

# Technology-Enabled Conceptual Framework for Collaborative Urban Innovation and Citizen Participation in Smart City Governance

Husna Norgina<sup>1,\*</sup>, Muhayat<sup>2</sup>, Siti Magfiratun Warahmah<sup>3</sup>

<sup>1,2,3</sup> Faculty of Da'wah and Communication Sciences, Department of Information Technology, Universitas Islam Negeri Antasari Banjarmasin, Banjarbaru, Indonesia

Email: <sup>1,\*</sup>230104040056@mhs.uin-antasari.ac.id, <sup>2</sup>muhayat@uin-antasari.ac.id,

<sup>3</sup>230104040059@mhs.uin-antasari.ac.id

<sup>\*)</sup> Corresponding email

**Abstrak**—Perkembangan *smart city* mendorong transformasi tata kelola perkotaan menuju pendekatan kolaboratif berbasis teknologi. Namun, implementasi *collaborative urban innovation* masih menghadapi keterbatasan dalam mengintegrasikan dimensi teknologi, sosial, dan institusional serta kesenjangan antara konsep partisipasi dan praktik. Penelitian ini bertujuan merumuskan kerangka konseptual integratif berbasis teknologi untuk mendukung inovasi kolaboratif dan partisipasi warga dalam *smart city governance*. Penelitian ini menggunakan pendekatan *integrative literature review* terhadap 25 artikel ilmiah periode 2021–2025 melalui tahapan identifikasi, seleksi, ekstraksi data, dan analisis tematik. Hasil penelitian menunjukkan tiga temuan utama, yaitu kolaborasi multi-aktor sebagai fondasi inovasi perkotaan, pemanfaatan teknologi digital sebagai *enabler* kolaborasi, dan partisipasi warga sebagai *co-creator* dalam inovasi. Selain itu, pendekatan seperti *urban living labs*, *Quadruple Helix*, dan *participatory co-design* memperkuat keterlibatan warga secara inklusif. Penelitian ini menghasilkan kerangka konseptual integratif berbasis teknologi yang menghubungkan dimensi teknologi, sosial, dan tata kelola secara sistematis. Kontribusi utama penelitian ini terletak pada perumusan model konseptual yang menjadi dasar analitis bagi pengembangan strategi partisipatif berbasis teknologi dalam mendukung *smart city* yang inklusif dan berkelanjutan.

**Kata Kunci:** Inovasi perkotaan kolaboratif, tata kelola *smart city*, partisipasi warga, *co-creation*, tata kelola kolaboratif

**Abstract**—The development of smart cities has driven a transformation in urban governance toward technology-enabled collaborative approaches. However, the implementation of collaborative urban innovation still faces limitations in integrating technological, social, and institutional dimensions, as well as a gap between participatory concepts and practice. This study aims to formulate an integrative conceptual framework to support collaborative innovation and citizen participation in smart city governance. This study adopts an integrative literature review approach by analyzing 25 scholarly articles published between 2021 and 2025 through identification, selection, data extraction, and thematic analysis. The findings reveal three main aspects of collaborative urban innovation, namely multi-actor collaboration as the foundation of urban innovation, digital technology utilization as an enabling factor, and citizen participation as co-creators in innovation. In addition, approaches such as urban living labs, the Quadruple Helix model, and participatory co-design strengthen inclusive citizen engagement. This study proposes an integrative conceptual framework that systematically connects technological, social, and governance dimensions. The main contribution lies in developing a conceptual framework that provides an analytical foundation for designing technology-based participatory strategies to support inclusive and sustainable smart city governance.

**Keywords:** Collaborative urban innovation, smart city governance, citizen participation, co-creation, collaborative governance

## 1. INTRODUCTION

The rapid development of urban environments driven by urbanization and digital transformation has significantly reshaped urban governance paradigms. Contemporary cities are increasingly characterized by complex socio-technical dynamics that require more adaptive and inclusive governance approaches. In this context, the smart city concept has developed as a strategic approach to address complex urban challenges by leveraging digital technologies and data-informed decision-making. However, despite its widespread adoption, many smart city initiatives remain predominantly technology-oriented and do not adequately incorporate meaningful citizen participation and collaborative innovation processes [1], [2].

Collaborative urban innovation has been widely recognized as an important approach to addressing increasingly complex urban challenges through multi-actor collaboration. This approach emphasizes that urban innovation should actively involve diverse stakeholders, such as government institutions, private organizations, academic actors, and citizens as key contributors in co-creation processes. Co-creation enables the effective mobilization of diverse knowledge and resources to generate sustainable urban solutions, thereby enhancing the legitimacy, transparency, and overall effectiveness of decision-making processes [3], [4]. Collaborative governance further supports coordination and shared responsibility among stakeholders [5]. Social innovation also strengthens community engagement and collective problem-solving in urban contexts [6].

The evolution of smart city governance increasingly demonstrates a transition from technology-centric approaches toward more participatory and human-centered models. Citizen participation is essential to ensuring that technological innovations effectively align with community needs and contribute to long-term social sustainability [7], [8]. It also supports the co-creation of more context-sensitive solutions and further strengthens overall social sustainability in urban environments [1], [9]. In addition, the integration of Product-Service Systems and sustainable innovation strategies further highlights the importance of balancing technological development with broader social and environmental considerations [10].

