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(Review Article)

Public-Private Partnerships in Smart City Development: A Bibliometric Analysis with a Sustainability Perspective

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Abstract
This study explores how Public-Private Partnerships (PPPs) analyzed through a sustainability-oriented perspective through a bibliometric approach. It reviews keyword trends, countries, and institutions actively involved in this field to provide insights into how such collaborations can enhance public service quality. Data was collected from the Scopus database for the 2014–2024 period, yielding 650 publications analyzed using Biblioshiny software in RStudio. The findings reveal a growing research trend, with China leading in publication contributions, while Australia ranks highest in citations. This study highlights the importance of integrating sustainability values into public-private collaborations, particularly to support smart city development focusing on environmentally friendly technologies and societal well-being. The research also provides recommendations for future studies and policies that support sustainable development.

Keywords
bibliometric, green public-private partnership, smart city, society 5.0, sustainability

Received: 25 January 2025; Revised: 11 March 2025; Accepted: 27 August 2025

Introduction

Rapid development of technology has required society and government to adapt and innovate. The arrival of the Society 5.0 era has united technology with competent human resources, reflected in the ease of work and services that we experience today. Society 5.0 directs technological advancement toward addressing social and environmental challenges, and global awareness of sustainability issues is increasing every year. The implementation of the Sustainable Development Goals (SDGs), particularly those concerning the environment and society, is highly relevant to public service innovation, one of which is the Smart City program.

The term Smart City refers to an interconnected urban framework that integrates infrastructure, technology, governance, and citizens to enhance efficiency and quality of life (Caragliu et al., 2011; Siokas et al., 2022). In this study, the phrase Smart City is not intended as a different concept, but rather to emphasize the range of innovations—such as smart mobility, smart governance, e-health, and the application of IoT and artificial intelligence—that emerge within the broader Smart City framework. To remain consistent with the established literature, this study therefore employs Smart City as the main concept, while "innovations" are understood as inherent dimensions of its implementation.

To realize sustainable and inclusive smart cities, governments cannot act alone. They require collaboration with actors that possess resources, knowledge, and expertise beyond what the public sector can provide. This collaboration is commonly framed as Public-Private Partnerships (PPPs). According to the National Council for Public-Private Partnership (NCPPP) in Tavana et al. (2022), PPPs are contractual agreements between public institutions and private entities to provide services or infrastructure by sharing

resources, risks, and benefits. PPPs have been widely implemented worldwide to overcome the limitations of government capacity in financing and managing development.

In recent years, scholars have highlighted the importance of embedding sustainability values into PPPs (Vassileva, 2022; Tavana et al., 2022). From this perspective, PPPs are not only mechanisms for efficiency and cost-sharing, but also instruments to promote environmentally responsible and socially inclusive development. This sustainability-oriented framing is often referred to as green PPPs. In this article, "green" is not treated as a separate or new concept, but as an analytical lens to emphasize how PPPs can support sustainable outcomes in urban development, including smart city initiatives.

This framing is especially relevant because smart cities inherently intersect with sustainability challenges, including climate change, energy efficiency, green infrastructure, and citizen well-being (Liu et al., 2020). However, despite the growing body of research on PPPs and smart cities, systematic mapping of how these two areas intersect—particularly through the lens of sustainability—remains limited.

From these developments, several research questions arise: (1) How has research on the participation of PPPs in sustainable smart city projects evolved? (2) Which institutions or countries are most active in PPP and smart city collaboration studies? (3) What are the most frequently occurring keywords and how are these concepts connected?

The aim of this study is to map the literature on PPPs and smart city development through a bibliometric approach with a sustainability perspective. By identifying key trends, keywords, and research gaps, this study provides insights into how PPPs can support smart city initiatives while embedding sustainability values. The findings are expected to inform both future collaborative research and policy development toward sustainable urban governance.

Literature Review

The concept of a smart city is not merely about a technologically advanced urban area. Rather, it is a comprehensive framework that integrates multiple factors such as natural resources, mobility, infrastructure, governance, economy, and people (Siokas et al., 2022). Caragliu et al. (2011) define smart cities as urban systems where investments in human and social capital, as well as modern ICT infrastructure, drive sustainable economic growth and quality of life. This perspective underlines that smart cities are not only technological but also socio-economic and governance innovations. Their connection with public services emphasizes the responsibility of governments in delivering efficient and inclusive infrastructure, transportation, social services, health, and education. In the era of Society 5.0, which stresses environmental and social challenges, smart cities become critical platforms for implementing sustainable and citizen-centered services.

Alongside this, Public-Private Partnerships (PPPs) have become one of the most significant governance models to support complex public services. PPPs are generally defined as contractual collaborations between public institutions and private actors, allowing them to share resources, risks, and benefits in delivering services or infrastructure (Raisbeck et al., 2010; Tavana et al., 2022). The model has been widely adopted to overcome limited government capacity in financing development and managing large-scale projects. Traditionally, PPPs are studied in terms of efficiency, cost-effectiveness, and risk-sharing mechanisms. Within the paradigm of New Public Governance (Osborne et al., 2014), PPPs also reflect a broader shift toward multi-actor collaboration, where the private sector and civil society play active roles in governance.

