📘 GPH-International Journal of Applied Management Science

(e-ISSN 3050-9688 | Open Access | Peer-Reviewed)

Article ID: gph/ijams/2025/2084

Mapping the Intellectual and Thematic Structure of Smart Cities and Sustainable Development: A Scientometric Analysis (2015 – 2018)

Mae Frances G. Sanico, LPT, MM[1]
Education Program Specialist, Research Services Office
Palompon Institute of Technology, Palompon, Leyte, Philippines
ORCID: 0009-0007-0002-049X

Volume: 05 | Issue: 08 | August 2025 | Pages: 01–13

DOI: 10.5281/zenodo.17152578 | www.gphjournal.org

How to cite: Sanico, M. F. (2025). Mapping the Intellectual and Thematic Structure of Smart Cities and Sustainable Development: A Scientometric Analysis (2015 – 2018). *GPH-International Journal of Applied Management Science*, 5(8), 01-13. https://doi.org/10.5281/zenodo.17152578

[1] Corresponding Author Email: maefrances.sanico@pit.edu.ph

Copyright © Author(s) 2025. All Rights Reserved. Published by GLOBAL PUBLICATION HOUSE. | Int. J. Applied Management Science

Abstract

Background: The convergence of digital innovation and sustainable urban development has become a central theme in contemporary urban discourse. Smart cities are increasingly seen as strategic responses to urbanization challenges, warranting a systematic understanding of the evolving research landscape. This study aims to map the intellectual and thematic development of scholarly work at the intersection of smart cities and sustainable development.

Methods: A scientometric analysis was conducted on publications from 2015 to 2018, with scientometric data retrieved from the Scopus database. Data were processed using Biblioshiny, the graphical interface of the Bibliometrix R-package. The analysis focused on key performance indicators including annual scientific production, citation metrics, leading source journals, most globally cited documents, and thematic structures derived from keyword co-occurrence and multiple correspondence analysis.

Results: A total of 2,998 peer-reviewed publications were analyzed. The findings indicate a steady increase in scientific output, demonstrating heightened scholarly and policy interest in the field. Core publications are concentrated in interdisciplinary journals covering sustainability science, information technology, and urban studies. Frequently cited articles emphasize enabling technologies such as the Internet of Things (IoT), big data, and 5G networks. Thematic mapping revealed four dominant research clusters: sustainability, urban governance, smart infrastructure, and environmental monitoring—signaling a shift from conceptual exploration toward practical implementation and equity-oriented outcomes.

Conclusion: This study provides a comprehensive overview of the knowledge structure and trajectory of research on smart cities and sustainable development. The observed thematic maturation and increasing policy relevance suggest a dynamic and interdisciplinary field with growing impact. These insights can inform future academic inquiries, strategic policymaking, and the design of inclusive, tech-driven urban solutions.

Keywords

Smart cities, sustainable development, scientometric analysis, thematic mapping, scientific production, intellectual structure, urban innovation.

Introduction

In an era marked by rapid urbanization, technological advancement, and mounting environmental challenges, smart cities have emerged as a strategic framework for addressing complex urban issues. The smart city concept integrates digital technologies, data-driven systems, and sustainable practices to enhance the efficiency of urban operations, improve citizens' quality of life, and promote resilience to social and environmental pressures (Bibri, 2019).

The smart city paradigm has gained particular traction within the context of the United Nations Sustainable Development Goals (SDGs), especially SDG 11, which advocates for making cities and human settlements inclusive, safe, resilient, and sustainable. As a result, governments, policymakers, and researchers have increasingly aligned smart city initiatives with broader sustainable development objectives. This convergence has fueled an exponential rise in scholarly interest, resulting in a growing body of literature that spans multiple disciplines including urban planning, ICT, environmental science, public policy, and social equity (Yigitcanlar et al., 2019).

Despite this expanding body of work, the intellectual structure and thematic evolution of smart city research remain fragmented and underexplored. The field's rapid development and interdisciplinary nature have led to a wide dispersion of topics, approaches, and research agendas. As such, a systematic synthesis of the literature is necessary to clarify the dominant themes, influential contributors, and emerging trends that shape the discourse (Bibri, 2019).

