

# Charting sustainable urban development through a systematic review of SDG11 research

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The Sustainable Development Goal (SDG) 11 underscores the imperative of creating inclusive, safe, resilient and sustainable cities and communities by 2030. Here we employ bibliometric techniques to assess the evolving landscape of SDG11 research. Using a comprehensive dataset of over 21,000 scholarly publications, we investigate publication trends, thematic focus areas, authorship patterns, keyword co-occurrences and citation networks related to SDG11 research. The results reveal a consistent increase in research output, reflecting the growing global interest in urban sustainability studies. We identify influential authors, organizations and countries shaping the research landscape, highlighting existing global collaborative networks and emerging research hubs. Core thematic areas emphasize critical topics and interdisciplinary connections. Citation networks underscore the impacts of disseminating research outputs, including seminal works. This study offers insights for policymakers, academics and practitioners to align their collective efforts toward sustainable, inclusive and climate-resilient urban development. Moreover, it advances SDG11 by noting opportunities for further research, knowledge dissemination and international collaboration.

The growing interest in sustainable urban development is driven by challenges posed by urbanization, socioeconomic activities and environmental issues<sup>1</sup>. Urban areas contribute 80% of the world's gross domestic product<sup>2</sup>, but also account for around 75% of global resource consumption, 65% of energy use and over 70% of carbon emissions<sup>3</sup>. The ecological footprint of urban environments, which measures the resources required to sustain socioeconomic activities, has been increasing<sup>4,5</sup>, and the global urban extent is projected to double by 2030<sup>6</sup>. Similarly, the global urban population is projected to reach 68% by 2050<sup>7</sup>, which could surpass the capacity of most urban areas<sup>8</sup>. Africa

and Asia will host most of the future urban populations despite housing and infrastructure inadequacies<sup>7</sup>. Rapid urbanization, poverty and climate change (CC) further intensify the vulnerability of urban dwellers<sup>9</sup>.

Sustainable urban development aims to balance economic production, environmental protection and social inclusiveness. It emerged as a response to the critique of modernist views that prioritized physical appearance and order in cities over context, equity and inclusion<sup>6</sup>. Due to the limited progress in achieving the Millennium Development Goals, the Sustainable Development Goals (SDGs) were established in 2015 to ensure that no country is left behind in achieving sustainable

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development by 2030<sup>10</sup>. Many of the SDGs are closely related to urban settings, where sustainability challenges are complex and interwoven<sup>11</sup>. SDG11 specifically focuses on urban challenges and aims to make ‘cities and human settlements inclusive, safe resilient and sustainable’ by reducing the negative effects of urban development while improving socioeconomic development<sup>10</sup>.

The importance of SDG11 stems from the principles of inclusive, safe and resilient city. An inclusive city is characterized by the idea that all individuals, irrespective of their economic status, gender, race, ethnicity or religion, have the ability and empowerment to actively engage in the social, economic and political opportunities available within urban environments<sup>6</sup>. It seeks to address environmental racism and promote inclusive and fair urban development through social justice and equitable distribution of environmental benefits and burdens. In such a city, everyone is afforded equal access and participation in the diverse aspects that cities provide. On the other hand, a safe city refers to a city that possesses the capacity to provide protection and security against potential dangers, harm or risks, while a resilient city denotes a city’s ability to recover and restore its fundamental functions and structures following natural disasters and crises caused by human activities<sup>6,8</sup>. SDG11 is significant because it aims to ensure that cities develop sustainably.

However, SDG11 has been criticized for its limited emphasis on urban inequalities, decentralization and funding for local authorities<sup>6</sup>. Other challenges include localizing the universal indicators<sup>12</sup>, governance issues<sup>13</sup>, data accessibility and comparability<sup>14</sup> and smart city development<sup>12,15</sup>. Nevertheless, SDG11 serves as a platform for directing and monitoring urban development, fostering socioeconomic development and ensuring equity, inclusion and environmental protection<sup>16</sup>. Therefore, it is crucial to assess the literature on progress toward SDG11 targets<sup>10</sup>, especially at the halfway point to the target year, to inform interventions necessary for their achievement<sup>17</sup>.

While SDG11 has attracted significant global research attention<sup>18</sup>, comprehensive reviews of SDG11 literature are limited. Existing studies have primarily focused on assessing all the SDGs<sup>19,20</sup>, which obscures specific challenges and makes it difficult to track progress or design targeted interventions for individual goals. Recent work has highlighted the insufficient achievement of the SDGs and the need for transformative governance and participatory approaches<sup>21</sup>. Other studies have underscored the gap between research and policies, the underutilization of cities as pivotal arenas for achieving SDGs<sup>22</sup> and the lack of indicators to measure progress toward implementing SDGs<sup>15</sup>. Some studies have assessed SDGs’ implementation in specific region<sup>17</sup>, their impacts on addressing risks<sup>23</sup> and crises<sup>1</sup>, and their implications for health and well-being<sup>24</sup>, environmental research<sup>25</sup> and private sector involvement<sup>26</sup>. Most of the SDG research emanates from developed countries, showing a gap in the coverage of developing countries<sup>27</sup>. The few SDG11 studies in the Global South have narrow focus. While one paper investigated the impact of SDG11 on forest-based livelihoods<sup>28</sup>, another study researched the challenges of SDG11 implementation using a single-country experience<sup>6</sup>. Therefore, an in-depth and broad review of SDG11 literature is necessary to bridge this knowledge gap and identify key challenges and opportunities as well as potential pathways for achieving the targets set in SDG11.