Despite these developments, several challenges remain insufficiently addressed in existing studies. Citizen participation in urban innovation initiatives often remains symbolic and has limited influence on actual decision-making processes [8], [11]. Collaborative initiatives also face difficulties in transforming innovative ideas into sustainable implementation [12]. Challenges related to power dynamics, social inclusion, and digital inequality further affect the effectiveness of co-creation processes [9], [13]. In addition, uncertainties regarding long-term sustainability and stakeholder capacity imbalances continue to pose significant obstacles [5].

From a methodological perspective, various approaches have been developed to support collaborative urban innovation and citizen participation. Approaches such as urban living labs provide experimental spaces for multi-actor collaboration in developing urban solutions [2]. In addition, frameworks such as the Quintuple Helix integrate technological, social, and environmental dimensions within structured processes [14]. Other approaches, including participatory co-design, agile governance, and citizen science, contribute to improving inclusiveness and responsiveness in urban innovation [15], [16], [17].

However, previous studies remain fragmented and have not yet provided a unified integrative framework that connects technological, social, and governance dimensions in collaborative urban innovation. Existing research tends to examine these dimensions separately, resulting in fragmented approaches. These limitations indicate a significant gap in the current literature, highlighting the importance of a more integrative and systematic approach to support effective and inclusive urban innovation.

Based on these issues, this study identifies a lack of a comprehensive and integrative framework capable of systematically combining technological infrastructure, collaborative governance, and citizen participation within smart city ecosystems. This limitation reduces the effectiveness of collaborative urban innovation in addressing increasingly complex urban challenges. To address this gap, the study develops a technology-enabled integrative conceptual framework.

This study develops an integrative conceptual framework for collaborative urban innovation that supports citizen participation within smart city governance. Its primary contribution lies in proposing a structured conceptual framework that brings together technological, social, and governance dimensions within a unified model. The framework offers both theoretical and practical value for policymakers, researchers, and practitioners in formulating inclusive and sustainable urban innovation strategies.

## **2. RESEARCH METHODS**

### **2.1 Research Design**

This study uses an integrative literature review with a systematic approach to ensure a structured, transparent, and reproducible synthesis process [4]. This approach is appropriate as it enables the integration of diverse theoretical perspectives and research findings into a coherent conceptual framework. It also facilitates the identification of conceptual relationships, methodological trends, and research gaps across interdisciplinary studies related to smart city governance and collaborative innovation.

The research design is organized into several systematic and well-defined stages, covering problem identification, literature search and selection, data extraction, thematic analysis, and conceptual framework development. Each stage is implemented in a structured and transparent manner to maintain consistency throughout the review process. This structured approach supports the development of a framework that is analytically grounded in a rigorous synthesis of relevant and up-to-date literature.

This study aims to formulate a technology-enabled collaborative urban innovation framework that supports citizen participation within smart city governance. To achieve this aim, it integrates key theoretical perspectives, including co-creation, collaborative governance, social innovation, and smart city governance. These perspectives are synthesized to construct a unified conceptual framework that reflects the multidimensional nature of collaborative urban innovation.

Furthermore, the integrative literature review approach enables a comprehensive understanding of fragmented knowledge across multiple disciplines, particularly across urban governance, digital transformation, and participatory innovation. By applying a systematic and transparent review process, this study ensures that the resulting framework is analytically grounded and reflects current developments in smart city research. This approach improves the reliability of the findings and increases their applicability.

## 2.2 Data Collection and Literature Selection

The data in this study consist of 25 scholarly articles obtained from reputable national and international journals. The selected articles, published between 2021 and 2025, focus on themes related to collaborative urban innovation, citizen participation, smart city governance, co-creation, collaborative governance, social innovation, and technology-enabled participation. These articles were selected because they offer relevant theoretical perspectives and methodological approaches related to collaborative innovation in urban contexts. The number of selected articles is considered sufficient to represent recent developments in the field while maintaining analytical depth and relevance.

A literature search was carried out using several academic databases, including Scopus, Google Scholar, and IEEE Xplore, to ensure broad coverage of relevant studies. These databases were selected to capture multidisciplinary research related to smart city governance, urban innovation, and digital technologies. The search strategy utilized keywords and Boolean operators, such as (“collaborative urban innovation” OR “urban innovation”) AND (“smart city governance” OR “smart city”) AND (“citizen participation” OR “co-creation”). The search results were organized using Mendeley reference management software, while Microsoft Excel was used to document, classify, and manage the data. The initial search identified 60 articles, which were subsequently screened and refined to 25 studies through a structured selection process.

The study selection followed a structured procedure based on the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), comprising identification, screening, eligibility, and inclusion stages, as illustrated in Figure 1. In the initial stage, articles were evaluated based on the relevance of their titles and abstracts to ensure alignment with the research objectives. This was followed by full-text screening to identify studies addressing collaborative urban innovation and citizen participation within smart city governance. The selected studies were then examined in depth to extract key information on theoretical frameworks, methodological approaches, research contexts, and research gaps.