This study addresses this gap by conducting a comprehensive scientometric analysis of scholarly publications on smart cities and sustainable development from 2015 to 2018. Using data extracted and analyzed via Biblioshiny, the graphical interface of the Bibliometrix R-package, the study examines key performance indicators such as publication trends, citation metrics, leading journals and authors, and thematic clusters derived from keyword analysis (Aria & Cuccurullo, 2017). By mapping the intellectual landscape of the field, this research provides valuable insights into the knowledge production processes and contributes to guiding future scholarly and practical efforts toward sustainable urban transformation.

Methods

Design: This study employed a scientometric research design to examine the scientific literature at the intersection of smart cities and sustainable development. The methodology integrated performance analysis and science mapping to evaluate publication productivity, impact, collaboration, and thematic structures. Visualization techniques further enhanced the interpretation of scholarly patterns and relationships within the research domain.

Data Source: Scientometric data were extracted from Scopus, a leading multidisciplinary scientific indexing database known for its comprehensive coverage of peer-reviewed and high-impact journals. Scopus was selected for its reliability, breadth of content, and advanced search capabilities, which are crucial for robust bibliometric analysis.

Search Strategy and Data Extraction: A total of 2,998 documents were retrieved from Scopus using a keyword-based search focused on terms such as *"smart city"* and *"sustainable development."* The publication window of 2015 to 2018 was selected to capture literature produced during the early implementation years of the United Nations Sustainable Development Goals (SDGs) particularly SDG 11, which promotes sustainable and resilient urban environments (United Nations, 2015).

Prior to analysis, the dataset underwent data cleaning and standardization to ensure consistency and accuracy. This process involved removing duplicate entries, normalizing author names and institutional affiliations, and merging keyword variants (e.g., "IoT" and "Internet of Things"). These preprocessing steps are essential to reduce noise and enhance the reliability of bibliometric outputs (Donthu et al., 2021).

Data Analysis: The extracted data were analyzed using Biblioshiny, the web-based interface of the Bibliometrix R-package (Aria & Cuccurullo, 2017). The analysis framework consisted of two primary components: performance analysis and science mapping.

Performance analysis focused on evaluating research productivity and academic influence. This included assessing annual scientific output, calculating total and average citation counts, and examining authorship patterns to uncover collaboration trends and identify the most prolific contributors. The impact of source journals was also analyzed using Bradford's Law, which helps determine the core journals that serve as major platforms for research dissemination in the field (Zupic & Čater, 2015).

Science mapping aimed to uncover the conceptual, intellectual, and social structures of the research domain. Keyword co-occurrence analysis was conducted to identify frequently appearing term pairings, which helped reveal dominant research themes and emerging areas of interest. To trace the development of these themes over time, thematic evolution mapping was applied. Furthermore, Multiple Correspondence Analysis (MCA) was used to reduce dimensionality and organize keywords within a conceptual space, forming thematic clusters that illustrate the field's cognitive structure (Aria & Cuccurullo, 2017). Co-word network analysis was also employed to visualize the linkages between terms, highlighting their centrality and interconnections within the broader research landscape (Callon, Courtial, & Laville, 1991).

To support interpretation, these scientometric techniques were complemented by advanced visualization tools built into Biblioshiny. Strategic diagrams were used to categorize research themes based on centrality and density, indicating whether a topic was considered motor, niche, emerging, or basic. Thematic maps and network graphs provided additional insight into the structural dynamics of the field, while collaboration networks illustrated co-authorship patterns and institutional affiliations (Cobo et al., 2011; van Eck & Waltman, 2010).

Results

Annual Scientific Production and Growth

The scientometric data indicate a steady and substantial increase in scholarly output on smart cities and sustainable development between 2015 and 2018. In 2015, a total of 281 articles were published; by 2018, this number had grown nearly fivefold to 1,405 publications. This upward trend reflects a rapidly expanding research interest, likely driven by global urbanization challenges, advances in digital technologies, and the strategic emphasis on achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 on sustainable cities and communities.

