

Research Article

Towards Smart Cities Implementing Collaborative Governance Models for Urban Sanitation Improvement

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Abstract.

This study examines the application of collaborative governance models to improve urban sanitation in the context of smart cities, especially in areas with rapid urbanization. Using a Systematic Literature Review (SLR) and bibliometric analysis, the study maps trends and opportunities for collaboration between various parties, including the government, private sector, communities, and academia. The findings reveal that collaborative approaches have proven effective in improving sanitation management capacity through technological integration and active participation of various stakeholders, although they still face challenges such as complex coordination and financial sustainability. By referring to the theoretical framework of collaborative governance and the concept of smart cities, this study provides a practical guide for policymakers to maximize collaboration in urban sanitation, strengthen the role of digital technologies, and accelerate the transition to cleaner, healthier, and more sustainable cities.

Keywords: smart city, urban sanitation, collaborative governance, SLR, bibliometric analysis

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1. Introduction

Rapid urbanization in various cities around the world, including Indonesia, has presented major challenges in the provision of basic infrastructure services, especially sanitation. Continuous population growth often exceeds the capacity of existing sanitation systems, resulting in increasingly complex environmental and public health problems (1). In this context, the concept of smart cities has begun to be introduced as an innovative solution to improve the efficiency of urban management, including in the sanitation sector (2). However, one of the main challenges to improving urban sanitation is the lack of effective coordination and collaboration among various stakeholders, such as the government, private sector, and communities (3). The relatively separate sanitation

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governance often causes limitations in the planning, funding, and implementation of sanitation programs (4). Therefore, this study aims to develop and evaluate a collaborative model of integrated sanitation governance within the framework of a smart city, involving the active participation of all stakeholders (5).

Although some studies have been conducted on sanitation innovation and urban management, there is still a gap in the literature on the application of collaborative models that unite various stakeholders under the smart city principle (6). Most of the existing studies focus on technical aspects without considering the role of cross-sectoral collaboration in achieving sanitation sustainability. This study fills this gap by proposing a governance approach that prioritizes cross-sectoral collaboration to improve sanitation services in smart cities (7). In addition, the novelty of this study lies in the integration of collaborative governance with digital technology elements that are key pillars of the smart city concept. Through this approach, this study offers a significant contribution to the development of literature in the field of urban management and sanitation and justifies that collaborative models are not only relevant but also urgent to implement amidst the challenges of modern urbanization (8).

This research is expected to provide practical solutions in urban sanitation management, as well as be a reference for policymakers and practitioners in formulating innovative, adaptive, and sustainable governance strategies for cities that are developing towards smart cities. Thus, this research not only contributes to improving the efficiency of the sanitation system but also to creating smart cities that are more inclusive and responsive to future challenges.

2. Theoretical Study

2.1. Smart City and Urban Sanitation Concept

A smart city is a concept that integrates digital, data, and communication technologies to improve the efficiency of public services, quality of life, and environmental sustainability in an urban context. Urban sanitation, as one of the main elements, includes waste management, drainage, and environmental cleanliness (2). Smart cities aim to provide efficient sanitation infrastructure by utilizing data-based technologies, which enable faster monitoring and response to sanitation issues.

2.2. Collaborative Governance Model in Smart Cities

Collaborative governance is a model that involves the participation of various stakeholders, including government, communities, the private sector, and non-governmental organizations, in policy planning and implementation. This collaboration aims to leverage diverse expertise and resources to achieve common goals (5). In the context of urban sanitation, collaborative governance provides a basis for cross-sectoral coordination that can strengthen sustainable sanitation infrastructure and services in smart cities.

2.3. Key Principles of Collaborative Governance

Some of the basic principles of collaborative governance that are relevant to smart city sanitation include (9):

- a. Inclusivity, Involving various parties, including citizens and local organizations, to ensure that decisions made meet the real needs of the community.
- b. Transparency, Ensuring openness of information and access to accurate data for all stakeholders.
- c. Accountability: Each party is responsible for their respective roles in achieving collaborative goals.
- d. Effective Communication, Ensuring good communication flows between stakeholders to facilitate the policy implementation process.
- e. Participatory Decision Making, Prioritizing deliberation and consensus in decision making that directly impacts the community.

2.4. Implementation of Collaborative Models in Smart City Urban Sanitation

The implementation of collaborative models in urban sanitation focuses on:

- a. Real-time Data Collection and Analysis, Sensors and IoT (Internet of Things) devices are used to monitor sanitation conditions in real time, such as drainage status, water pollution levels, and waste management. This data can be accessed by all stakeholders for rapid response coordination (10).