Therefore, this research aims to assess the SDG11 research trends and themes using a bibliometric technique. It is the first global and comprehensive scientometric study on the SDG11 domain. By focusing on research conducted since the formulation of the SDGs, the study addresses the following research questions: (1) what are the global trends in SDG11 research? (2) How has the thematic focus of SDG11 research evolved over time? (3) What are the challenges and priority areas for SDG11 research? The contributions of the study to theory and practice are to:

- Identify significant thematic areas and trends in SDG11 research since the promulgation of the SDGs, which can inform research-

ers, policymakers and practitioners about the current state of knowledge within the field and highlight priority areas for SDG11 research.

- Map research clusters, knowledge sharing and collaboration patterns, thereby providing insights into the dynamics of research networks and facilitating the formulation of strategies to foster research excellence, interdisciplinary and international collaborations and the effective allocating of research resources.
- Underscore the knowledge gaps, emerging topics and challenges within SDG11 research, offering evidence-based insights to align urban development initiatives with SDG11 research frontiers, enhance the efficacy of interventions and contribute to the development of inclusive, safe, resilient and sustainable cities.

## Results

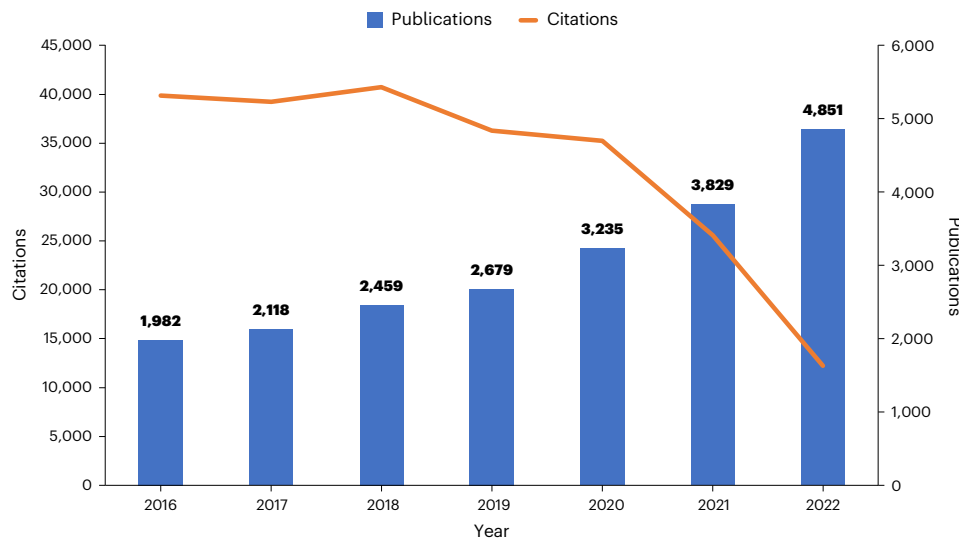
### SDG11 research trends

Research on SDG11 has significantly grown in terms of annual publications and citations since 2016, indicating a rising interest in this field (Fig. 1). The number of publications has increased by 1.3-fold, and this upward trajectory is expected to continue. Notable emerging research areas include the institutionalization of SDGs within local and global settings<sup>18</sup> and the impact of smart cities on advancing the SDGs<sup>12,15</sup>. Previously, studies on the epistemology and challenges of urban population growth were prevalent<sup>29</sup>. However, SDG11 research has now evolved into multidisciplinary fields, driven by heightened attention to urban challenges such as CC, urbanization and population growth.

The increasing trend in SDG11 publications can be attributed to several factors, including the desire to improve institutional rankings, a supportive research environment, investments and endowments, faculty promotion requirements and advancements in information and communication technology. There are also socioeconomic factors, such as increasing urbanization rates and gross domestic product, urban expansion and transformation, a deeper understanding of urban dynamics and challenges. Additionally, the policy environments in different countries can influence academic interests and research in urban studies, shaping research priorities and collaborations. Other contributing factors include research challenges faced by low-income countries and research support by governments, the private sector, international development agencies and scholars, all focusing on sustainable urban development.

SDG11 research is further propelled by recent international summits and collaborations that highlight the urgency of protecting the ecosystem and ensuring human safety<sup>1</sup>. Since 2015, CC issues have received greater attention due to key factors. The adoption of the Paris Agreement raised awareness and urgency for action on CC, resulting in a greater focus on related issues in various sectors, including urban planning and policy<sup>13</sup>. Scientific consensus on CC impacts and the role of human activities has also strengthened over the years, with Intergovernmental Panel on Climate Change assessments emphasizing the significance of cities in addressing CC<sup>23</sup>. As a result, CC considerations are increasingly integrated into research, policy and planning processes.

Urban planning and development strategies have prioritized climate mitigation and adaptation measures, such as reducing greenhouse gas emissions, promoting renewable energy, enhancing resilience to extreme weather events and incorporating green infrastructure. The focus on CC has accelerated the transition toward low-carbon and resilient cities, with efforts directed toward sustainable transportation, energy-efficient buildings, green spaces and climate-responsive infrastructure<sup>5</sup>. Collaboration and international cooperation are essential in addressing climate change, with cities and countries sharing best practices, knowledge and resources to develop and implement climate action plans<sup>24</sup>. Initiatives such as the C40 Cities Climate Leadership Group facilitate knowledge exchange and collective action among cities<sup>30</sup>. The increased attention to CC signifies a shift



**Fig. 1 | Annual publication and citation trends for SDG11 research, 2016–2022.** A total of 21,153 articles were published, receiving 229,182 citations. The number of publications rose from 9,238 in period 1 (2016–2019) to 11,915 in period 2 (2020–2022).

toward more sustainable and resilient urban development, emphasizing the need for proactive measures to mitigate greenhouse gas emissions, adapt to climate risks and promote equitable and sustainable urban environments.