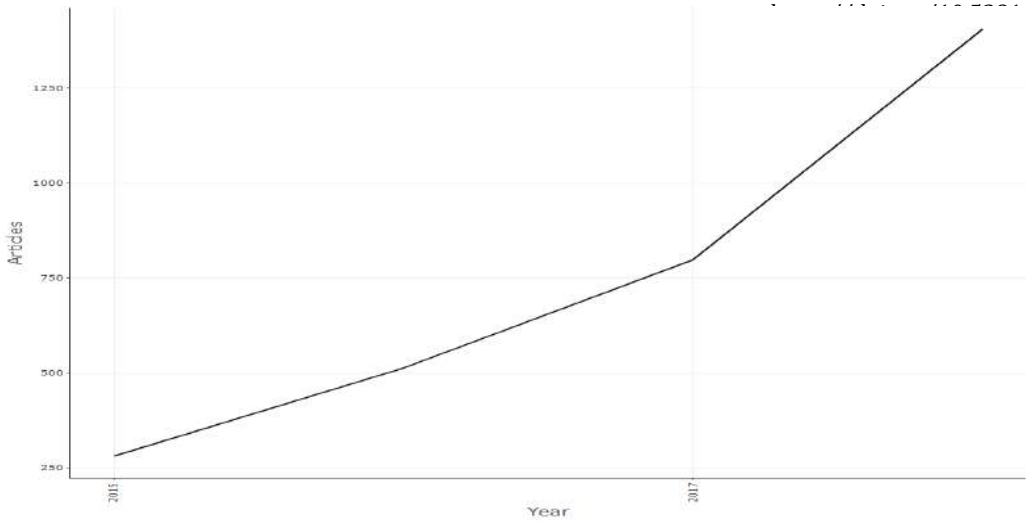

Figure 1: Annual Scientific Production and Growth

The mean citation rate, highest in 2015 (114.91 citations/article), suggests that foundational publications from that year played a critical role in shaping subsequent research directions. These early contributions laid theoretical and technological groundwork that newer studies frequently build upon. In contrast, while 2018 had the largest number of publications, the average citation per article was lower (65.11), which is typical for newer publications that have had less time to accumulate citations.

This trend also signals the growing maturity and complexity of the field: earlier work focused on defining concepts and highlighting possibilities, while later research increasingly emphasizes practical applications, policy integration, and systems-based urban planning. The data suggests that scholarly attention is expanding not just in volume, but also in depth and diversity, with increasing focus on interdisciplinary and solution-oriented studies.

Geographical Distribution of Research Output

The color-coded global map of scientific production, as seen in *Figure 2*, illustrates a distinct geographical pattern in smart city and sustainable development research, revealing both concentration and diffusion of academic activity. Darker-shaded countries such as China (1,305 publications), Italy (1,302), and the United States (827) emerge as the most prolific contributors between 2015 and 2018. The near-equal output of China and Italy reflects parallel research intensity, likely driven by China's aggressive digital infrastructure strategies and Italy's participation in EU-funded smart city initiatives.