- b. Technology-Based Sanitation Infrastructure Improvement, Collaboration with the private sector can facilitate the development of more modern and sustainable sanitation infrastructure (11).
- c. Community Empowerment, Through education and training, communities are encouraged to play an active role in maintaining environmental cleanliness and managing household waste (12).
- d. Public-Private Partnership: The public and private sectors can work together to provide investments and technologies that support urban sanitation, such as wastewater management and recycling technologies (13).

2.5. Challenges in Implementing Collaborative Governance in Urban Sanitation

- a. Some of the main challenges in implementing collaborative governance models for sanitation in smart cities are (13)
- b. Resource Constraints, Funding and technical skills are challenges, especially in developing countries (14).
- c. Resident Resistance, Not all citizens immediately accept changes related to sanitation management and new technologies(15).
- d. Coordination and Synchronization, Bringing together various parties with different interests requires strong communication and coordination efforts (16).
- e. Data Protection and Privacy: With the large amount of data being collected, it is important to ensure the protection of citizen data and avoid potential misuse (17).

2.6. Case Study Implementing Collaboration for Urban Sanitation in Smart Cities

Examples of collaborative implementation can be found in several large cities that have implemented the smart city concept, such as Singapore, Amsterdam, or Seoul. In these cities, the government works with the private sector to use sensory data in monitoring drainage and waste and collaborate with residents through environmental hygiene education programs. For example, Singapore uses technologies such as smart

water channels and sensors to detect potential flooding, optimize wastewater systems, and respond quickly to sanitation incidents (18).

3. Research methods

This study uses a Bibliometric Analysis approach combined with a Systematic Literature Review (SLR) to explore relevant literature on urban sanitation management in the context of smart cities (19). Bibliometric Analysis is applied to analyze publication patterns, research trends, and citation relationships among published articles. This analysis includes quantitative data collection on keywords, researchers' collaboration networks, and citation impacts that help identify current research focuses in the field of sanitation management and smart cities.

Meanwhile, a Systematic Literature Review (SLR) was applied to screen and critically evaluate published studies, to detect existing research gaps and provide a comprehensive understanding of the methodologies used, as well as significant results of previous studies. A literature search was conducted through major scientific databases, such as Scopus, Web of Science, and Google Scholar, using specific keywords such as “smart city,” “urban sanitation,” “collaborative governance,” and “public-private partnership.” The selected articles were the result of a strict selection based on inclusion criteria, namely peer-reviewed journal articles that are relevant to sanitation management and stakeholder collaboration in the context of smart cities.

The research procedure began with a literature search followed by the selection of articles based on inclusion and exclusion criteria. The selected articles were then analyzed using bibliometric analysis tools, such as VOSviewer, to map trends, collaboration patterns, and interconnectedness between studies. After that, a systematic literature analysis was conducted by examining in depth the main themes that emerged, such as collaborative approaches in sanitation management and the role of technology in smart city development. The findings from both methods were combined to develop a collaborative model of sanitation management that can be effectively implemented in smart cities.

The selection of relevant studies was based on criteria that prioritize articles that focus on sanitation management in the context of smart cities and use an empirical approach that supports cross-sector collaborative discussions. Ultimately, the research workflow starts from keyword identification, literature selection, bibliometric analysis,

and systematic review, to synthesis of findings to develop an innovative and sustainable collaborative management model for sanitation in smart cities.

4. Results and Discussion

4.1. Global Publication Analysis

The results of the analysis of 2814 scientific publications from the Scopus database produced diverse information. There are many scientific publications discussing the topic of Towards Smart Cities Implementing Collaborative Governance Models for Urban Sanitation Improvement from 2018 to 2024. This study analyzes and classifies data based on the year of scientific publication, the country that contributed the most, journal sources, authors, institutional outputs, and document affiliations.