### Thematic focus of SDG11 research

There is an imbalance in the attention given to research themes within SDG11 as revealed by co-occurrence map (Supplementary Fig. 1). The dominant themes are affordable housing (SDG11.1), urban transport (SDG11.2), policy and governance (SDG11.3) and access to public spaces (SDG11.7). Housing affordability issues have consistently remained a focal point in SDG11 research, with urban studies, policy development and community-driven efforts for finding solutions to these complex challenges<sup>30,31</sup>. These issues were highlighted in Habitat I (Vancouver, 1976), which emphasized the importance of shifting governance and planning paradigms to develop policies and strategies to address rapid urbanization challenges, including shelter shortages and urban inequalities, and promote affordable housing options<sup>30,32</sup>. Habitat I has laid the foundation for subsequent global efforts and policy frameworks, such as Habitat II (Istanbul, 1996) and the New Urban Agenda, which continue to prioritize housing as a pivotal component of sustainable urban development. The persistent focus on affordable housing shows that cities still face many challenges in providing adequate housing for all<sup>30</sup>.

Urban policy and governance are other significant terms, indicating scholarly focus on strategies for promoting inclusive and sustainable urban development, enhancing participatory, integrated and sustainable urban planning and management. However, many cities lack the capacity to address urban inequalities, provide adequate housing<sup>31</sup>, public spaces and other urban services, which disproportionately affect women and racial minorities<sup>30</sup>. Moreover, urban redevelopment practices that lead to gentrification exacerbate existing inequalities<sup>32</sup>. Governance-based approaches seek to improve collaboration between public agencies and civil society to prioritize the implementation of urban planning strategies that enhance livability standards while addressing challenges such as CC and sustainability<sup>30</sup>.

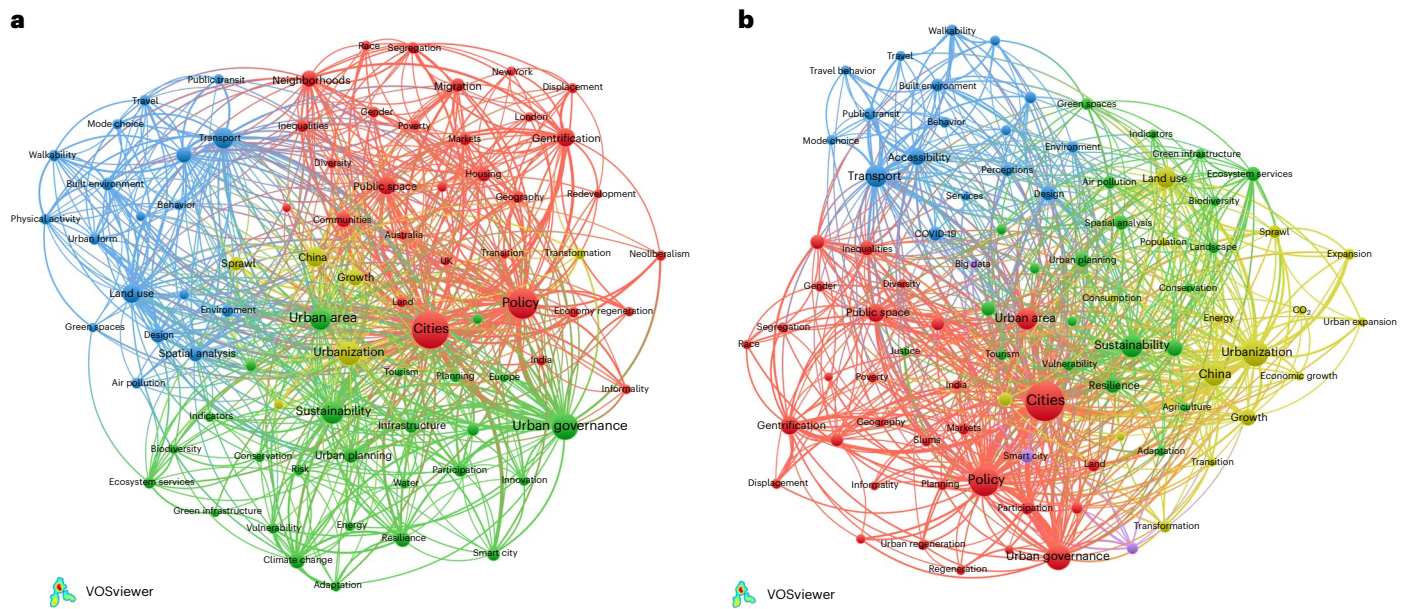
Urban transport, which is related to SDG11.2 aiming to ensure safe, affordable, accessible and sustainable transport systems for all, has emerged as a key research theme. Important issues related to mobility, transportation and urban form include increased automobile dependence amid growing urbanization and suburbanization, challenges faced by public transit systems, growing awareness of environmental concerns, shift toward sustainable and multimodal

transportation, transit-oriented development, integration of technology in transportation systems and the relationship between transportation and urban densification, compact development, CC adaptation and resilience, equity and social inclusion, and shifts in policy and governance approaches<sup>1,6,11</sup>. This theme also emphasizes the importance of walkability, public transit infrastructure and their role in enhancing transportation accessibility and influencing mode choice<sup>33</sup>. The transportation cluster also suggests that improving accessibility through urban form and built environment interventions can impact the travel behavior of urban residents and offer cobenefits for human health and environmental sustainability<sup>24</sup>. Incorporating such cobenefits in SDG11.2 could provide more incentives for access to safe efficient, equitable and sustainable transport infrastructure and systems in cities.