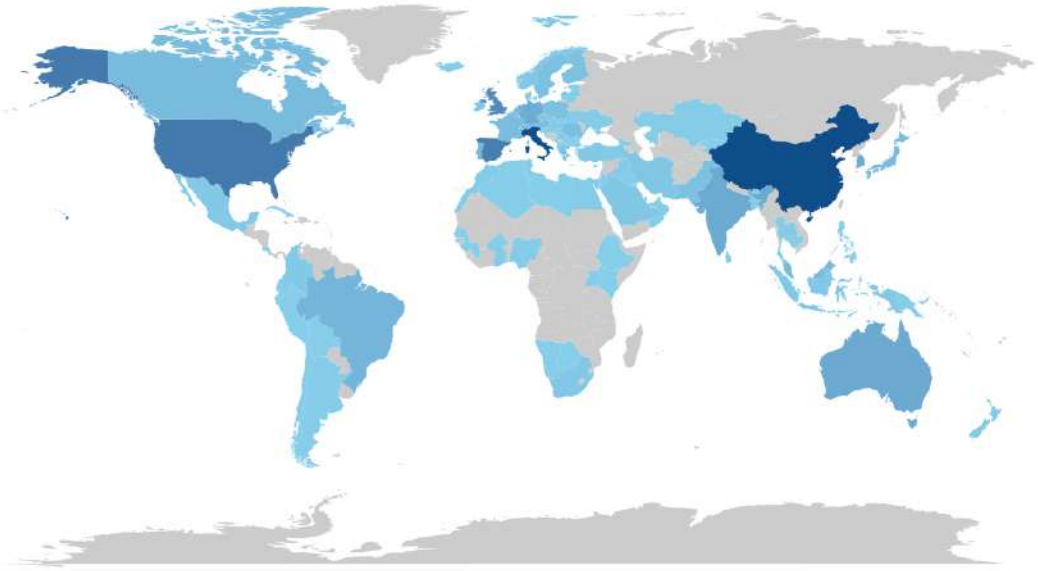

Figure 2. Geographical Distribution of Research Output

These nations not only produce a large volume of research but also exhibit strong international collaboration, as evidenced by co-authorship networks. Notably, the map highlights robust academic synergies across Europe and between China and Western hubs, reinforcing the globalized nature of urban innovation research.

The thematic diversity across regions adds further dimension to this pattern. For instance, China often focuses on large-scale IoT implementation and AI-powered infrastructure, aligning with its top-down urban digitalization model. Italy, on the other hand, brings a heritage-sensitive and sustainability-driven approach, emphasizing smart mobility and urban regeneration. Meanwhile, U.S. research tends to address data governance, urban resilience, and public-private innovation frameworks, reflecting its decentralized policy landscape and market-driven urban tech development.

Beyond the dominant players, the map also reveals important developments in emerging economies. Countries such as India, Brazil, and South Africa, though lighter in shade due to lower overall output, are becoming increasingly visible in the global research landscape. Co-authorship data suggest these countries are growing participants in international scholarly networks. Their contributions often emphasize localized urban challenges, such as informal housing, infrastructure access, and climate adaptation—perspectives crucial for ensuring the contextual relevance of global smart city strategies.

This geographical and thematic evolution underscores the need to view smart city development not as a one-size-fits-all agenda, but as a multi-scalar, culturally grounded, and transdisciplinary effort. The map's gradients of productivity and collaboration speak to both the concentration of expertise and the emergence of inclusive innovation dialogues. Ultimately, transnational cooperation rooted

in mutual learning and regional responsiveness—will be essential in designing context-sensitive urban models that balance technological capacity with social equity and sustainability goals.

Source Productivity and Interdisciplinary Nature

Analysis of source productivity identified *Sustainability (Switzerland)* as the most prolific journal during the period. Other top contributors included the *Journal of Cleaner Production*, *Sustainable Cities and Society*, and *Sensors (Switzerland)*. These journals published high volumes of articles intersecting smart cities and sustainable development, signifying their interdisciplinary influence across engineering, environmental science, and urban studies.