Studies were included based on the following criteria: (1) publication in peer-reviewed journals, (2) relevance to collaborative urban innovation and citizen participation, (3) discussion of methodological approaches or conceptual frameworks, and (4) publication within the specified time range. Articles that did not directly address collaborative innovation or smart city participation were excluded. This selection process ensures that the analyzed literature remains relevant, credible, and of high academic quality.

To enhance methodological rigor, the selection process also considered the relevance of research contexts, theoretical depth, and methodological transparency. By applying clearly defined inclusion and exclusion criteria, the review process minimizes selection bias and improves the reliability of the findings.

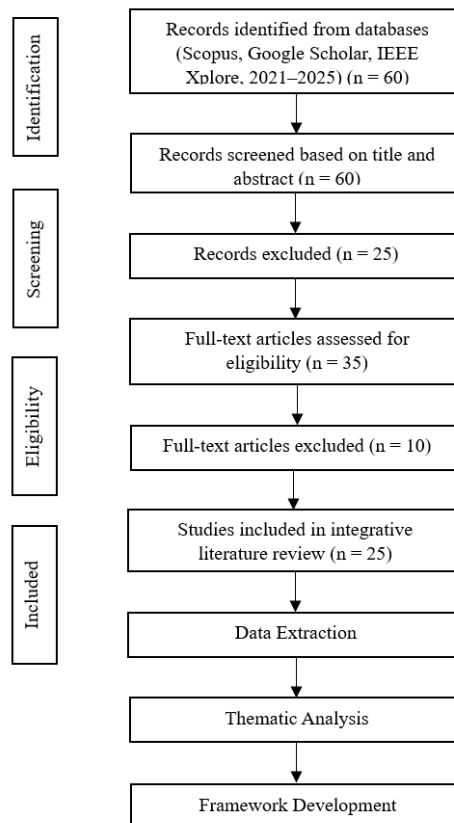


Figure 1. PRISMA-inspired Flow Diagram for Literature Selection Process

As shown in Figure 1, the research process consists of several stages, including literature identification, screening, eligibility assessment, data extraction, and thematic analysis. It begins with a comprehensive literature search, followed by the screening of titles, abstracts, and full-text articles to ensure alignment with the research objectives. The selected studies are then analyzed through data extraction and thematic analysis to uncover key conceptual patterns and methodological approaches. This structured procedure enhances the transparency, validity, and reproducibility of the review process.

### **2.3 Data Analysis and Synthesis**

This study applied a thematic comparative approach for data analysis. The selected studies were examined to identify recurring themes, conceptual frameworks, methodological approaches, and research gaps related to collaborative urban innovation and citizen participation [3]. The analysis involved a systematic coding procedure, in which key findings were grouped into thematic categories, including co-creation practices, collaborative governance, technology utilization, citizen participation models, and implementation challenges. The coding stage started with open coding to identify initial concepts, followed by axial coding to examine relationships among emerging themes. This iterative procedure ensured consistency and supported the systematic identification of conceptual patterns and relationships across the selected studies.

Following the coding process, a comparative synthesis was conducted to systematically examine similarities and differences across the selected studies in a structured manner. This process enabled the identification of dominant conceptual trends and methodological patterns within the literature, as well as key limitations in existing studies, particularly regarding how technological, social, and governance dimensions are integrated in collaborative urban innovation [5], [6].

To enhance analytical rigor, the coding and thematic categorization were conducted iteratively to ensure consistency and conceptual clarity across the analyzed studies while allowing refinement of thematic categories. Patterns of convergence and divergence among theoretical perspectives were systematically examined to identify areas of conceptual overlap and fragmentation. The analysis was supported using Microsoft Excel as a data organization and coding support tool.

The final stage of the analysis focused on developing a comprehensive integrative conceptual framework based on systematically synthesized findings. The framework brings together multi-actor collaboration, digital technology utilization, and citizen participation within a unified smart city governance model. It represents a significant conceptual contribution that supports future research and guides the practical implementation of collaborative urban innovation.

### **2.4 Research Framework Development**

Based on the synthesis of the selected literature, this study develops an integrative conceptual framework grounded in systematically synthesized findings. The framework integrates three main dimensions: technological infrastructure, collaborative governance mechanisms, and citizen participation processes within the smart city governance ecosystem. These dimensions are interrelated and collectively influence the effectiveness of collaborative urban innovation.

The integration of these dimensions reflects a broader understanding that collaborative urban innovation functions as an evolving system instead of a linear governance model. Each dimension interacts through continuous and adaptive feedback mechanisms. Technological infrastructure supports participatory processes by enabling digital platforms and real-time communication channels. Collaborative governance mechanisms ensure that these technologies are effectively embedded within institutional arrangements that promote transparency, accountability, and shared decision-making. Citizen participation processes contribute valuable contextual knowledge that informs both technological design and governance practices.