The implications of urbanization and land-use changes for sustainability, resilience and CC adaptation and mitigation in cities are also major themes. SDG11.6 aims to reduce the environmental impacts of cities, particularly in relation to air pollution and waste. The literature suggests that regulating urban growth<sup>6</sup>, controlling land-use changes, conserving biodiversity<sup>27</sup> and promoting green infrastructure are essential for achieving this target<sup>34</sup>. These actions, when implemented within integrated planning frameworks, can also reduce vulnerability, enhance resilience and contribute to progress in CC adaptation and mitigation, as emphasized in SDG11.5 (ref. 6). Such integrated frameworks should recognize the interconnections between various urban systems, including water, food, energy, waste and transportation, to promote sustainable and resilient urban development<sup>35</sup>. Cities are adopting strategies to reduce their carbon footprint, enhance energy efficiency and prepare for climate risks.

Smart cities and innovation enabled by information and communication technologies have increasingly been utilized to tackle urban development challenges and facilitate innovative and transformative urban governance mechanisms that contribute to the SDGs<sup>15</sup>. The rapid development and integration of digital technologies, such as the Internet of Things, artificial intelligence, big data analytics and sensor networks, have opened new possibilities for improving urban services, infrastructure and quality of life<sup>33</sup>. Smart cities leverage these technologies to enhance efficiency, connectivity and sustainability. The interest in smart cities stems from the recognition that technology can play a transformative role in addressing urban challenges, improving quality of life, promoting sustainability and fostering economic growth<sup>12,36</sup>. However, it is important to ensure that smart city initiatives





**Fig. 2 | The thematic focus areas for periods 1 (2016–2019) and 2 (2020–2022).** **a,b**, The key thematic areas in period 1 (2016–2019) (**a**) are urban governance and policy (red), transportation (blue), urban sustainability and resilience (green),

and urbanization and urban growth (yellow), while period 2 (2020–2022) (**b**) primarily focuses on urban governance and policies (red), urban studies (red), transportation (blue) and urbanization (green), particularly after the pandemic.

are inclusive, equitable and responsive to the needs and aspirations of all residents.

Comparing the co-occurrence maps of period 1 and period 2 reveals limited changes in key thematic areas, despite the emergence of the coronavirus disease 2019 (COVID-19) pandemic during period 2 (Fig. 2). The key thematic areas in period 2, including urban governance and policy, transportation, urban sustainability and resilience, and urbanization and urban growth, remain consistent with period 1, indicating the continued relevance of these topics in research, albeit with potential expansions. However, a closer analysis of the clusters reveals that COVID-19 has emerged as a new area of SDG11 research in period 2, as attention has shifted toward adapting to the pandemic’s detrimental effects on cities. The pandemic has triggered paradigm shifts in various SDG11 domains, including public health, remote work, digitalization, vulnerabilities, inequalities, resilience, sustainability, urban spaces, proximity-based planning approaches such as the 15-minute city and global cooperation<sup>9</sup>. These shifts have influenced work, health, social equity, environmental stewardship<sup>2</sup> and urban planning, shaping innovative approaches and priorities in the post-pandemic world. Urban inequality terms, such as slums and informality, inadequate housing and poverty, are brought to the forefront by the pandemic. Controlling the pandemic and addressing the citizen demand in slums and informal settlements has received significant attention<sup>37–40</sup>. Mobility restrictions and lockdowns to curb the virus’s transmission have presented challenges for service accessibility, particularly in disadvantaged neighborhoods where vulnerable groups reside. Lastly, the connection between sustainability and resilience has strengthened in the postpandemic period. The pandemic has offered new insights into the susceptibility of cities to various stressors and highlighted the inseparable connections between urban resilience and SDG11 (ref. 28).

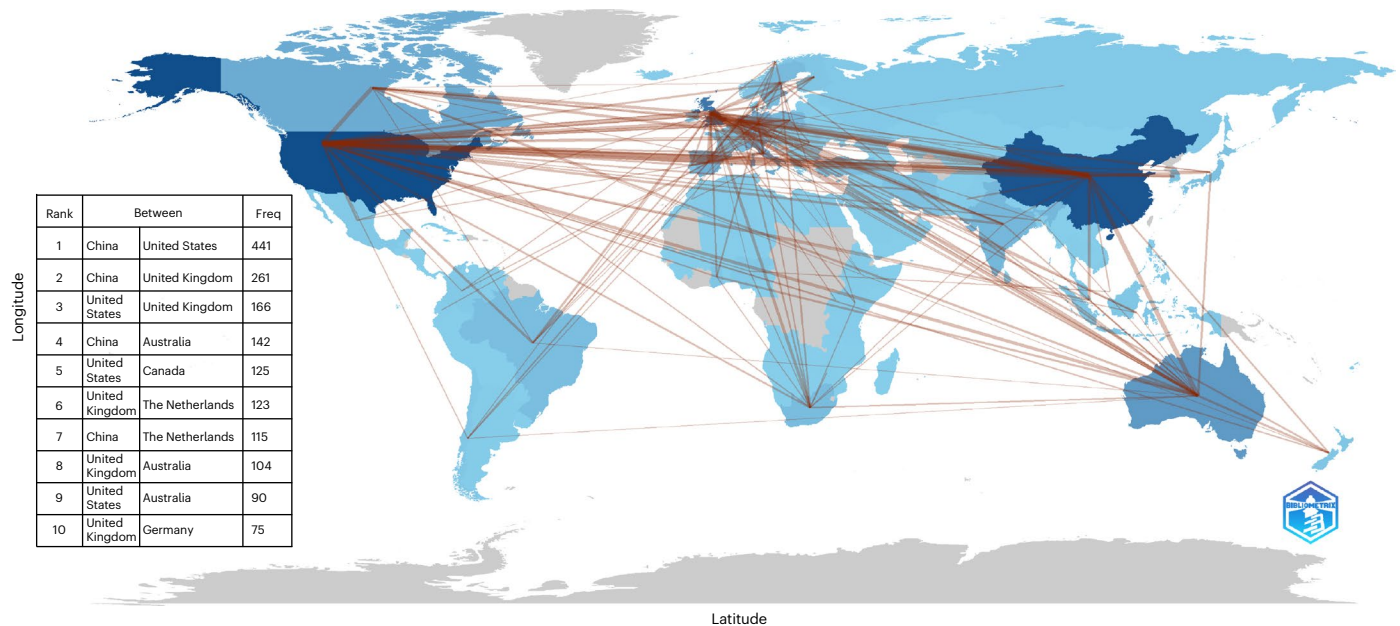
However, three SDG11 targets are not well-represented in both periods. One such target is SDG11.4, which aims to enhance efforts in preserving and conserving natural heritage, vital for improving urban sustainability<sup>41</sup>. Another target, SDG11.a, which focuses on strengthening urban–rural linkages, is also not adequately reflected in Fig. 2. The intrinsic connection between cities and their surrounding rural areas necessitates the incorporation and strengthening of