In recent years, scholars have stressed the importance of embedding sustainability into PPPs. Vassileva (2022) argues that PPPs can be understood through a sustainability-

oriented perspective, sometimes referred to as green PPPs in the literature (Vassileva, 2022). This framing emphasizes that partnerships should not only pursue efficiency but also integrate long-term goals such as environmental protection, climate change mitigation, and social inclusion. In this study, "green" is not introduced as a separate concept, but as an analytical lens that highlights how PPPs can contribute to sustainable development agendas, particularly those aligned with the Sustainable Development Goals (SDGs).

This sustainability perspective is particularly relevant in the context of smart cities. Smart city initiatives often involve innovation in energy efficiency, waste management, digital governance, and green infrastructure—all of which demand sustainable approaches (Liu et al., 2020; Siokas et al., 2022). Previous studies highlight that PPPs embedded with sustainability values are more adaptive to these demands, supporting both technological innovation and societal well-being (Siokas et al., 2022; Vassileva, 2022).

Therefore, the synergy between PPPs and smart city development can be viewed not only as a collaboration for efficiency, but also as a pathway toward environmentally sustainable urban transformation. The novelty of this paper lies in exploring how PPPs relate to smart cities when analyzed through a sustainability-oriented perspective. While many earlier studies have focused on PPPs in terms of efficiency and governance, fewer have explicitly addressed how sustainability considerations shape collaborative practices. By adopting this lens, the study provides a bibliometric mapping of PPP and smart city research (2014–2024) that emphasizes sustainability as an integral dimension of future public-private collaboration in the realization of Society 5.0.

Method

This research uses bibliometric analysis, Donthu et. al., (2021) grouped bibliometric analysis techniques into two categories; these are performance analysis and science mapping. Both have different output focuses where science mapping aims to find out the intellectual mapping and relationships between ideas or research entities, while performance analysis focuses on quantitative evaluation of productivity and contribution impact. Bibliometrics is currently used by administrators, journal editors, librarians, administrative researchers or other researchers for academic programs and policy makers, this method is often used as a benchmark to assess the productivity and impact of science on the development of a topic. Research on bibliometrics is the focus of research in the discipline of bibliometrics. Ye, et.al., (2012) said bibliometric research is observed based on research results, including topics, methodological approaches, and samples. Then the data is processed with the use of basic or level statistics on data derived from previous studies such as books, proceedings, and journals.

The data for this research was extracted from the Scopus database by conducting search terms "("Public Private-Partnership" OR "Government Collaboration") AND ("Green Public-Private Partnership" OR "Smart City")" with a range of years 2014-2024 with restrictions; scientific articles, conference papers, book chapters, reviews and books and English language limitations. These filters produced a search of 650 results with the relevant subject area limitation including; o; 1) Social Sciences; 2) Computer Science; 3) Engineering; 4) Business, Management, and Accounting; 6) Energy; 7) Economics, Econometrics, and Finance; and 8) Environmental Science. Through the bibliometric approach, it is able to produce visualizations and tables of research data based on author, year, citation, country, information source, and research trends according to the selected scientific topic. Further variables collected include publication date, journal, country of origin of first and last author, total citations (Barrington, et.al., (2023).

To enhance the presentation of descriptive data and make it more visual, the first stage of the analysis used biblioshiny software in the RStudio Software (Suwandi et al., 2024)

with Posit Cloud. The steps of bibliometric mapping used the PRISMA diagram to demonstrate screening strategy for included literature in the illustrated in the following figure;

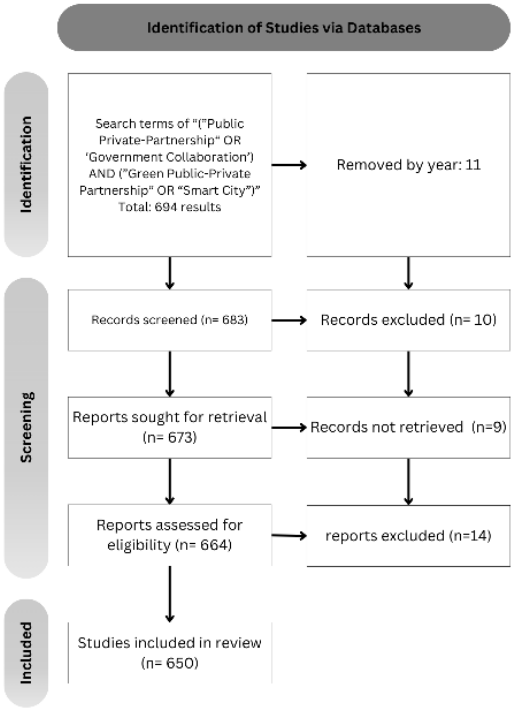

Figure 1.
PRISMA diagram demonstrating screening strategy for included articles
Source: processed by researchers, 2024

The PRISMA flow chart consists of the following three key steps;

1. **Identification:** Lists the total records from search terms retrieved from Scopus database, followed by the removal of duplicates and irrelevant studies. With focusing search terms of "("Public Private-Partnership" OR "Government Collaboration") AND ("Green Public-Private Partnership" OR "Smart City")" results yielded 694 total results. These key string targets studies that explore the intersection of public-private partnership, smart city (as public service), and government collaboration.
2. **Screening:** Initial review of titles and abstracts based on excluding filters criteria;

Table 1.
Accumulate of Filtering Data

Category	Information
Database Research	Scopus
Time Span	2014 - 2024
Language	English
Search Terms	"Green Public-Private Partnership" OR "Smart City"
Document Type	Article, Conference Paper, Book Chapter, Review, and Book
Extraction	Extracted fully (cited, bibliography, abstract & keyword, and other information) with CSV format
Total Results	650

Research Area	1) Social Sciences; 2) Computer Science; 3) Engineering; 4) Business, Management, and Accounting; 6) Energy; 7) Economics, Econometrics, and Finance; and 8) Environmental Science.