This integrative structure positions collaborative urban innovation as a holistic governance approach capable of addressing complex urban challenges. By aligning technological systems with institutional coordination and active citizen engagement, the framework moves beyond fragmented smart city implementations that prioritize technological deployment without sufficient social integration. As a result, the framework emphasizes balanced interaction among dimensions to ensure that innovation processes are technologically effective, socially inclusive, and institutionally sustainable.

Technological infrastructure includes digital platforms, data systems, and communication technologies that facilitate collaboration and information exchange. Collaborative governance mechanisms encompass institutional arrangements, participatory processes, and multi-actor coordination that enable joint decision-making and co-creation. Citizen participation processes involve active citizen engagement in identifying problems, designing solutions, and evaluating outcomes.

A conceptual framework is introduced in the results and discussion section as a visual representation of the relationships among three dimensions. It serves as a structured reference for future research and the practical implementation of collaborative urban innovation within smart city governance. It also provides a foundation for empirical validation and comparative analysis across diverse urban contexts.

### 3. RESULTS AND DISCUSSIONS

#### 3.1 Research Framework Development

The analysis of the selected studies clearly reveals three key findings. First, multi-actor collaboration consistently emerges as the core driver of collaborative urban innovation processes. Second, digital technologies act as enabling infrastructures that facilitate coordination, communication, and data-informed decision-making processes. Third, citizen participation plays a pivotal role as co-creators in shaping context-sensitive and sustainable urban solutions. Collectively, these findings provide a coherent and structured foundation for the development of the proposed integrative framework.

The synthesis of the reviewed literature further indicates that collaborative urban innovation has increasingly evolved into a central paradigm in contemporary smart city governance. Through systematic thematic coding, this study conceptualizes urban innovation as a collaborative ecosystem that integrates technological advancement, institutional coordination, and active citizen engagement, rather than a purely technology-oriented approach. The identified patterns were systematically grouped into key dimensions, including co-creation, governance, technology, and participation. These dimensions reflect the increasing complexity of urban challenges and highlight the need for more integrative and participatory approaches capable of mobilizing diverse resources, knowledge, and stakeholder capacities.

Table 1 presents a structured overview of the reviewed studies and highlights key patterns within the literature. Most studies emphasize co-creation and collaborative governance as dominant themes, while only a limited number explicitly integrate technological, social, and governance dimensions within a unified framework. This pattern indicates that existing research remains fragmented and lacks a comprehensive integrative perspective. Such fragmentation underscores a critical gap and reinforces the need for a systematic framework that connects these dimensions within collaborative urban innovation.

**Table 1.** Summary of Selected Key Studies

Author(s)	Year	Research Focus	Method / Approach	Key Contribution
Ansell & Torfing	2021	Co-creation in governance	Conceptual Study	Positions co-creation as a central paradigm in collaborative governance
Paskaleva et al.	2021	Co-production in smart cities	Empirical Study	Demonstrates Quadruple Helix collaboration in smart city governance
Sillak et al.	2021	Co-creation in energy transitions	Empirical Study	Demonstrates collaborative innovation in sustainability transitions
Tanda & Marco	2021	Urban living lab initiatives	Case Study	Examines participatory innovation in urban living lab initiatives
Temmerman et al.	2021	Collaborative governance platforms	Empirical Study	Examines governance mechanisms in social innovation platforms
Cerreta & Panaro	2022	Collaborative Urban Living Lab	Methodological Framework	Proposes the CoULL model for collaborative urban innovation
Hofstad et al.	2022	Collaborative climate governance	Comparative Study	Examines leadership and institutional design in climate governance
Ansell et al.	2023	Democratic quality of co-creation	Theoretical Analysis	Highlights the democratic role of citizen participation in co-creation
Anthony	2023	Community engagement in smart cities	Empirical Study	Demonstrates citizen engagement in urban innovation
Ostanel	2023	Social innovation in urban governance	Conceptual Framework	Highlights social innovation in urban strategic planning

Author(s)	Year	Research Focus	Method / Approach	Key Contribution
Popescul et al.	2024	Digital co-creation in smart cities	Empirical Study	Demonstrates digital platforms for participatory co-creation
Wang	2024	Human-centric smart city governance	Case Study	Highlights human-centric governance approaches in smart cities

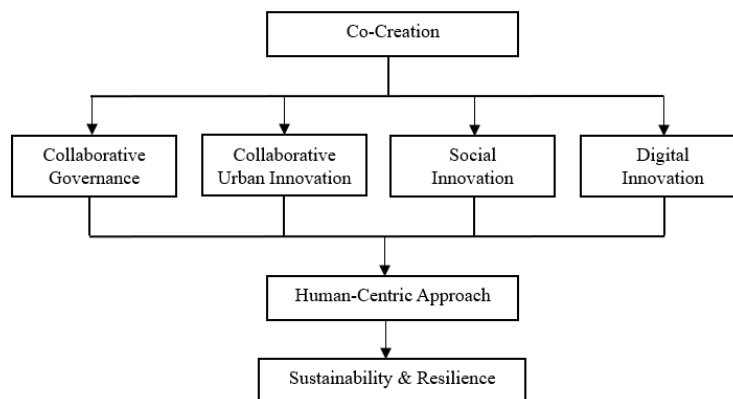
Based on the synthesis presented in Table 1, this study identifies key conceptual dimensions of collaborative urban innovation. The literature indicates that collaborative urban innovation integrates co-creation, collaborative governance, social innovation, digital innovation, human-centric approaches, and sustainability-oriented urban development. These dimensions reflect a multidimensional structure in which technological, social, and institutional elements are interconnected within smart city governance.