ties between urban and rural regions to achieve SDG11 (ref. 6). Gaps related to rural–urban linkages include limited understanding of interdependencies, inadequate infrastructure and services in rural areas, weak governance and coordination mechanisms, and social and cultural disconnect<sup>13</sup>. These gaps hinder the development of integrated strategies, contribute to economic disparities, limit access to services, impact agricultural productivity and food security, and create environmental and social challenges. Lastly, there is a lack of research on SDG11.c, which aims to support least-developed nations in developing safe and resilient urban areas, which is not surprising as these countries are often underrepresented in urban studies research<sup>30</sup>.

### Major contributors to SDG11 research

Various countries, institutions, journals and authors have contributed to SDG11 research between 2016 and 2022. China leads in terms of the number of publications and citations generated, followed by the United States and the United Kingdom (Supplementary Fig. 2 and Supplementary Table 1). Among the top 20 productive countries, 14 are from the Global North countries, with South Africa and Brazil as the sole representative of Africa and Latin America and the Caribbean, respectively (Supplementary Fig. 3 and Supplementary Table 2). Increasing research collaboration among the top countries (Fig. 3), research infrastructure and facilities, manpower and financial support significantly contribute to their high SDG11 research output.

A co-citation analysis (Supplementary Table 3) reveals that Chinese institutions, such as the Chinese Academy of Sciences, have the highest number of articles and citation counts, followed by University College London and the University of Melbourne. The leading affiliations have changed over time, highlighting the strengthening of research institutes and the correlation between research collaboration and societal impacts (Supplementary Table 4). In terms of influential journals for SDG11 research, ‘land’ followed by ‘cities and land use’ policy tops the list (Supplementary Tables 5 and 6), with a growing interest in fields related to smart and sustainable cities, transport policies, regional planning and environmentally conscious building practices (Supplementary Fig. 4). These journals also address multiple issues related to environmental concerns,



**Fig. 3 | Top 10 collaborating countries in SDG11 research.** China followed by the United States and the United Kingdom dominates SDG11 research collaborations. There are significant connections among European, North American and Asian institutions, while Africa is less connected with Asia and Latin America and the Caribbean. Freq, frequently.

technological advancements, economic benefits, quality of life, justice and public awareness, driving the development of smart and sustainable cities.

The 15 most published authors in both periods focused on urbanization and urban growth, and the implementation, challenges and achievements of SDG11 (Supplementary Fig 5). This indicates an increased recognition of the SDG11 targets and their implementation over time, with the contributions of these authors significantly increasing from 2002 to 2016. Supplementary Table 7 shows that Chinese authors dominate the SDG11 publications, which correlates with China's lead in institutions, affiliations and collaborations related to SDG11 research. The most cited SDG11 articles are revealed in Supplementary Table 8, while the prominent authors that influenced SDG11 research are reported in Supplementary Table 9. The top cited papers by SDG11 research are presented in Supplementary Tables 10 and 11.

## Discussion

### Key facts from the bibliometric analysis

The research on SDG11 has gained significant prominence across various fields, including urban studies, environmental sciences, geography, transportation and urban governance (Supplementary Table 12). The increasing environmental concerns, urbanization and global economic growth have spurred academic interest in SDG11 research from disciplines such as human geography, transportation, forestry, CC and sustainability science (Supplementary Table 13). Key thematic areas within SDG11 research encompass urban governance, affordable housing, transportation, urban sustainability and resilience, smart cities, urbanization and urban growth, which align closely with SDG11 targets<sup>18,20,42,43</sup>. However, research focus on SDG11 has remained relatively stable, with limited attention given to urban inequalities, safeguarding cultural and natural heritage<sup>41</sup> and specific impacts of the COVID-19 pandemic on urban sustainability.

This study reveals a notable increase in the total SDG11 research output from 2016 to 2022, reflecting the growing emphasis on SDG11 research in recent years compared with earlier periods. China emerges as the leaders in terms of research outputs, citations, authors, institutions and collaborations, closely followed by the United States and the

United Kingdom. These three countries contribute 47.71% of SDG11 research productivity within this period, which is higher than 31% reported in a previous similar study<sup>28</sup>.

The dominance of Global North countries in the top 20 countries with the highest number of publications and citations related to SDG11 research is expected given their strong institutional capacity, research funding, highly ranked universities and collaborations. China's surge in publications on SDG11 can be attributed to rapid urbanization, economic growth, government support and active international collaborations<sup>2,11</sup>. Generally, the landscape of research on SDG11 demonstrates an Anglo–American hegemony, which may reinforce power asymmetries and have significant implications for sustainability and resilience<sup>30</sup>. It is concerning that while projections indicate that 90% of future urban population growth will occur in cities of the Global South, particularly Africa and Asia, there is limited research on urban development challenges in these regions<sup>7</sup>.