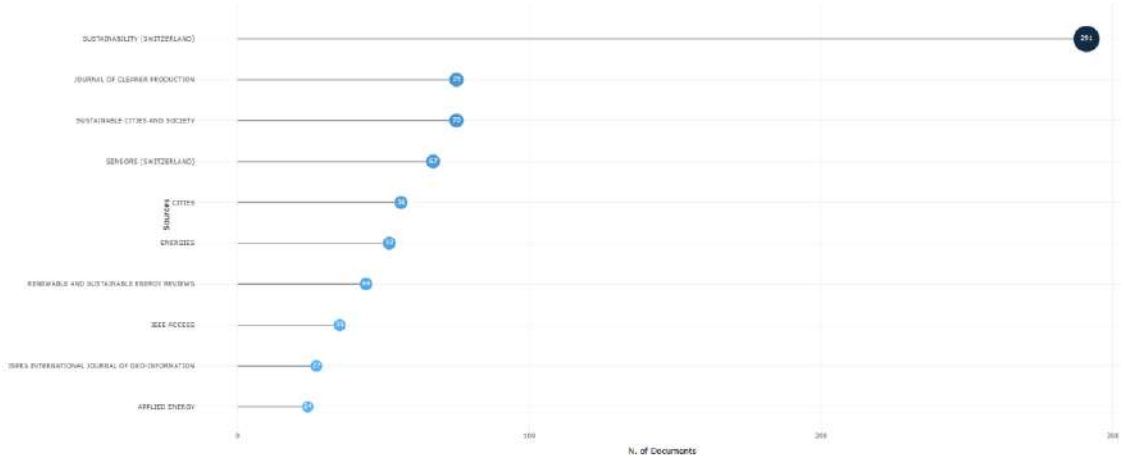

Figure 3. Top 10 Most Relevant Sources

This mix of environmental, urban, and technology-focused journals confirms that smart cities are a cross-disciplinary domain. The convergence of topics in these journals also reflects shifts from theoretical exploration toward real-world applications and performance assessments.

Moreover, these sources are not only prolific but also highly cited, suggesting their central role in shaping emerging smart city paradigms. Journals like *Sustainable Cities and Society* frequently feature case studies and policy evaluations, while *Sensors* focuses on the technical underpinnings of smart environments, such as real-time monitoring and IoT architecture. *Journal of Cleaner Production* often anchors discussions on sustainability metrics and resource efficiency in urban systems.

The breadth of publication topics across these journals also indicates how smart city research has evolved from experimental technologies to integrated frameworks that encompass energy, mobility, governance, and citizen well-being. This evolution highlights the journals' contribution to nurturing an interdisciplinary space where engineering innovations, environmental imperatives, and social inclusion intersect.

Finally, the diversity in journal origin—ranging from European to international open-access publishers—illustrates the global openness and accessibility of smart city scholarship, which has helped fuel the rapid exchange of ideas and scaling of best practices across continents.

Relevant Authors and Intellectual Contributions

In parallel with source productivity, author-level analysis sheds light on the field's most influential contributors. Wang Y and Zhang Y emerged as the most prolific authors during the period, each with 18 publications, while Li X, Li Z, and Wang J each contributed 16 articles. Their high output and strong presence in co-authorship networks suggest active involvement in research collaborations, particularly across Asian institutions. Their work frequently intersects with technological pillars of smart cities, including IoT systems, AI integration, and smart infrastructure design.

