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Toward smart cities: A systematic literature review of digital collaboration among institutions

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Abstract

This study systematically reviews the literature on institutional digital collaboration in smart city initiatives to examine (1) the most prevalent collaboration models, (2) the enabling and limiting factors shaping these collaborations, and (3) their contributions to innovation and governance improvement. Following the PRISMA 2020 guidelines, we systematically searched the Scopus and PubMed databases for peer-reviewed studies published between 2015 and 2025 on inter-institutional digital collaboration in smart-city contexts; 30 studies met the inclusion criteria and were critically appraised using the CASP checklist. Public–Private Partnerships (PPP) were most frequent (10/30), followed by Quadruple Helix (9/30), Open Data Ecosystems (6/30), Smart Governance (4/30), Urban Living Labs (2/30), and Triple Helix (1/30). Because several studies employed more than one model, categories were coded non-exclusively. Key enablers included advanced digital technologies (IoT, AI, big data), strong political and legal support, and active multi-stakeholder engagement. Conversely, fragmented governance structures, resource constraints, and technical challenges, especially interoperability and privacy concerns, were the most significant barriers. Outcomes primarily comprised conceptual and implementation frameworks (60%), followed by prototypes (20%) and policy insights (20%). The findings highlight a shift from traditional PPPs to more inclusive and data-driven collaboration frameworks, reinforcing the dual role of these partnerships in advancing urban innovation and strengthening governance capacity. Future research should prioritize empirical and longitudinal evaluations to assess the scalability and long-term impact of collaborative models in diverse urban contexts.

Keywords: Governance, Innovation, Public-Private Partnerships, Quadruple Helix, Digital collaboration, Smart cities.

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1. Introduction

The smart city has become a leading framework for tackling the pressing challenges of rapid urbanization, digital transformation, and sustainable development. By integrating information and communication technologies (ICT), data-driven decision-making, and participatory governance, smart cities aim to improve service delivery, enhance sustainability, and create more inclusive urban environments [1, 2]. Yet, as Komninos [3] emphasizes, a smart city is not merely a technological project; it is also a social and institutional endeavor that combines human, collective, and technological intelligence to address complex urban problems collaboratively.

A central but underexplored aspect of this endeavor is digital collaboration among institutions. Governments, universities, businesses, and civil society are increasingly working together in digital environments to co-develop innovative urban solutions. Frameworks such as the Triple and Quadruple Helix underscore the value of these multi-actor ecosystems in driving knowledge co-creation and innovation [4, 5]. Such collaborations move beyond functional partnerships; they build trust, align diverse interests, and create shared governance mechanisms that are essential for long-term urban transformation [6, 7].

However, most smart city research still concentrates on technological infrastructures, such as IoT, big data, and digital twins, while neglecting the institutional dynamics of collaboration in digital ecosystems [8, 9]. Although cases like Turin and Lugano demonstrate that multi-institutional digital collaborations can enhance governance and performance [10] a systematic understanding of their structures, enablers, barriers, and outcomes remains limited [11]. This knowledge gap is particularly urgent in the current context, where post-pandemic governance, AI-driven city management, and the global race for urban innovation demand more integrated and collaborative approaches to smart city development.

This study addresses this gap through a systematic literature review (SLR) of 30 peer-reviewed studies published between 2015 and 2025. It explores three key questions: (1) What forms of institutional digital collaboration are most prevalent in smart city initiatives? (2) What enablers and barriers shape these collaborations? (3) How do these partnerships contribute to innovation and improved governance?

This review contributes to the literature by developing a typology of collaboration models, identifying cross-cutting enablers and barriers, and synthesizing evidence on how institutional partnerships drive innovation and governance in smart cities. It offers practical recommendations for policymakers and urban practitioners seeking to strengthen collaborative digital ecosystems.

To achieve these objectives, we applied a PRISMA-guided SLR methodology to ensure transparency and rigor in identifying, screening, and synthesizing relevant studies.

2. Materials and Methods

This systematic literature review (SLR) was conducted in accordance with the PRISMA 2020 guidelines, ensuring transparency, reproducibility, and traceability throughout the review process. The PRISMA framework guided the identification, screening, eligibility assessment, and inclusion of relevant studies.

2.1. Search Strategy

The literature search was conducted between January and March 2025 across two major academic databases: Scopus and PubMed, chosen for their comprehensive coverage of multidisciplinary research in urban studies, governance, and technology.

- Scopus Search Query: ("smart city" OR "smart cities") AND ("digital collaboration" OR "collaborative platform" OR "inter-institutional collaboration" OR "cross-sector collaboration" OR "public-private partnership") AND ("institution*" OR "government" OR "university" OR "industry" OR "NGO")
- PubMed Search Query: ((“smart city”[Title/Abstract] OR “smart cities”[Title/Abstract]) AND (collab*[Title/Abstract] OR partnership*[Title/Abstract] OR “public-private”[Title/Abstract] OR “quadruple helix”[Title/Abstract] OR “urban living lab*”[Title/Abstract] OR governance[Title/Abstract])) AND (institution*[Title/Abstract] OR government[Title/Abstract] OR university[Title/Abstract] OR industry[Title/Abstract] OR NGO[Title/Abstract])

  Note: The last search was run on 31 March 2025.