The debate about the politics of knowledge production in SDG11 research often revolves around the controls of knowledge production processes. Large, well-funded institutions in developed countries tend to dominate research agendas, focusing on themes and solutions relevant to their own contexts, overlooking the unique needs and challenges of the Global South, which perpetuate existing inequalities and privileging certain types of knowledge. Also, knowledge production involves recognizing and integrating diverse ways of knowing. While Western scientific paradigms have traditionally dominated SDG11 research, there is an increasing recognition of the importance of indigenous and non-Western knowledge systems. Integrating these diverse epistemologies enriches understanding and leads to more effective and culturally relevant solutions.

Additionally, SDG11 research is inherently interdisciplinary, involving fields such as urban planning, sociology, environmental science and public policy. However, interdisciplinary collaboration can be challenging due to differing terminologies, methodologies and research priorities. Navigating these differences becomes crucial in the politics of knowledge production to create cohesive and comprehensive research outputs. Finally, bridging the gap between knowledge production and its implementation faces political, economic and social



barriers. Researchers and practitioners are increasingly considering how knowledge on urban sustainability can effectively influence policy-making and practice in diverse urban contexts. Mobilizing knowledge to address these barriers becomes a key consideration in the politics of knowledge production.

### Challenges to achieving SDG11

There are several challenges to achieving SDG11 targets, including inadequate provision of affordable housing<sup>31</sup>, essential services<sup>24</sup>, green spaces<sup>2,34</sup>, efficient transportation<sup>33</sup> and conservation of cultural and natural assets<sup>25</sup>. Rapid urbanization<sup>1,7</sup>, CC impacts<sup>44</sup>, insufficient investment in public infrastructure<sup>30</sup>, poor governance<sup>13</sup> and widening livelihood, land and resources inequalities<sup>43</sup> further exacerbate these challenges. For example, rapid urbanization puts immense pressure on housing, infrastructure, services and resources, making it challenging to effectively manage urban growth and ensure sustainable urban development<sup>11</sup>. Inadequate urban planning and land-use policies lead to inefficient land utilization, urban sprawl and inadequate provision of basic services<sup>7,21</sup>. The existence of slums and informal settlements where a large portion of the urban dwellers live in substandard housing conditions without tenure security<sup>14</sup> and limited access to electricity, water, sanitation, education, healthcare and employment opportunities<sup>23,37</sup>, and marginalized and vulnerable populations facing social exclusion, add to the complexity.

Moreover, competing priorities and trade-offs, lack of integration among various urban sectors and agencies<sup>35</sup>, inadequate human, technical and material resources at local government levels<sup>45</sup>, and insufficient local indicators and methods for implementation and monitoring<sup>46</sup> often hamper the implementation of SDG11 targets. Additionally, limited awareness of SDG-related challenges for policy formulation and implementation hinders context-dependent decision-making and targeted interventions<sup>21,27</sup>. Addressing social inequalities, ensuring inclusivity in urban development and synergy among multiple fields, including social, technical, environmental, policy and management are crucial for achieving SDG11 (refs. 14,26,46). A valuable lesson can be learned from the success of the framework for assessing the implementation of SDG11 targets at the local level in Japan<sup>42</sup>.

### Conclusions

This study aims to enhance our understanding of urban sustainability and provide insights for future research, policies and actions needed to achieve SDG11 targets. By conducting a comprehensive bibliometric assessment of over 21,000 publications from 2016 to 2022, it significantly contributes to the existing body of knowledge, highlighting trends, thematic areas and knowledge gaps related to SDG11 research across countries, institutions, authors and journals. SDG11 research has evolved into a multidisciplinary field, encompassing diverse themes, such as transportation, housing, urban sustainability, smart cities, urbanization and urban governance and policy. However, there is a need to address the gaps in research on urban safety and inclusion, which are critical dimensions often overlooked in favor of environmental and economic aspects of sustainability. This imbalance in research thematic areas risks perpetuation of already existing disparities within SDG11 research and its goals.

China, the United States and the United Kingdom emerge as the top contributors to SDG11 research and collaboration. To foster more SDG11 research in low-income economies, it is essential to provide increased funding support, capacity building and training for scholars, promote collaboration and knowledge exchange, and improve research infrastructure and data collection. Despite global challenges such as armed conflicts, CC and the COVID-19 pandemic, progress toward achieving the SDGs will become apparent by 2030. However, there are still opportunities for further research, knowledge dissemination and international collaboration toward developing safe, sustainable

**Table 1 | Summary about the data used in the analysis**

Description	Results
• Timespan	2016–2022
• Sources (journals, books and so on)	349
• Documents	21,153
• Annual growth rate (%)	16.09
• Document average age (year)	3.39
• Average citations per document	10.83
• Total citations	229,182
<b>Document contents</b>	
• Keywords plus	12,629
• Author's keywords	43,545
<b>Authors</b>	
• Authors	36,990
• Authors of single-authored documents	4,397
<b>Authors collaboration</b>	
• Single-authored documents	5,356
• Co-authors per document	2.77
• International co-authorships (%)	23.5
<b>References</b>	709,852
<b>Document types</b>	
• Article	21,153

Between 2016 and 2022, a total of 21,153 articles related to SDG11 were published by 349 journals. These articles have amassed 229,182 citations in total.

and inclusive urban development. The following are priority areas for SDG11 research:

- **Urban policy and governance:** reforms should focus on providing equitable access to basic services such as water, sanitation, electricity, healthcare and education; upgrading and formalizing informal settlements; and improving living conditions of over one billion people residing in slums<sup>37</sup>. Participatory governance, community engagement and empowerment can enhance social inclusion by considering the voices and needs of marginalized groups<sup>13,23</sup>. Urban policy should also prioritize preserving historic and natural resources, protecting vulnerable areas and implementing sustainable urban design principles<sup>47</sup>. Future studies can help understand the dynamics, challenges and opportunities and monitor progress toward SDG11 targets<sup>15</sup>.
- **Localizing SDG11 targets:** spatial planning and land-use strategies should consider the needs of diverse urban populations, promote inclusive zoning and engage local communities and stakeholders in decision-making processes, crucial for fostering ownership, empowerment and social cohesion, leading to more sustainable and inclusive urban development<sup>3</sup>. However, enhancing the capacity for localizing SDG11 targets requires building the knowledge and skills of local governments, policymakers and practitioners. Capacity-building initiatives, such as training programs, workshops and knowledge exchange, can promote interdisciplinary understanding and sharing of best practices.
- **Concerted and collaborative efforts:** the international community, academics, policymakers and stakeholders can work together to create inclusive, safe, resilient and sustainable communities. Collaborative efforts can facilitate a comprehensive understanding of urban challenges and potential solutions by integrating diverse perspectives, data and methodologies. Disseminating research findings contributes to evidence-based policy development and

informed decision-making, enabling the learning of lessons and replication of successful interventions.

- Breaking down silos: integrated and cross-sectoral approaches help narrow the gaps between sectors, local governments, policy-makers and stakeholders, leveraging local resources and capacities while fostering communication, knowledge sharing and collaboration<sup>31</sup>. Cross-sectoral working groups, joint planning processes and integrated policy frameworks promote holistic and coordinated decision-making among various sectors, including urban planning, housing, transportation, health, education, environment and social welfare<sup>47</sup>.
- Digitalization and smart city development: maximizing the benefits of digitalization and smart city solutions requires addressing challenges such as bridging digital divides and ensuring data access, privacy and security. Prioritizing citizen-centric approaches and public accessibility to technology<sup>36</sup> are essential for leveraging expertise and resources<sup>15</sup>. Interoperability, scalability, data-driven decision-making and inclusivity contribute to evidence-based planning and equitable access to smart city technologies<sup>12,48–51</sup>.

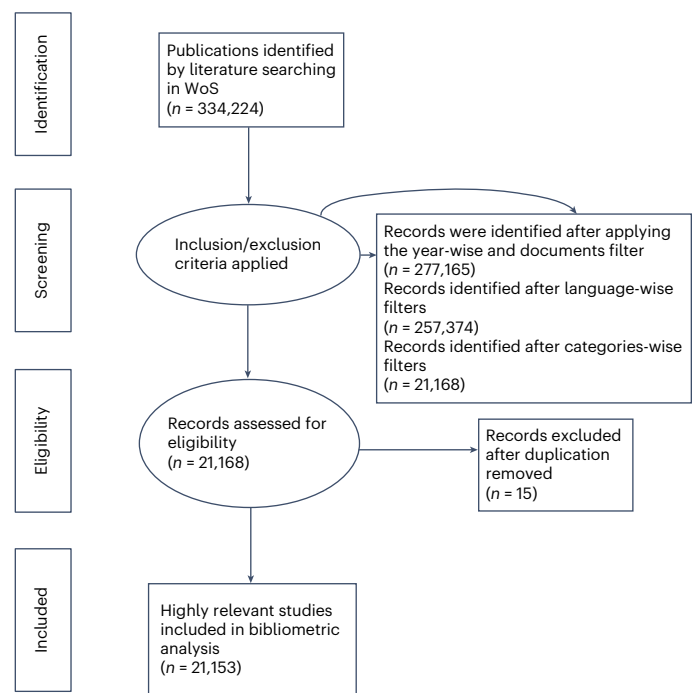
This study comprehensively assessed SDG11 research, emphasizing significant thematic areas, trends, challenges and suggestions for prioritizing SDG11, including effective urban policy and governance, localizing SDG11 targets, concerted and collaborative efforts, and digitalization and smart city development. To broaden the scope of SDG11 research, future bibliometric reviews should encompass non-Web of Science databases and gray literature, including publications from government and nongovernmental agencies. Despite its limitations, this study's findings provide valuable references for further research on SDG11.

## Methods

The present study utilized a bibliometric technique to analyze academic publication on SDG11, tracing the research trend, the evolving key themes and identifying contributing authors, institutions and countries. Bibliometrics is a quantitative technique that allows for the analysis of trends in scholarly publications, such as research articles, conference papers and books, and visualizes scholarly publication patterns<sup>52</sup>. This technique is instrumental in analyzing extensive literature sets by relying on statistical observations and text-mining capabilities, which qualitative review methods such as systematic reviews cannot accomplish<sup>53</sup>. Additionally, it presents a scientific landscape of authors, countries, organizations and collaborations that contribute to worldwide scientific literature.

Bibliometric analysis requires interpretation, introducing an element of subjectivity<sup>54</sup>. Therefore, a sensemaking approach was adopted to transition from describing the bibliometric results to interpreting them. Sensemaking helps derive insightful information from bibliometric analysis and can be integrated into systematic literature reviews<sup>55,56</sup>. It applies to various international indexing, abstracting and citation databases, such as Scopus, Web of Science, Dimensions, PubMed and Education Resources Information Center, which cover journals, books, reviews and conference proceedings from around the world and different regions. For this study, Web of Science was chosen as the database to obtain bibliographic data due to its wide range of topics in various fields of study such as natural sciences, health sciences, engineering, social science, computer science and materials sciences. It is one of the world's largest peer-reviewed scientific literature databases, with 87 million indexed items.