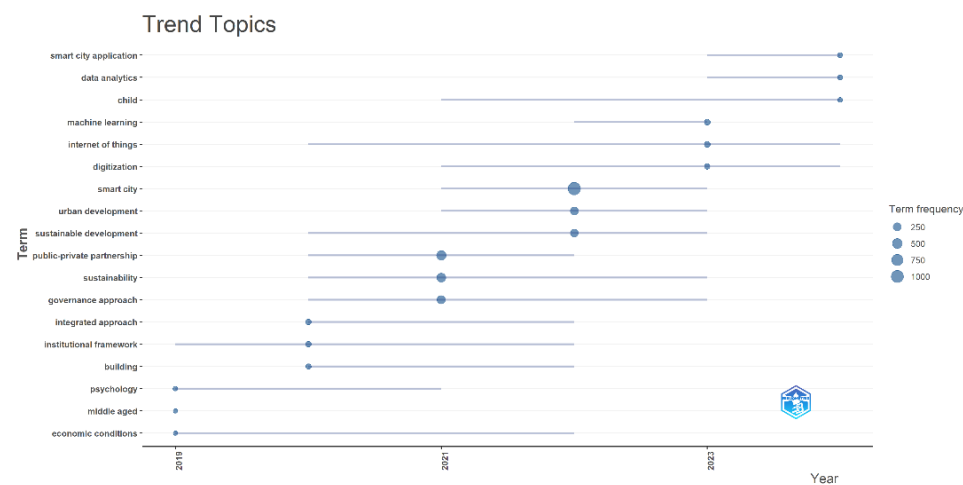


Figure 1: Analysis Based on Topic Trends.

Based on the visualization of topic trends above, various topics have high frequency and have shown significant development in recent years. The topic of “smart city” is at the top with the highest frequency, reaching its peak around 2021 and beyond. This reflects the increasing attention to smart cities and the application of technology in urban management.

Topics such as “public-private partnerships,” “sustainability,” and “governance approaches” also gained significant attention, especially between 2020 and 2023, signaling the importance of collaboration and sustainability in the quest to build more efficient and environmentally friendly smart cities. In addition, “sustainable development” and “urban development” continue to grow as the push to integrate sustainable solutions into city design and construction continues.

Technology topics, such as “machine learning,” “internet of things,” and “digital-ization,” also began to emerge significantly after 2020, with the trend continuing to increase until 2023 and 2024. This shows that the adoption of digital technology in city management is an important pillar in realizing a smart city.

The topics of “smart city applications”, “data analytics”, and “children” also showed an increasing trend, especially in the last two years (2023 and 2024), indicating that the application of smart city applications and data analytics is increasingly relevant, not only in infrastructure and technology but also in social aspects and child welfare.

Overall, this visualization illustrates that topics related to smart cities, public-private collaboration, and digital technologies have become a major focus in research in recent years, with a trend that continues to increase from 2021 to 2024.

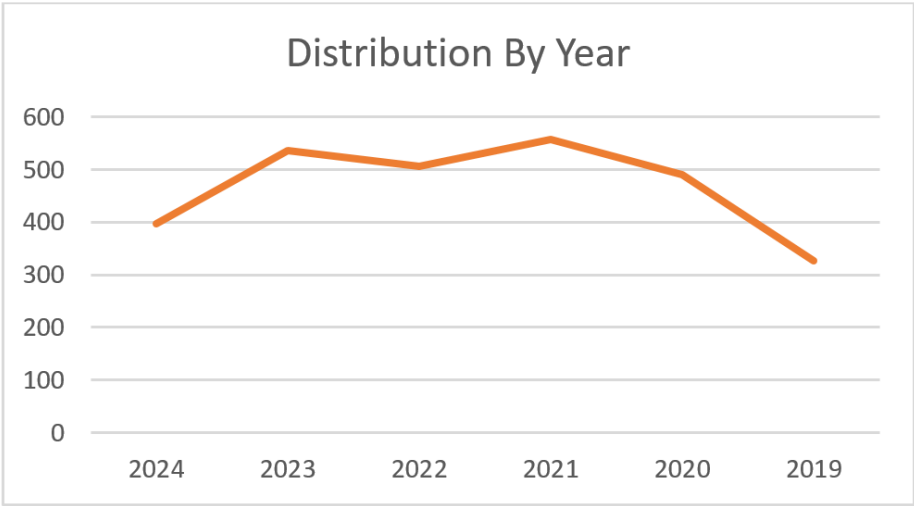


Figure 2: Distribution of publications by year.

Based on the “Publication by Year” data, there is a significant increase in the number of publications on smart cities, urban sanitation, and collaborative governance during the period 2019 to 2024. In 2019, there were 327 publications, indicating that attention to these topics is starting to grow. The number of publications then increased significantly in 2020 to 491 publications, reflecting the growing interest in developing innovative urban solutions, especially amidst global challenges such as the COVID-19 pandemic.

The peak number of publications occurred in 2021, with 557 papers published, indicating a surge in attention to smart cities and more collaborative sanitation issues. After that, the number of publications decreased slightly to 506 in 2022 and 536 in 2023, but this number still shows a high interest in research on urban governance and sustainable sanitation solutions. In 2024, the number of publications reached 397,

indicating a trend that remains strong, albeit slightly decreasing. Overall, this publication trend reflects a steady and growing interest in efforts to create smart cities and more efficient and collaborative sanitation governance solutions.