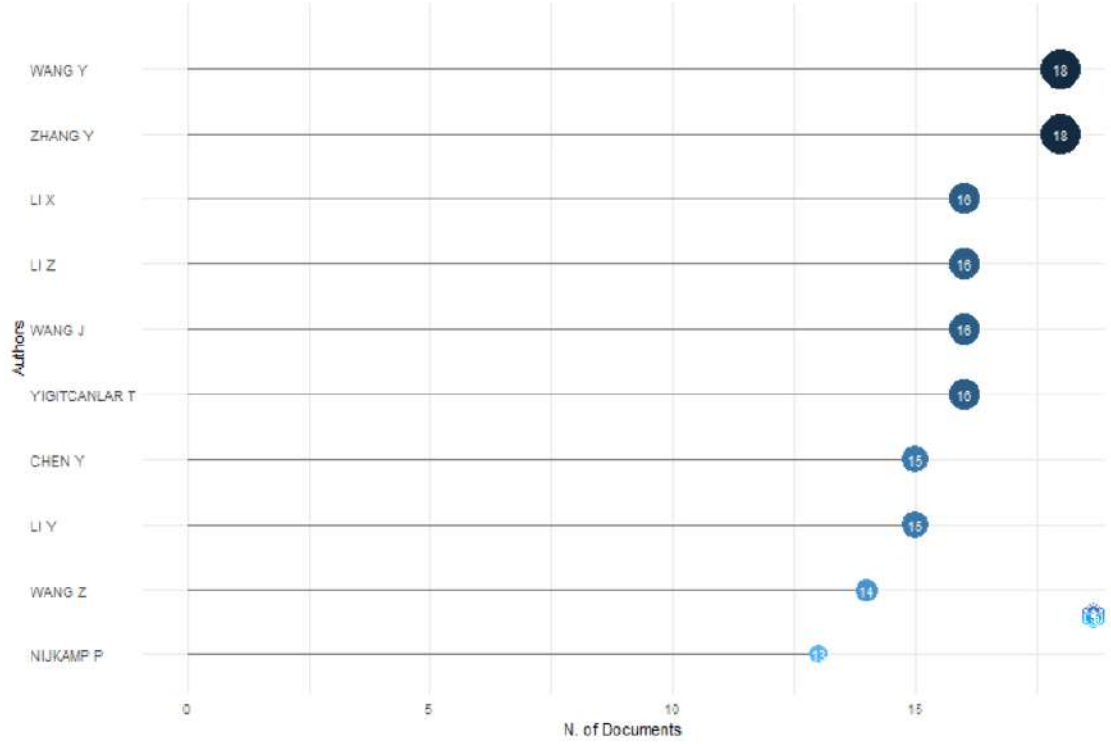

Figure 4. Top 10 Most Relevant Authors

The productivity of these authors reflects both the expansion of institutional support in countries like China and the growing international demand for technical expertise in urban digitalization. Their contributions help shape the research landscape by producing foundational knowledge and enabling broader adoption of smart technologies across different urban contexts.

Citation Impact and Foundational Works

Citation analysis identifies foundational works that have significantly shaped the intellectual development of the field. The most globally cited article was authored by Al-Fuqaha et al. (2015), published in *IEEE Communications Surveys & Tutorials*. This article, which offers a comprehensive overview of the enabling technologies and protocols for the Internet of Things (IoT), has amassed 6,794 citations, with an impressive average of 617.64 citations per year. Its impact is reflective of the critical role IoT plays in operationalizing smart city infrastructure and services.

Other highly cited publications include:

Author(s)	Year	Source	Total Citations	Citations/ Year
Al-Fuqaha et al.	2015	IEEE Commun. Surv. Tutor.	6,794	617.64
Agiwal et al.	2016	IEEE Commun. Surv. Tutor.	2,877	287.70
Albino et al.	2015	J. Urban Technol.	2,506	227.82
Islam et al.	2015	IEEE Access	2,435	221.36
Silva et al.	2018	Sustainable Cities and Society	1,368	171.00

The contributions of these authors span various core topics including 5G networks, urban definitions and frameworks, and technological applications in healthcare and urban management. Their high citation counts confirm the foundational role of technological foresight and conceptual clarity in advancing the smart city discourse.

Thematic Structure and Evolution

The conceptual structure of smart cities and sustainable development research was analyzed through keyword co-occurrence networks and Multiple Correspondence Analysis (MCA), allowing for the identification of dominant and emerging themes. Thematic mapping revealed several well-defined clusters centered around keywords such as sustainability, smart infrastructure, big data, IoT, and urban governance.

Figure 3. Word Cloud

These clusters demonstrate the field's inherently interdisciplinary character, combining insights from data science, public policy, systems engineering, and environmental planning. The themes align with practical implementations of smart city solutions, such as smart grids, intelligent transportation systems, real-time monitoring, and citizen engagement platforms.

Factorial analysis further emphasized the centrality of concepts like digital governance, urban resilience, energy efficiency, and environmental monitoring, suggesting a transition from purely technology-focused discussions to more holistic frameworks that integrate governance, equity, and sustainability.

The results also point to a maturing research agenda, where emerging themes are progressively addressing complex urban realities—such as climate adaptation, participatory planning, and ethical considerations in AI and surveillance systems. This thematic evolution reflects the growing ambition of the field to not only implement smart technologies but also align them with inclusive and sustainable development goals.

Discussion

The patterns revealed in this scientometric analysis suggest that the study of smart cities and sustainable development has transitioned from an emergent topic to a rapidly consolidating field of inquiry. Rather than simply reflecting quantitative growth in publications and citations, these trends point to a broader shift in how urban sustainability is conceptualized and pursued within academia. The increasing volume of research aligns with global policy movements such as the SDGs, signaling that scholars are responding to pressing urban challenges with both theoretical and applied perspectives.

More than a record of productivity, the analysis of leading sources and authors demonstrates that the field draws strength from its interdisciplinarity. The dominance of journals that span environmental sciences, urban planning, and digital technologies confirms a shared understanding that smart urbanism cannot be tackled within disciplinary silos. Importantly, this multidisciplinarity is not merely academic; it echoes the real-world complexity of cities where data governance, infrastructure design, and social equity converge.