The analysis of Table 1 further confirms that most studies tend to focus on specific aspects of collaborative urban innovation rather than providing a comprehensive integrative perspective. This fragmentation highlights a critical gap in the literature and reinforces the need for a unified framework that systematically connects technological, social, and governance dimensions.

A comparative analysis of the reviewed studies reveals that empirical research predominantly focuses on implementation practices of co-creation and citizen engagement, while conceptual and methodological studies emphasize theoretical integration and governance structures. This disparity reflects a disconnect between practical implementation and integrative framework development, pointing to the necessity of a more systematic synthesis of technological, social, and governance dimensions.

These findings clearly reinforce that collaborative urban innovation is driven by multi-actor collaboration supported by digital technologies. In this context, citizen participation functions as a core co-creation mechanism within smart city governance.

As illustrated in Figure 2, co-creation functions as the central mechanism linking multiple dimensions, while collaborative governance, social innovation, and digital innovation act as enabling components that facilitate interaction and innovation processes. These dimensions are further aligned through a human-centric approach to ensure responsiveness to citizen needs, thereby enhancing sustainability and resilience in urban development. This finding indicates that collaborative urban innovation operates as an integrated system rather than isolated components, highlighting the importance of coordinated interactions to support inclusive and sustainable smart city governance.



**Figure 2.** Conceptual Framework of Collaborative Urban Innovation in Smart City Governance

Figure 2 demonstrates that collaborative urban innovation operates as a multidimensional ecosystem integrating participatory design, institutional collaboration, social innovation, and sustainability-oriented governance. This integration reflects a shift from technology-centric urban management toward more inclusive and adaptive governance models. By positioning collaborative urban innovation within interconnected dimensions, the framework emphasizes the need to integrate technological advancements with participatory and sustainability-oriented approaches in smart city development.

The synthesis further identifies co-creation as a central mechanism that enables collaborative urban innovation [3]. Co-creation facilitates collaboration among governments, private sectors, academic institutions, and citizens in designing and implementing solutions to complex urban challenges. Through this process, stakeholders share knowledge and resources, resulting in more adaptive and context-sensitive solutions. In addition, co-creation strengthens the legitimacy and transparency of decision-making processes by directly involving citizens in shaping public policies and services.

Collaborative governance is consistently identified as an institutional foundation supporting collaborative urban innovation [5], [18]. It provides structured mechanisms for dialogue, coordination, and joint decision-making among stakeholders. These mechanisms enable shared understanding of urban challenges and support collective solution-building. Furthermore, collaborative governance enhances accountability and promotes shared responsibility to sustain long-term urban innovation initiatives.

In addition, social innovation contributes to strengthening collaborative urban innovation by addressing societal needs through collective problem-solving [6], [13]. It enables the involvement of community groups and civil society in developing solutions related to sustainability, public services, and urban well-being. This integration enhances community resilience and promotes inclusive participation, particularly by engaging diverse and marginalized groups in urban governance processes.

The findings suggest a transition in smart city governance toward increasingly human-centric and participatory approaches [19]. While earlier smart city models primarily emphasized technological efficiency, the literature indicates that technological advancement alone is insufficient. Instead, effective urban innovation relies on combining digital technologies with participatory governance mechanisms, ensuring alignment across technological, social, and institutional dimensions.

Furthermore, collaborative urban innovation contributes to sustainability and resilience by enabling stakeholders to co-design context-sensitive solutions [9], [10]. Citizen engagement strengthens social sustainability by fostering ownership and responsibility within communities. As a result, collaborative urban innovation contributes to building inclusive and resilient urban systems.

Overall, these findings demonstrate that collaborative urban innovation integrates technological, social, and institutional dimensions within smart city governance. The interaction between co-creation, collaborative governance, and social innovation enhances the capacity of urban systems to respond to complex challenges. This synthesis provides a conceptual foundation for developing an integrative framework for collaborative urban innovation and inclusive citizen participation.

### **3.1.1 Integration of Smart City Governance and Citizen Participation**

The analysis of selected studies shows that integrating smart city governance with citizen participation represents a critical dimension of contemporary urban innovation. Smart city initiatives are increasingly conceptualized as socio-technical systems that require not only technological infrastructure but also active citizen engagement to ensure effectiveness and sustainability. In this context, citizen participation enhances the relevance and responsiveness of smart city solutions by incorporating local knowledge, experiences, and preferences into policy and service design, thereby aligning technological innovation with community needs.

Digital technologies are consistently identified as key enablers of citizen participation within smart city governance contexts. Digital platforms, mobile-based applications, and integrated data systems enable real-time interaction while fostering coordination between public institutions and citizens. These technologies significantly enhance transparency, accountability, and responsiveness by providing structured and accessible channels for feedback and engagement. Furthermore, digital participation platforms support evidence-based decision-making by facilitating the structured collection and interpretation of citizen input. This indicates that technology-enabled participation has become an increasingly defining feature of contemporary smart city governance [9].