Source: processed by researches using the biblioshiny in RStudio Software, 2024

The screening process aims to ensure that data analyzed is relevant and of good quality (Suwandi et al., 2024), the screening process selected a total of 650 articles included in the study. The results of the Scopus database were converted to .csv format to process in biblioshiny in RStudio.

3. **Visualization and Interpretation:** In this section, network analysis and descriptive statistics from biblioshiny were used to visualize research trend and the geographical distribution of publications related to public-private partnerships and smart city. From those analysis are allowed to identify relationships between key concepts, authors, and institutions, providing a clearer picture of active research centers and the most frequently discussed topics. (Suwandi et al., 2024).

To ensure transparency in the data collection process, Table 1 presents the filtering criteria applied in the bibliometric analysis, including database source, time span, language, and document type. This step is essential to establish the boundaries of the dataset and to guarantee replicability. After the filtering process, a total of 650 documents were included in the analysis, providing a representative foundation for mapping the intersection of PPPs and smart city research.

Results

The aim of this research is to map literature on green public-private partnership synergy and smart cities innovation services using a bibliometric approach through descriptive analysis. This approach allows identifying the extent of trends/development in the use of keywords in Green Public-Private Partnership participation efforts, knowing the countries and institutions that are actively making Green Public-Private Partnership engagement studies on public services, and how green public-private partnership participation can improve public services. The time span analyzed covers 2014 to 2024, which is the period in which publications on Green Public-Private Partnership and sustainable Smart Cities are recorded in Scopus by identifying key trends, keywords, and gaps in the literature.

Study Participation of Green Public-Private Partnership in Smart Cities

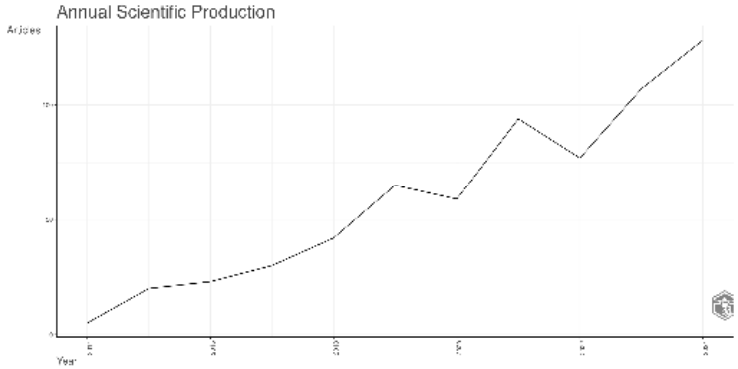

Figure 2.
Annual Scientific Production 2014 - 2024 Related to Public-Private Partnership and Smart City

Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 2 illustrates the annual scientific production related to PPPs, government collaboration, and smart cities. The output shows consistent growth, with a notable increase after 2020 and an overall annual growth rate of 38.3%. This trend reflects a growing academic interest in sustainability-oriented urban governance and highlights the increasing global relevance of PPPs in smart city contexts. The growth of trends shows the increasing attention to these topics in academic discussions and in line with global sustainability goals (Suwandi et al., 2024)

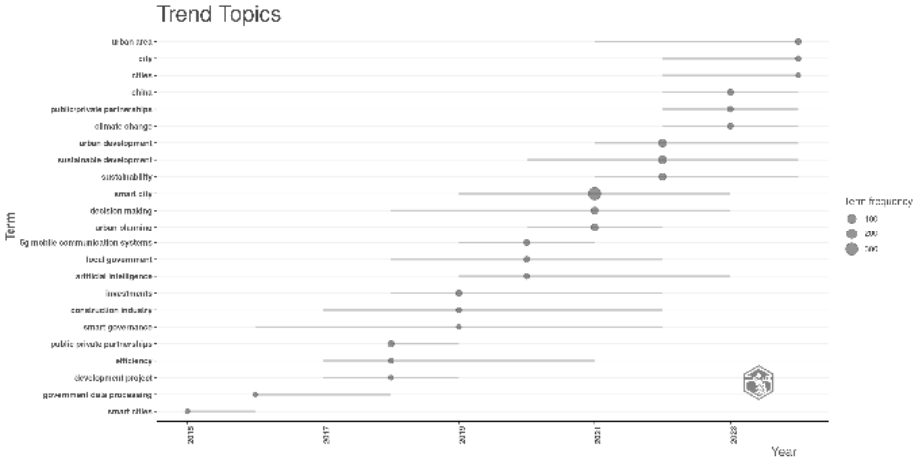

Figure 3.
Trend Topics 2014 - 2024
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 3 depicts the evolution of research topics over the past decade, as reflected by keyword usage. Sustainability and smart city appear as dominant and persistent themes, while PPP-related terms occur less frequently and only emerge in recent years. This indicates that although smart cities and sustainability are well-established research areas, the explicit integration of PPPs into this discourse remains limited, underscoring the research gap that this study addresses.