Although the results of this study provide a clear picture of the publication trends around smart cities, urban sanitation, and collaborative governance during the period 2019 to 2024, some limitations need to be considered. First, the data used in this study were only taken from the Scopus database, which despite being one of the largest sources of literature, does not cover all relevant publications, especially those that may be indexed in other databases such as Web of Science, Google Scholar, or publications in non-English languages. This may lead to bias in the results, where only publications from journals indexed in Scopus were involved in the analysis. Second, the use of specific keywords such as “smart cities,” “urban sanitation,” and “collaborative governance” may not cover all broader or more specific aspects in the context of urban governance and sanitation. As a result, these results may not fully represent all ongoing research in this field. Third, the number of publications may be influenced by external factors, such as publishing policies or temporary academic trends, which do not always reflect long-term research needs. These limitations may affect the generalizability of the results of this study, and therefore, it is recommended that future studies expand the database used and consider more comprehensive keywords to provide a deeper understanding of research trends in this field.

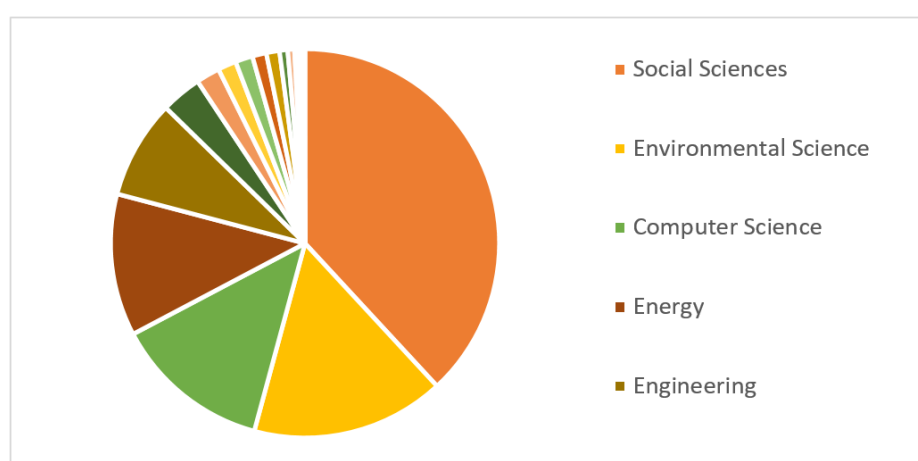


Figure 3: Distribution By Subject Area.

The data collection process in this study was carried out by analyzing the distribution of research subjects related to smart cities, urban sanitation, and collaborative governance from various disciplines. Data were obtained from academic databases that

group articles based on fields of investigation, such as Social Sciences, Environmental Sciences, Computer Science, Management, and other fields. The results of the analysis show that Social Sciences and Environmental Sciences dominate in the related literature, emphasizing the importance of socio-ecological aspects in smart city and sanitation management. This reflects that public policy, community interaction, and environmental sustainability are the main focuses in efforts to improve urban sanitation. In addition, significant contributions from Computer Science and Management show that technological innovation and managerial strategies play an important role in developing more effective and efficient smart city solutions. This distribution of disciplines also indicates that a multidisciplinary approach is increasingly needed in addressing the complexity of urban sanitation problems, which require not only technical solutions but also responsive and inclusive policies. Therefore, these results provide in-depth insights into how each discipline contributes to each other in creating sustainable smart city governance.

Although the results of this study provide important insights into the distribution of subjects related to smart cities, urban sanitation, and collaborative governance, some limitations should be noted. One of the main limitations is the dominance of various disciplines, such as Social Sciences and Environmental Sciences, which suggests that the focus of research tends to emphasize the socio-ecological aspects. As a result, other disciplines such as Energy, Engineering, and Economics may be underrepresented, which may impact the overall results of the study. This limitation may result in a lack of exploration of the important role of energy technologies and financial aspects in smart city management. In addition, the data collection methodology that relies only on one particular academic database may also narrow the scope of the study, as not all important publications from other disciplines may be indexed in the database used. This has the potential to cause bias in the study results, which do not include a broader perspective from various relevant disciplines. Therefore, for future research, it is important to use a wider database and expand the range of disciplines involved, to provide a more comprehensive picture of the contributions of various fields in the development of sustainable smart cities.

