities, employing tools such as geospatial modeling, remote sensing, and artificial intelligence to assess the effectiveness of green infrastructure across various climatic conditions. Equally crucial is the emphasis on social equity and inclusivity, ensuring that access to green spaces is a right for all, not just a privilege for some. For landscape architecture, these directions present both challenges and opportunities to redefine urban spaces as regenerative systems that bridge the gap between humans and nature. Ultimately, the future of GOS hinges on its capacity to underpin adaptive, equitable, and climate-resilient cities, reinforcing the pivotal role of landscape architecture in creating sustainable urban futures worldwide.

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