This graph is helpful in discussing how the focus of interest in topics has evolved in the academic field and also identifies P3s or Smart Cities that are gaining prominence. The graphic above shows the interest in topics that support the green public-private partnership study on smart city using the terms of topics; urban area, city, cities, china, public/private partnerships, climate change, urban development, sustainable development, sustainability, smart city, decision making, urban planning, 5g mobile communication systems, local government, artificial intelligence, investments, construction industry, smart governance, public private partnerships, efficiency, development projects, government data processing, and smart cities. It is observed that several keywords connected for these topics exist at one time depending on trends of that year. As shown the topics of urban area, city, cities, china, public/private partnerships, climate change, sustainable development, and sustainability, which are still current topics since 2021 with a term frequency of around 100-200 words. The existence of these keywords also shows the intersection of relevant topics related to partnerships, programs, and sustainability in building society 5.0.

Global and Institution Leaders in Research and Implementation in Green Public-Private Partnership Collaboration

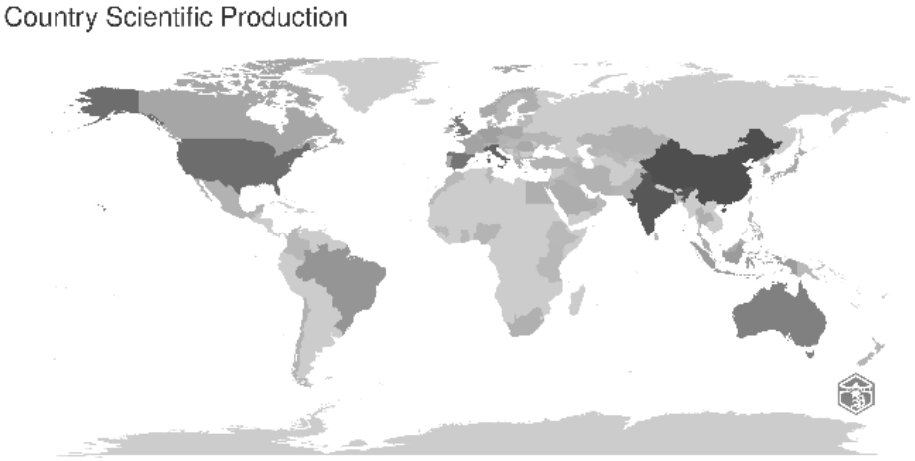

Figure 4.
Country Scientific Production
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 4 illustrates the Country Scientific Production based on the keywords related to Green Public-Private Partnership and Smart City. This illustration depicts the productivity of publications on Green Public-Private Partnership and Smart City based on the country's scientific production. The dark blue region shows countries that have the highest scientific production in this field, while the gray color shows the absence of production that discusses studies with these keywords. Suwandi et.al. (2024) describe this figure as follows;

1. **High Output Countries (Dark Blue)**
   The darkest blue countries, China and India, indicate the highest production of study publications relevant to green public-private partnerships and smart cities. These countries are likely to have strong research institutions, significant funding for sustainability initiatives and high academic output in these areas. (Suwandi et al., 2024)
2. **Moderate Output (Lighter Blue)**
   The lighter blue colors such as Australia, Spain, Italy, United Kingdom and United States, as well as the slightly brighter blue in the Brazil and Indonesia areas show the existence of scientific publication production is not as high as the leading nations in the darkest blue area, but they still contribute significantly to the field.
3. **Low Output (Light Blue)**
   Light blue indicates lower production of articles in this field, as some countries in East Asia, Middle East, South Africa, Latin America are still engaged with research related to green public-private partnerships and smart cities.
4. **No Output (Gray Areas)**
   Several countries in Africa and Central Asia show an absence of scientific publications on these topics and keywords. However, it is expected that there will be future publications on green public-private partnerships.

The data interpretation of Country Scientific Production presented that aligns with the graphic of figure 5 about Country Production over Time.

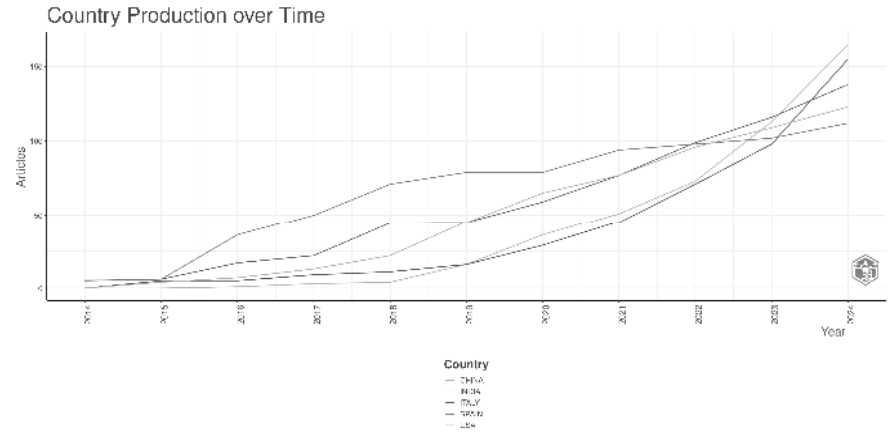

Figure 5.
Country Production over Time
Source: processed by researches using the biblioshiny in RStudio Software, 2024

This graph presents a simpler visualization of the top 5 countries contribution in development research each year, the graph shows that China, India, Italy, Spain, and the United States are countries that have the highest productivity in publications in the fields of green public-private partnerships and smart cities which can certainly influence policies in various regions.