However, the literature also reveals persistent challenges in effectively integrating citizen participation into governance processes. Digital inequality remains a significant structural barrier, limiting access to participation platforms and resulting in unequal representation. In addition, institutional and bureaucratic constraints often restrict participation to consultative roles rather than enabling meaningful co-creation, thereby reducing its influence on policy outcomes [8], [11]. Moreover, structural and organizational limitations hinder the sustainability of participatory initiatives, as many projects struggle to transition from pilot stages to long-term implementation due to limited institutional support, resource constraints, and weak stakeholder coordination [12].

Taken together, these findings suggest that effective integration requires alignment between technological infrastructure and participatory governance mechanisms. Inclusive participation strategies, supported by capacity-building initiatives, are essential to enhance digital literacy and strengthen stakeholder collaboration. By integrating technological and participatory dimensions, smart city governance can foster collaborative ecosystems that support sustainable urban innovation and inclusive development [1], [5]. Overall, these findings indicate that citizen participation is essential for advancing sustainable and inclusive urban development, as it enhances the quality of urban solutions while strengthening democratic legitimacy and social cohesion.

### **3.2 Methodological Approaches in Collaborative Urban Innovation**

The synthesis of the reviewed literature indicates that collaborative urban innovation is supported by diverse methodological approaches that facilitate multi-actor collaboration and encourage citizen engagement within smart city governance contexts. Rather than relying on a single framework, these approaches reflect a combination of participatory and technology-enabled strategies that allow stakeholders to co-design, test, and evaluate urban

solutions. This diversity demonstrates that collaborative urban innovation operates through flexible, context-dependent methodological configurations.

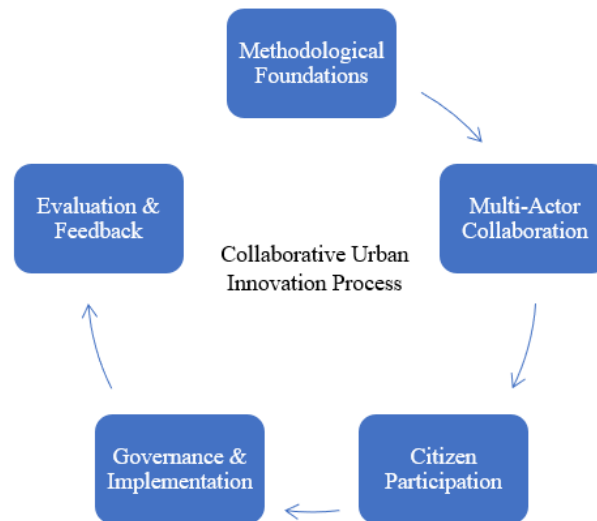
Among the identified approaches, urban living labs are consistently highlighted as key experimental environments for collaborative innovation. These labs enable stakeholders to design and evaluate solutions within actual urban environments, fostering iterative learning and co-creation processes. Through continuous interaction among government institutions, private organizations, academic institutions, and citizens, urban living labs support the refinement of solutions based on feedback and contextual conditions, thereby enhancing the adaptability and responsiveness of urban innovation initiatives [2], [14].

In addition, helix-based collaboration models, particularly the Quadruple Helix and Quintuple Helix, provide structured frameworks for integrating multiple stakeholders in innovation processes. By incorporating government, industry, academia, civil society, and environmental actors, these models strengthen the capacity of urban systems to generate inclusive and sustainable solutions. The Quintuple Helix further emphasizes the alignment of technological and social innovation with sustainability objectives, highlighting the systemic nature of collaborative urban innovation [20], [21]. Complementary approaches such as participatory co-design and agile governance further support this process by enabling user-centered solution development and adaptive policy implementation through iterative feedback mechanisms [15], [16].

Citizen science initiatives also contribute to collaborative urban innovation by involving communities in data collection, analysis, and knowledge production. This approach enhances transparency, democratizes knowledge generation, and strengthens community engagement in urban governance processes. By enabling citizens to actively participate in producing data and insights, citizen science supports more inclusive and evidence-based decision-making while reinforcing local capacity-building [22], [23].

Despite the variety of methodological approaches, the literature identifies persistent challenges in implementation. Institutional constraints, limited resources, and weak coordination among stakeholders often hinder the sustainability of collaborative initiatives. In addition, disparities in stakeholder capacities may reduce the effectiveness of collaborative processes, with many initiatives struggling to transition from pilot phases to long-term implementation. These findings suggest that integrative frameworks are essential for coordinating technological, social, and governance dimensions to achieve sustainable collaborative urban innovation [5], [18].

Figure 3 illustrates the integrative relationships among key methodological components identified in the literature, emphasizing how diverse approaches interact and complement each other in supporting collaborative urban innovation within smart city governance.