The thematic mapping further illustrates this evolution. Earlier works largely focused on enabling technologies like IoT and data infrastructure. However, emerging clusters now incorporate more holistic concerns such as governance, participatory design, and resilience. This thematic maturation is encouraging. It shows that scholars are increasingly attentive to how smart technologies operate within broader systems of power, culture, and ecological limits.

Geographical patterns also provide a nuanced view of global engagement. While countries like China, Italy, and the United States dominate in volume, the presence of emerging economies suggests growing democratization of urban innovation research. Nevertheless, disparities in knowledge production remind us that smart city discourse remains uneven. Future directions must prioritize knowledge co-creation with cities in the Global South, where urban challenges are acute and solutions must be contextually grounded.

In sum, this analysis reveals a field moving beyond its technological roots toward a more reflexive, integrative, and impact-oriented scholarship. However, key questions persist: How inclusive are smart city initiatives in practice? What governance models ensure transparency and accountability in the use of urban data? And how can cities harness technology without reinforcing inequality or undermining sustainability? Addressing these questions will determine whether smart cities can truly serve as instruments of sustainable development.

Conclusion

The scientometric analysis of smart city and sustainable development research from 2015 to 2018 reveals a rapidly evolving field characterized by growing publication output, interdisciplinary collaboration, and a shift toward applied, equity-focused research. Foundational technologies such as IoT, 5G, and big data continue to shape the intellectual core of the discourse, while leading journals underscore the field's integration of urban studies, environmental science, and digital innovation. Despite notable progress, gaps remain in empirical research, particularly in areas of implementation, stakeholder inclusion, and regional equity. Moving forward, greater attention to social justice and inclusive governance is critical to ensuring that smart city initiatives contribute meaningfully to sustainable and resilient urban futures.

References:

Agiwal, M., Roy, A., & Saxena, N. (2016). Next generation 5G wireless networks: A comprehensive survey. IEEE Communications Surveys & Tutorials, 18(3), 1617–1655. https://doi.org/10.1109/COMST.2016.2532458

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? Cities, 60, 234–245. https://doi.org/10.1016/j.cities.2016.09.009

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. Journal of Urban Technology, 22(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet

of Things: A survey on enabling technologies, protocols, and applications. IEEE Communications Surveys & Tutorials, 17(4), 2347–2376. https://doi.org/10.1109/COMST.2015.2444095

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Bibri, S. E. (2019). Smart sustainable cities of the future: The untapped potential of big data analytics and context-aware computing for advancing sustainability. Energy Informatics, 2, 7. https://doi.org/10.1186/s42162-019-0022-3

Callon, M., Courtial, J. P., & Laville, F. (1991). Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry. Scientometrics, 22(1), 155–205. https://doi.org/10.1007/BF02019280

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools: Review, analysis, and cooperative study among tools. Journal of the American Society for Information Science and Technology, 62(7), 1382–1402. https://doi.org/10.1002/asi.21525

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Hashem, I. A. T., Yaqoob, I., Anuar, N. B., Mokhtar, S., Gani, A., & Khan, S. U. (2016). The rise of "big data" on cloud computing: Review and open research issues. Information Systems, 47, 98–115. https://doi.org/10.1016/j.is.2014.07.006

Islam, S. M. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The Internet of Things for health care: A comprehensive survey. IEEE Access, 3, 678–708. https://doi.org/10.1109/ACCESS.2015.2437951

Kumar, T., Dahiya, B., & Ayar, Z. (2020). Smart sustainable cities: Toward digital transformation. In T. Kumar & B. Dahiya (Eds.), Smart economy in smart cities (pp. 1–23). Springer. https://doi.org/10.1007/978-981-13-8393-7_1

Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. Sustainable Cities and Society, 38, 697–713. https://doi.org/10.1016/j.scs.2018.01.053

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. https://sdgs.un.org/2030agenda

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., da Costa, E., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic review of the literature. Sustainable Cities and Society, 45, 348–365. https://doi.org/10.1016/j.scs.2018.11.033

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. Organizational Research Methods, 18(3), 429–472. https://doi.org/10.1177/1094428114562629