Figures 4 and 5 show scientific production by country, both in cumulative terms and by year. China and India stand out as the most productive countries, while Italy, Spain, and the United States also contribute significantly. These figures highlight the geographical concentration of research activity. However, productivity alone does not guarantee influence, as the citation analysis in Figure 6 reveals. This suggests that while Asia is emerging as a hub for volume of publications, other regions may exert stronger scholarly impact.

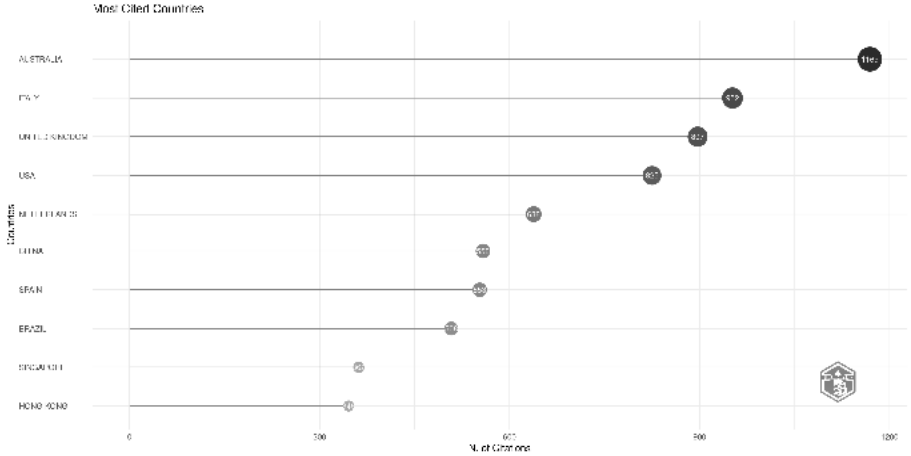

Figure 6.
Most Cited Countries
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 6 ranks countries according to citation impact. Interestingly, Australia emerges as the most cited country despite producing fewer publications than China or India. This finding highlights the disproportionate influence of certain countries in shaping the global discourse. It also suggests that impactful scholarship on PPPs and smart cities may not necessarily come from the most prolific regions, but from contexts

where research aligns more closely with global policy and sustainability debates. Several factors that Australia can be the leader of cited countries are including;

1. **Comprehensive implementation of smart city initiative**: Australian governance has significant strides of smart city implementation fully supporting integration of advanced digital technologies to enhance efficiency, sustainability and inclusivity services. This factor made Australian researchers invest in research and development in developing smart city infrastructure, highlighting their importance in achieving sustainable urban development (Sulistia & Nam, 2022). The R&D also influences policy-making and practical application in urban planning.
2. **Strong public-private partnerships**: the huge opportunities of public-private partnerships (PPPs) is recognized by their governance, the implementation of PPPs in Australia is well-documented (Raisbeck et al., 2010). The collaboration has **facilitated** the development of sustainable infrastructure and services, which are critical smart cities initiatives.
3. **Global recognition and benchmarking**: Australia is frequently benchmarked against other leading countries in smart city development. The implementation has been **recognized** globally for their innovative approaches and effectiveness. Reports such as the IMD Smart City Index have ranked Australian cities highly, reinforcing their reputation as models for smart urban management (Hedegaard et al., 2024). This visibility attracts further research interest and citations.

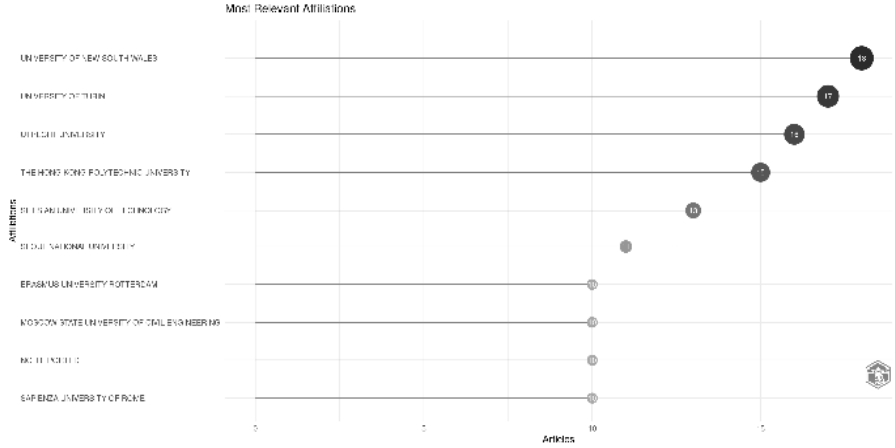

Figure 7.
Most Relevant Affiliations
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 7 presents the institutions most actively engaged in PPP and smart city research. The University of New South Wales, University of Turin, and Utrecht University dominate in terms of scholarly output. This indicates that academic leadership in the field is spread across different regions, with both developed and emerging economies contributing. These institutional patterns reinforce the global nature of smart city and PPP studies, particularly when sustainability goals are considered.