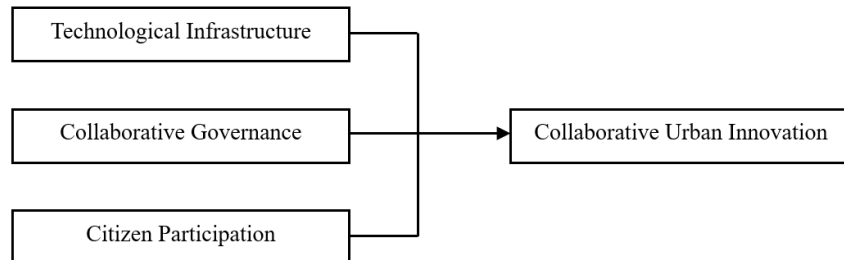


**Figure 3.** Collaborative Urban Innovation Process

The figure further illustrates how methodological foundations, multi-actor collaboration, citizen participation, governance and implementation processes, and evaluation mechanisms operate as interconnected components within collaborative urban innovation. These elements interact dynamically in an iterative cycle, where each stage influences and reinforces the others. Rather than representing a linear sequence, the process reflects a continuous and adaptive mechanism that enables the co-design, testing, and refinement of urban solutions. This integrative process underscores the need to align methodological, social, and governance dimensions in order to enable effective and sustainable smart city innovation. It also reflects the adaptive and continuous nature of collaborative urban innovation within smart city governance.

### 3.3 Proposed Integrative Framework for Collaborative Urban Innovation

Based on the synthesis of the reviewed literature, this study proposes an integrative conceptual framework for collaborative urban innovation in smart city governance. The framework emphasizes technology-enabled processes that actively support and enhance meaningful citizen participation. It integrates three core dimensions, namely technological infrastructure, collaborative governance mechanisms, and citizen participation processes, which interact dynamically to form a collaborative innovation ecosystem capable of addressing increasingly complex urban challenges. As illustrated in Figure 4, these dimensions function as interconnected components within a unified and adaptive system.



**Figure 4.** Collaborative Urban Innovation Framework

Technological infrastructure constitutes the foundational layer of collaborative urban innovation by enabling communication, data sharing, and coordination among diverse stakeholders. Digital platforms, smart applications, and data-driven systems facilitate real-time interaction and collaborative problem-solving, thereby enhancing transparency and responsiveness in urban governance. These technological capabilities significantly strengthen the capacity of cities to address complex urban challenges through more efficient and adaptive innovation processes [7], [24].

Collaborative governance mechanisms provide the institutional structure necessary to support multi-actor collaboration and participatory decision-making. These mechanisms include policy frameworks, participatory platforms, and coordination structures that enable stakeholders to jointly design and implement urban solutions. Effective collaborative governance requires institutional capacity, leadership, and shared responsibility among stakeholders, which collectively enhance the legitimacy and sustainability of innovation processes [4], [5].

Citizen participation processes represent a central component of collaborative urban innovation, positioning citizens as key contributors in shaping innovation outcomes. Through participatory mechanisms such as living labs, co-design approaches, and citizen science initiatives, they contribute to problem identification, solution development, and evaluation. This engagement enhances the relevance, inclusiveness, and social acceptance of innovation outcomes, while also strengthening transparency and accountability in governance [1].

The interaction among technological infrastructure, collaborative governance, and citizen participation forms an integrated ecosystem. This ecosystem supports continuous learning, adaptive governance, and sustainable innovation. By systematically linking technological, social, and institutional dimensions, the framework addresses fragmentation identified in previous studies. It provides a structured perspective for understanding how technology-enabled collaboration can effectively support inclusive and sustainable smart city governance [9], [10], [25].

Furthermore, the framework highlights the importance of continuous adaptation within collaborative urban innovation processes. The interaction among key dimensions evolves in response to changing urban conditions, stakeholder capacities, and technological developments. Through iterative learning and collaborative experimentation, stakeholders can refine policies, improve digital platforms, and strengthen participatory mechanisms over time. This adaptive capacity supports resilient smart city governance capable of responding to uncertainty and complexity in urban environments.

Overall, these findings demonstrate that collaborative urban innovation and citizen participation are inherently interdependent components of effective smart city governance. The proposed framework contributes to bridging technological, social, and institutional dimensions within urban innovation research, providing both theoretical insights and practical guidance for policymakers and practitioners. This integrative perspective contributes to advancing inclusive, adaptive, and sustainable approaches to smart city governance.

To further synthesize the proposed framework and clarify the relationships among its key dimensions, Table 2 presents a structured synthesis of the main components and their roles in collaborative urban innovation. The table highlights how technological infrastructure, collaborative governance, and citizen participation contribute to the development of an integrated and adaptive urban innovation ecosystem.