The data collection process in this study utilized VOSviewer and metadata from Scopus to identify publication trends related to smart cities, urban sanitation, and collaborative governance. This stage included selecting keywords such as “smart city,” “public-private partnership” (PPP), and “Internet of Things” (IoT) that were relevant to the research theme. The results of the analysis showed a strong relationship between

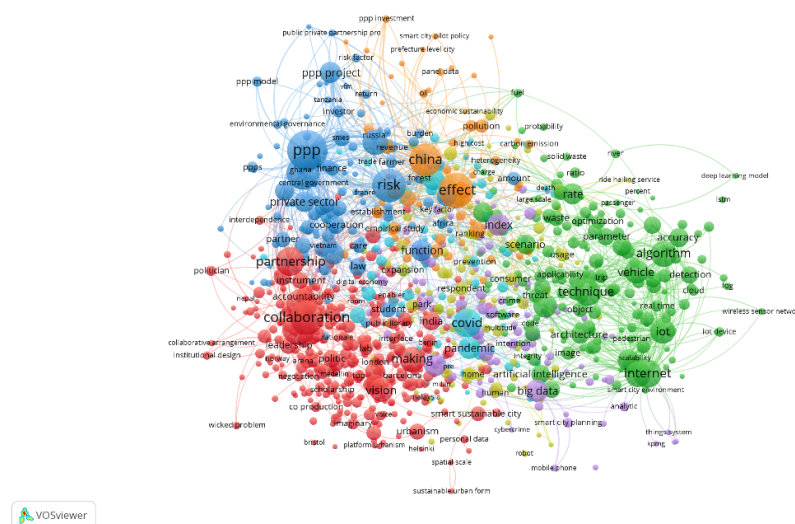


Figure 4: Bibliometric Network Visualization by VOSviewer, 2024.

the public and private sectors in improving sanitation in smart cities, with cross-sector collaboration proven to increase efficiency and accountability in governance. Technology, especially IoT and big data, plays an important role in monitoring and managing sanitation infrastructure in real time, allowing for faster responses to sanitation issues in urban areas.

Theoretically, this research contributes to the development of collaborative governance by strengthening the integration between technology, policy, and cross-sector cooperation. This multidisciplinary approach emphasizes that successful sanitation improvements in smart cities require close collaboration between the public, private, and community sectors (7). From a practical perspective, the findings of this study provide applicable guidance for policymakers and stakeholders to apply collaboration models and digital technologies, to improve sanitation services sustainably.

However, this study has limitations, especially because it only relies on one database, namely Scopus. Although Scopus is a credible database, this limitation may cause some important literature indexed in other databases, such as Web of Science or regional publications, to be unreachable. This may affect the completeness of the research perspective, especially regarding the local context that may be more relevant in improving urban sanitation in developing countries. The selection of Scopus-indexed journals was carried out to ensure the quality of the sources used, but this limitation needs to be considered when interpreting the research results.

For future research, it is recommended that the database used be more diverse by integrating various platforms such as Web of Science and Google Scholar and

involving local case studies. This will provide a more comprehensive and holistic view of governance collaboration in sanitation improvement in smart cities. In addition, further research can also focus on the application of new technologies, such as artificial intelligence (AI) and blockchain, to improve transparency and efficiency in sanitation management.

The social and ethical implications of this research are significant, particularly in ensuring that the application of technology in sanitation governance remains inclusive and equitable. The use of IoT and big data can accelerate the response to sanitation issues, but must also be accompanied by efforts to address the digital divide. Collaboration between the public and private sectors should be carried out with high transparency and accountability to avoid unequal access to sanitation services. Therefore, sustainable and socially just governance must be a priority in the development of smart cities that can improve the welfare of society as a whole.

5. Conclusion

The collaborative model of urban sanitation management within the smart city framework has proven to be an effective approach to improve efficiency in sanitation management, especially in areas experiencing rapid urbanization. This study shows the importance of technology, especially the Internet of Things (IoT) and big data, in improving monitoring and rapid response to sanitation problems. Cross-sector collaboration between government, private sector, and community is key to strengthening this management.

However, while this collaboration offers innovative solutions, the study also highlights several limitations such as challenges in cross-sector coordination, financial sustainability, and the importance of considering local contexts, especially in developing countries. The use of data only from the Scopus database is also a limitation because it does not cover all relevant literature, especially those indexed on other platforms.

In the future, further research is expected to expand the scope of data sources and consider new technologies such as artificial intelligence (AI) and blockchain to improve transparency and efficiency in sanitation management. This study also emphasizes that the application of technology must be carried out with fair social inclusion so that its benefits can be felt by all levels of society.

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