The spread of institutions in this graph also reflects the global nature of the research, with universities from different regions of the world involved. This shows that issues such as climate change, sustainable urban development and public-private collaboration do require multidisciplinary approaches and cross-border cooperation. The presence of these leading institutions also indicates strategic priorities, funding support, or collaborative networks that drive their publication productivity. By understanding these patterns, we can identify trends in institutional leadership as well as opportunities to expand research cooperation globally.

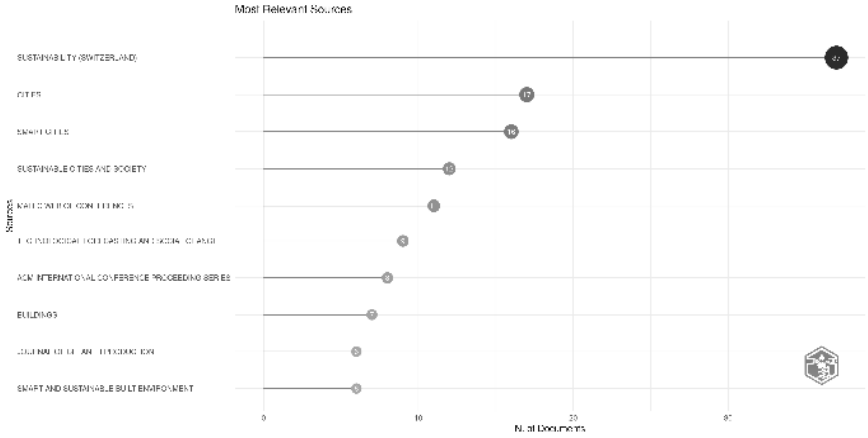

Figure 8.
Publication Production with Relevant Sources
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 8 identifies the journals that publish the largest share of research in this domain. Sustainability (Switzerland) and Cities emerge as the top sources, suggesting that the discourse is primarily rooted in sustainability and urban studies journals. This highlights the interdisciplinary character of the field, where urban planning, governance, and environmental sustainability converge.

The data shows that the journal Sustainability (Switzerland) is the most productive source with a total of 37 publications, emphasizing its focus on cross-disciplinary research related to sustainability. Journal Cities ranked 2nd in contributions with 17 publications, followed by Smart Cities which contributed 16 publications. Both journals play an important role in exploring urban development issues, technological innovations, and policies that support the concept of smart and sustainable cities. Other significant sources include Sustainable Cities and Society with 12 publications, and Matec Web of Conferences with 11 publications, which emphasize sustainable urban practices and the application of technology in infrastructure, respectively. Technological Forecasting and Social Change also accounted for 9 publications, highlighting its role in predicting the impact of technology on social and urban development.

Furthermore, the ACM International Conference Proceeding Series recorded 8 publications, showing its focus on advances in technology and computing, while Buildings produced 7 publications, many of which discussed green building practices. Finally, Journal of Cleaner Production and Smart and Sustainable Built Environment contributed 6 publications each, focusing on environmental sustainability and innovation in green building. These publications reflect the multidisciplinary nature of the field. In addition, these sources confirm their role as key platforms for researchers to publish relevant findings.

In the next step is to understand the contributions of the studies that have had the greatest influence in this field. Table 2 presents the Top 10 Most Cited Publications in the dataset (2014–2024). Interestingly, none of these highly cited works explicitly focus on PPPs or green PPPs. Instead, they primarily address smart city concepts, governance, and sustainability dimensions (Gil-Garcia, 2015; Allam, 2018; Ullah, 2021). This reflects the dominance of smart city research in the broader field and indicates that studies connecting PPPs with smart city development remain less visible in highly cited literature.

This finding highlights an important research gap: while smart cities are widely studied, the role of PPPs—especially through a sustainability-oriented or "green" perspective—has not yet received comparable scholarly attention. Thus, this study

contributes by mapping the intersection of PPPs and smart cities, offering insights into an area that is underrepresented in the most influential publications.

Table 2.
Top 10 Most Cited Publication in 2014-2024

Author	Title	Journal	Total Citations	TC per Year
GIL-GARCIA JR, 2015, INF POLITY	What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization	Information Polity	314	31.4
ALLAM Z, 2018, SMART CITIES	Redefining the Smart City: Culture, Metabolism and Governance	Multidisciplinary Digital Publishing Institute	305	43.57
DE GUIMARÃES JCF, 2020, J CLEAN PROD	Governance and quality of life in smart cities: Towards sustainable development goals	Journal of Cleaner Production	256	51.2
PAPA A, 2020, TECHNOL FORECAST SOC CHANGE	E-health and wellbeing monitoring using smart healthcare devices: An empirical investigation	Technological Forecasting and Social Change	216	43.2
ULLAH F, 2021, TECHNOL FORECAST SOC CHANGE	Risk management in sustainable smart cities governance: A TOE framework	Technological Forecasting and Social Change	213	53.25
HE B-J, 2019, LAND USE POLICY	Co-benefits approach: Opportunities for implementing sponge city and urban heat island mitigation	Land Use Policy	193	32.17
TAN SY, 2020, SUSTAINABILITY	Smart City Governance in Developing Countries: A Systematic Literature Review	Multidisciplinary Digital Publishing Institute	191	38.2
BARNS S, 2018, CITY CULT SOC	Smart cities and urban data platforms: Designing interfaces for smart governance	City, Culture, and Society	188	26.86
RANA NP, 2019, INF SYST FRONT	Barriers to the Development of Smart Cities in Indian Context	Springer Nature Link	186	31
ZHENG C, 2020, J CLEAN PROD	From digital to sustainable: A scientometric review of smart city literature between 1990 and 2019	Journal of Cleaner Production	179	35.8