**Table 2.** Synthesis of the Proposed Collaborative Urban Innovation Framework

Dimension	Key Components	Analytical Role	Contribution to Urban Innovation
Technological Infrastructure	Digital platforms, smart applications, data-driven systems	Enables integration of information flows, real-time interaction, and stakeholder coordination	Enhances efficiency, transparency, and responsiveness in urban governance processes
Collaborative Governance	Policy frameworks, coordination mechanisms, participatory platforms	Provides institutional structure for multi-actor collaboration and collective decision-making	Strengthens legitimacy, accountability, and sustainability of innovation initiatives
Citizen Participation	Living labs, co-design approaches, citizen science initiatives	Positions citizens as active co-creators in problem-solving and innovation processes	Improves inclusiveness, relevance, and social acceptance of urban solutions
Integrated Interaction	Dynamic interaction among technological, governance, and participatory dimensions	Facilitates continuous learning, adaptive governance, and systemic integration	Supports resilient and sustainable urban innovation ecosystems

The synthesis presented in Table 2 highlights that collaborative urban innovation is structured through the integration of technological infrastructure, collaborative governance, and citizen participation as interdependent dimensions. Each dimension performs a distinct but complementary role in supporting urban innovation processes. Technological infrastructure enables coordination and data-driven interaction, collaborative governance provides institutional support for multi-actor collaboration, and citizen participation ensures inclusiveness and relevance in innovation outcomes.

Furthermore, the integration of these dimensions demonstrates that collaborative urban innovation operates as a systemic and adaptive process rather than as isolated components. The interaction among technological, social, and institutional elements facilitates continuous learning and supports the development of resilient and sustainable urban innovation ecosystems. These findings highlight the importance of implementing integrative and participatory approaches in smart city governance.

### 3.4 Theoretical and Practical Implications

The proposed integrative framework offers significant theoretical contributions to the study of collaborative urban innovation within the context of smart city governance. This study reconceptualizes collaborative urban innovation as a multidimensional governance paradigm rather than a purely technology-driven process, informed by the synthesis of selected studies. By integrating perspectives such as co-creation, collaborative governance, social innovation, and technology-enabled approaches, the framework provides a clearer understanding of how technological and social dimensions interact in shaping inclusive urban governance systems. The findings highlight the role of participatory governance in improving the legitimacy and effectiveness of decision-making processes within smart city ecosystems [3]. Moreover, they indicate that sustainable smart city development depends on the integration of technological and social dimensions, thereby fostering more collaborative and participatory approaches [5], [9].

From a governance perspective, the findings indicate that sustainable smart city development requires a shift toward human-centric and participatory approaches [8]. Technological advancement alone is insufficient to address complex urban challenges. Instead, meaningful citizen engagement and multi-actor collaboration must be systematically embedded within both institutional and technological structures. This perspective extends existing smart city governance literature by emphasizing collaborative ecosystems that support collective problem-solving and shared responsibility [6], [11].

In practical terms, the framework provides a structured reference for policymakers, urban planners, and practitioners to develop inclusive urban innovation strategies. The integration of technological infrastructure, collaborative governance, and citizen participation enables more transparent, responsive, and participatory decision-making processes. Governments can leverage digital platforms and participatory technologies to facilitate communication and collaboration with citizens. However, participatory mechanisms should be institutionally embedded rather than treated as symbolic initiatives. Strengthening institutional coordination and leadership support is essential to ensure the sustainability and long-term impact of collaborative innovation initiatives [12]. Additionally, agile governance approaches support adaptive policy implementation and continuous innovation within smart city environments [16].

Furthermore, the findings highlight the significance of capacity development and digital literacy in supporting effective and inclusive participation. Without adequate skills and equitable access to digital technologies, the benefits of collaborative innovation may not be equitably distributed. Addressing digital inequality is therefore essential to ensure inclusive participation. Strengthening stakeholder competencies and promoting community-based learning can further enhance participation in co-creation and urban innovation processes. These efforts contribute to collaborative knowledge production and support resilient and adaptive urban systems capable of responding to emerging challenges [9].

Finally, this study provides a foundation for future research on collaborative urban innovation and participatory smart city governance. While the proposed framework offers a robust conceptual framework, empirical validation across diverse urban contexts remains necessary. Future research should further investigate how emerging technologies, including artificial intelligence, big data analytics, and the Internet of Things (IoT), contribute to improving collaborative governance processes and strengthening citizen engagement [10], [19]. Comparative and case-based studies are also needed to examine how institutional conditions, stakeholder capacities, and socio-technical dynamics influence the implementation of collaborative urban innovation in different contexts.

#### 4. CONCLUSION

This study addresses the lack of an integrative framework that systematically connects technological, social, and governance dimensions in collaborative urban innovation within smart city governance. Based on an integrative literature review of 25 scholarly articles, this study proposes a technology-enabled conceptual framework that integrates technological infrastructure, collaborative governance, and citizen participation into a unified system. The findings demonstrate that collaborative urban innovation operates as a multidimensional and adaptive governance paradigm rather than a purely technology-driven approach. The proposed framework responds to the identified research problem by providing a structured integration of key dimensions that support inclusive, participatory, and technology-enabled urban governance.

This study contributes by offering a novel integrative perspective that reduces fragmentation in previous research and provides a structured reference for policymakers and practitioners in designing participatory urban innovation strategies. However, this study is limited to conceptual synthesis and lacks empirical validation. Future research should evaluate the applicability of the proposed framework across diverse urban contexts and further examine how emerging digital technologies can support collaborative governance and enhance citizen participation. Such efforts are essential for strengthening evidence-based smart city governance.

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