Specialized bibliometrics software were employed, including VOSviewer (version 1.6.19)<sup>52</sup>, Biblioshiny (version 4.1.3)<sup>55</sup> and BibExcel (version 2017)<sup>57</sup>. VOSviewer, known for its user-friendly interface, was used to understand the thematic focus and evolution of research on SDG11. It generates networks of nodes and links, with node size



**Fig. 4 | PRISMA flow diagram.** A four-phase flow diagram of the data extraction and filtration process of SDG11 literature, adapted from Priyadarshini<sup>57</sup>. WoS, Web of Science.

representing the frequency of the studied item, and link width indicating the strength of connections between items. Clusters of intricately linked nodes are shown in distinct colors. The thematic focus was examined for two periods: period 1 (2016–2019) and period 2 (2020–2022), considering the time since the SDGs were introduced to the time of data collection in this study. Another reason for this categorization is that evidence shows that the pandemic has significantly affected progress toward achieving SDGs<sup>58</sup>. VOSviewer allows for various types of analysis, including term co-occurrence, co-citation, citation and bibliographic coupling<sup>53</sup>. A term co-occurrence analysis was used in this study to highlight key thematic areas. To ensure accuracy and avoid separate counting of synonyms, a thesaurus file was developed and added to the software before the analysis. A summary of the data, including the number of authors and journals, used in the analysis is presented in Table 1 and will be further explained below.

A comprehensive search query was formulated to retrieve relevant data on SDG11, and it was executed in the title, abstract and keywords fields (TS) in Web of Science on 5 July 2023. The initial query shown the following box resulted in a total of 334,224 documents. Co-citation analysis was employed to identify the most influential journals contributing to SDG11 research. Two works are considered co-cited when they are both mentioned in the works cited section of a subsequent publication<sup>59</sup> (Zhao, 2006).

TS = (('city' OR 'cities' OR 'human settlement\*' OR 'urban' OR 'metropoli\*' OR 'town\*' OR 'municipal\*' OR 'peri-urban\*' OR 'urban-rural' OR 'rural-urban') AND ('gentrification' OR 'congestion' OR 'transport\*' OR 'housing' OR 'slum\*' OR 'informal settlement\*' OR 'sendai framework' OR 'Disaster Risk Reduction' OR 'disaster' OR 'DRR' OR 'smart cit\*' OR 'resilient building\*' OR 'sustainable building\*' OR 'building design' OR 'buildings design' OR 'urbani?ation' OR 'zero energy' OR 'zero-energy' OR 'basic service\*' OR 'governance' OR 'citizen participation' OR 'collaborative planning' OR 'participatory planning' OR 'inclusiveness' OR 'cultural heritage' OR 'natural heritage' OR 'UNESCO' OR 'ecological footprint' OR 'environmental footprint' OR 'waste' OR 'pollution' OR 'pollutant\*' OR 'waste water' OR wastewater\*' OR waste-water\*

OR 'recycling' OR 'circular economy' OR 'air quality' OR 'green space' OR 'green spaces' OR 'nature inclusive' OR 'nature inclusive building' OR 'nature inclusive buildings' OR 'resilient' OR 'resilience' OR 'healthy cit\*' OR 'sustainable' OR 'sustainability' OR 'green' OR 'nature\*' OR 'Green infrastructure\*' OR 'nature-based solution\*' OR 'nature based solution\*' OR 'child\*' OR 'wom?n' OR 'elderl\*' OR 'disabl\*' OR 'disabilit\*' OR 'disabled') AND PY = (2016–2022) NOT PY = (2023)

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was used to report document search and filtration process. The PRISMA framework is designed to help scholars transparently report why their review study is conducted, what activities are performed and what discoveries are made, ideal for both systematic reviews and bibliometric studies<sup>60</sup>. PRISMA presents the four stages of the above query's overall searching and filtration process (Fig. 4). The identification stage yielded 334,224 records, which were then screened to select only article-type documents ( $n = 277,165$ ). Subsequently, documents were further screened based on language, selecting only English documents ( $n = 257,374$ ). In the final stage, documents were screened based on specific categories closely related to cities and SDG11, resulting in a selection of six major categories: urban studies, environmental studies, geography, urban and regional planning, architecture, transportation and physical geography ( $n = 21,168$ ). Finally, 15 duplicated documents were removed, resulting in a final dataset of 21,153 documents.

### Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

### Data availability

The data that support the findings of this study are available as supplementary information. The steps for curating the data from the Web of Science have been provided in the text. If there is a further need, data are available on figshare at <https://doi.org/10.6084/m9.figshare.26360125>. Source data are provided with this paper.

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## Author contributions

A.I.A.: conceptualization, methodology, formal analysis, data curation, writing—original draft, writing—review and editing, investigation and project administration. A.S.: methodology, software, formal analysis, visualization and writing—original draft. Y.A.A.: conceptualization, writing—original draft, investigation and validation. S.A.: methodology, software, formal analysis, visualization and data curation. L.M.: writing—review and editing, and investigation. W.L.F.: writing—review and editing, and investigation. I.R.A.: writing—review and editing, investigation, supervision, validation and resources.

## Competing interests

The authors declare no competing interests.

## Additional information

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Data collection No software was used.

Data analysis Data was analyzed using VOSviewer version 1.6.19. Available at: <https://www.vosviewer.com/>

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Study description	Quantitative bibliographic data obtained from the Web of Science.
Research sample	Bibliographic data of 21,153 articles obtained from the Web of Science.
Sampling strategy	NA
Data collection	Obtained from the Web of Science.
Timing	Data collected on 5th July 2023.
Data exclusions	N=15
Non-participation	NA
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