Source: processed by researches using the biblioshiny in RStudio Software, 2024

Table 2 lists the most cited publications in the dataset, which serve as benchmarks for influential scholarship. Most of these works emphasize smart city governance, technological innovation, and sustainability dimensions. The leader of the most cited paper based on time span (2014-2024) is by Gil-Garcia JR. (2015), with a total of 314

citations and an impressive 31.4 citations per year. The top five publications with >212 indexed citations indicate the high impact productivity and influence in this field of research. Four of them have the word “smart city” or “smart cities” in each title, and one of them discusses e-health as smart healthcare which is more related to public-private partnerships. While the last 5 publications of articles that have a total citation of 194>n>179 focus on smart cities which also still have highly potential influential pieces of research.

The absence of PPPs among the most cited publications reveals a significant research gap: although collaboration is critical to smart city implementation, it has not yet received equivalent academic attention. This study therefore contributes by explicitly mapping PPPs in relation to smart cities from a sustainability perspective. However, these 10 publications have helped the development of the study of green public-private partnerships and smart cities.

The Most Often Keywords Connected

Analyzing the most frequently connected keywords provides critical insights into the core concepts shaping the research domain. This section employs network visualization, word clouds, and thematic analysis from Biblioshiny to uncover dominant terms such as "smart city," "sustainable development," and "urban developments." These visualizations highlight the relationships between key concepts, group them into thematic clusters, and reveal evolving trends to make the field of green public-private partnership. Together, these tools offer a deeper understanding of the interconnected themes driving innovation in public-private partnership to make a green public service.

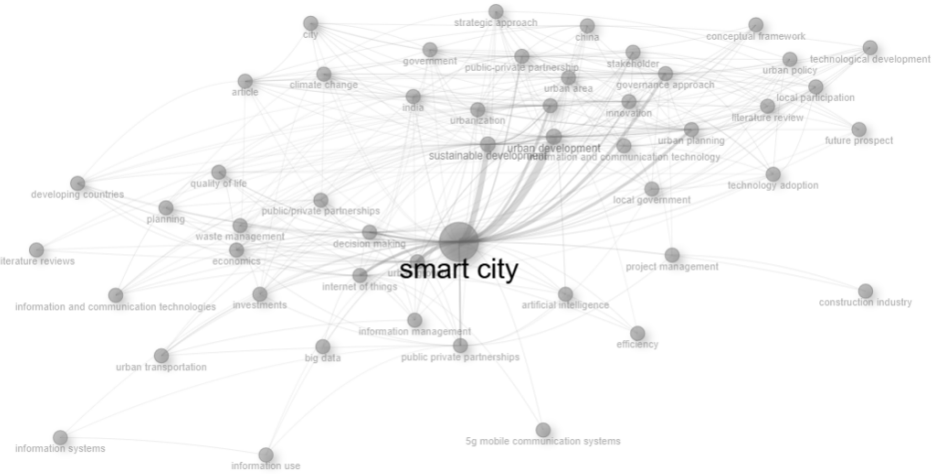

Figure 9. Network Visualization
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 9 illustrates the co-occurrence network of keywords. The largest clusters revolve around “smart city,” “sustainability,” and “urban development,” while PPP-related terms appear smaller and less central. The purpose of this visualization is to reveal the structural connections between concepts, showing that PPPs are currently peripheral in the discourse. This reinforces the novelty of positioning PPPs as a sustainability-oriented framework within smart city research.

The size of the nodes (circles) shows the frequency of occurrence of the theme keyword “smart city”, the thickness of the edges (connecting lines) between the word “smart city” and other keywords (e.g. “public-private partnerships”) shows the connection between keywords that often appear together, while the color clusters show differences in topics but are still relevant. Green is marked as keywords tied to policy, technology, and innovation in development, blue focuses on infrastructure, information

technology, and sustainability, while red is keywords with a more separate relationship such as information systems.

Figure 10.
Wordcloud
Source: processed by researches using the biblioshiny in RStudio Software, 2024

Figure 10 visually represents the most frequent keywords in the dataset. As expected, "smart city" is the most prominent, followed by "sustainability" and "urban planning." PPP-related terms appear relatively small, signaling their limited integration into mainstream smart city research. This further emphasizes the relevance of the present study in addressing the underrepresentation of PPPs within the field.

The keyword "smart city" is most often the visualization, indicating its critical role in the discourse. A smart city refers to an urban development framework that integrates technology, governance, and environmental sustainability to enhance public services and improve quality of life. The other frequently appearing keywords, such as "sustainable development," "sustainability," "urban development" etc. are highlighted additional themes central to this field. These probably include concepts related to innovation or government collaboration, underscoring the multidisciplinary if studies in this area. The clustering and size of words in the visualization suggest emerging trends and priority areas, which could guide future research directions. The figure also shows that the keyword identified not only the dominant topics but also gaps or underexplored areas within the field of green public-private partnerships.

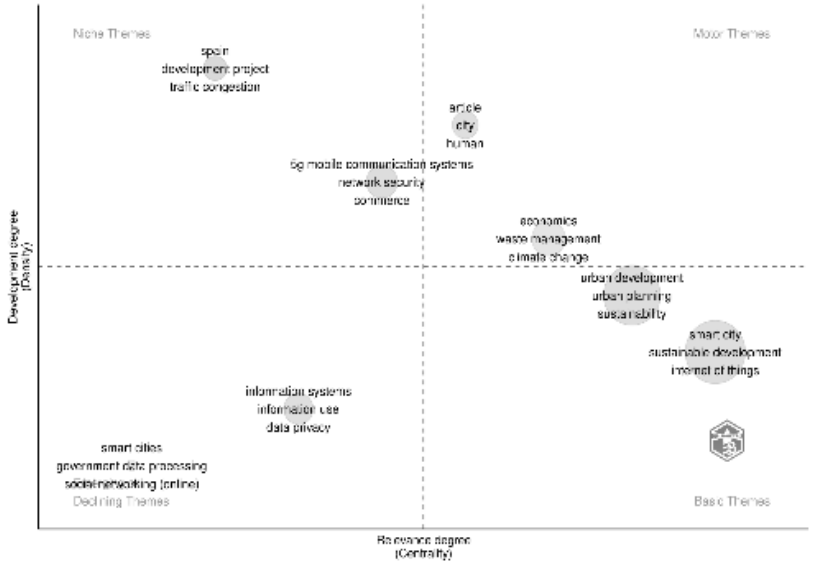

Figure 11.
Thematic Map
Source: processed by researches using the biblioshiny in RStudio Software, 2024

The thematic map in Figure 11 provides a visualization of the research topics based on their development degree (density) and relevance degree (centrality), derived from the bibliometric analysis using Biblioshiny. The quadrants categorize topics into four types:

1. **Motor Themes (upper-right quadrant):** These themes are well-developed and central, making them both relevant and influential within the research field. In this study, topics such as "economics," "waste management," and "climate change" fall under this category. These themes are integral to the discourse and indicate areas where research has achieved both depth and widespread applicability.
2. **Basic Themes (lower-right quadrant):** Representing foundational and highly relevant topics, this quadrant includes themes such as "smart city," "sustainable development," and the "internet of things." These topics serve as the backbone of the field, providing essential concepts that underpin further investigations.
3. **Niche Themes (upper-left quadrant):** This quadrant captures topics that are highly specialized but less central to the overall field. For example, "Spain," "development project," and "traffic congestion" are niche themes that suggest localized or highly specific applications and studies.
4. **Declining or Emerging Themes (lower-left quadrant):** This quadrant identifies themes with low development and relevance, which might either be losing significance or in the early stages of research. Topics such as "smart cities," "government data processing," and "social networking (online)" are located here, possibly indicating areas that require further exploration or have seen a decrease in focus.

Overall, Figure 11 categorizes research themes into motor, basic, niche, and emerging themes. Smart city and sustainability appear as basic themes, reflecting their established position in the literature. PPP-related keywords, on the other hand, appear in less central clusters, suggesting that they remain an emerging or niche topic. This classification confirms the novelty of focusing on PPPs from a sustainability perspective and demonstrates the need for further scholarly attention in this area.

Discussions

The bibliometric results show that research on smart cities and sustainability has developed strongly over the last decade, while public-private partnerships (PPPs) remain peripheral in the discourse. Existing studies focus heavily on technological and governance innovations, which is a strength, but they often overlook the role of collaborative frameworks such as PPPs. This creates an imbalance: smart cities are well studied from a technological perspective, but less so from an institutional and governance perspective.

At the global level, countries such as China and India are highly productive but have limited influence, while Australia produces fewer but more impactful works. This contrast reflects a gap between productivity and visibility, suggesting the need for stronger global collaboration. Similarly, leading institutions such as UNSW and Utrecht play central roles, but cross-regional cooperation remains weak, limiting comparative insights. Keyword and thematic mapping confirm this pattern, with PPPs still positioned as an emerging theme rather than a core element of smart city research.

These findings highlight both the strengths and limitations of the current literature. The strength lies in the maturity of smart city and sustainability research, while the weakness lies in the marginalization of PPPs. This study contributes by reframing PPPs through a sustainability-oriented perspective, showing their potential not only for efficiency but also for advancing inclusive and environmentally sustainable smart city development in the era of Society 5.0.

Conclusion

This study mapped the relationship between public-private partnerships (PPPs) and smart cities through a bibliometric analysis of publications from 2014–2024. The results indicate that while smart city and sustainability research have become dominant, PPPs remain relatively marginal in the discourse. This highlights a gap in the literature, as collaborative governance models are essential for the implementation of complex urban innovations.

By adopting a sustainability-oriented perspective, this study reframes the role of PPPs not only as efficiency-driven mechanisms but also as enablers of inclusive and environmentally responsible urban development. The contribution of this paper lies in identifying the current imbalance and offering directions for future research, encouraging scholars to more explicitly integrate PPPs into smart city studies to strengthen their capacity in supporting the goals of sustainable and resilient cities in the era of Society 5.0.

Acknowledgments

Thanks to the two of my supervisors; Rully Khairul Anwar and Yunus Winoto as lecturers of the Infometrics course for their knowledge and funding this article in full

Declaration of conflicting interests

This study never had any conflict and there is no conflict of interest relating to the research. If any conflict of interest exists, the author(s) must disclose it explicitly with the statement that 'there is a conflict of interest with a particular person or organization'.

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