The queries were refined iteratively to capture studies focusing on institutional collaboration in smart city contexts, ensuring the inclusion of diverse models such as public-private partnerships, collaborative platforms, and cross-sector initiatives.

2.2. Screening and Eligibility

The initial search retrieved 1,832 records (110 from Scopus and 1,722 from PubMed). The following inclusion and exclusion criteria were applied:

- Inclusion criteria:

1. Published between 2015–2025.
2. Peer-reviewed journal articles in their final publication stage.
3. Written in English.
4. Focused on institutional collaboration in smart city initiatives, including public-private partnerships, cross-sector collaboration, or inter-institutional digital platforms.
5. Open-access or institutionally accessible full text.

- Exclusion criteria:
1. Editorials, conference papers, book chapters, or non-peer-reviewed sources.
2. Articles focusing solely on technical aspects (e.g., IoT, AI algorithms) without institutional or collaborative dimensions.
3. Studies with insufficient methodological or conceptual relevance.

After applying these filters, the records were screened by titles and abstracts for relevance, followed by full-text reviews.

2.3. Selection Process

- Scopus: 110 initial records → 108 after date filtering → 52 after document-type filtering → 45 after relevance screening → 21 after open-access filtering → 15 included.
- PubMed: 1,722 initial records → 1,715 after date filtering → 1,603 after document-type filtering → 1,259 after availability filtering → 1,255 after language filtering → 15 after relevance screening → 15 included.

This process resulted in a final set of 30 articles (15 from each database), representing a diverse range of geographic contexts, collaboration models, and methodological approaches.

2.4. Data Extraction and Synthesis

Key information from each study, including author(s), year, country, collaboration model, methodological approach, and key findings, was extracted into a structured database for thematic synthesis. Studies were analyzed to identify patterns, enablers, barriers, and outcomes of digital collaboration among institutions in smart city initiatives.

The selection process is summarized in Figure 1 (PRISMA Flow Diagram), beginning with an initial pool of 1,832 records and culminating in 30 studies included in the final synthesis.

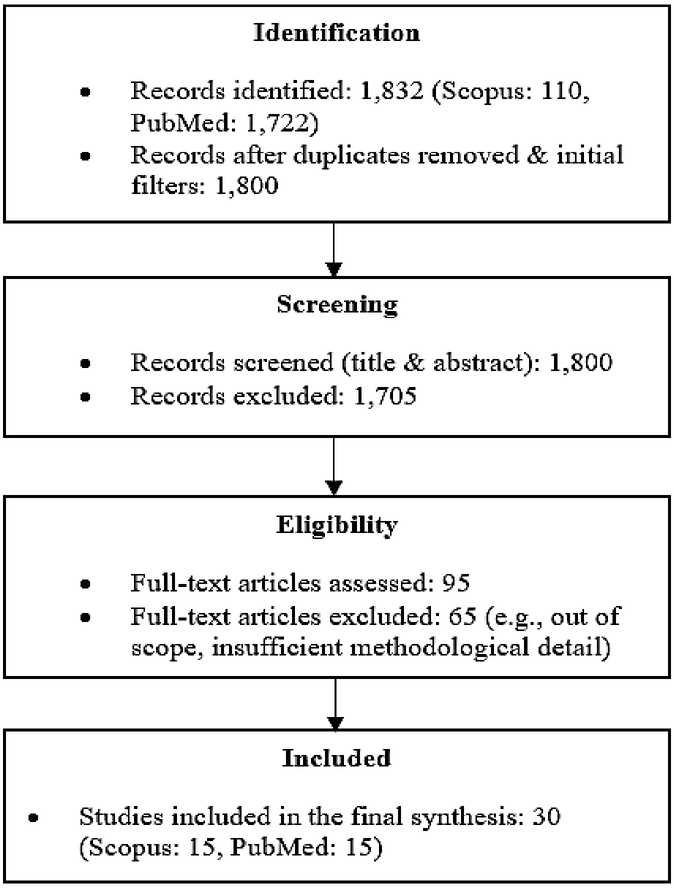

Figure 1.
PRISMA 2020 flow diagram of study selection (initial n=1,832; included n=30).

3. Results

This section presents the synthesized findings from 30 peer-reviewed studies, structured around collaboration models, methodological approaches, enabling and limiting factors, and key outcomes. It also includes a quality appraisal to ensure the reliability of the evidence base.

3.1. Overview of Reviewed Studies

The 30 selected studies span a diverse range of geographic regions, collaboration models, and thematic focuses. Table 1 summarizes their key characteristics, including study focus, collaboration model, methodology, enablers, barriers, and key outcomes.

Table 1.
Summary characteristics of the 30 included studies.

No	Author(s) & Year	Country/Region	Study Focus	Collaboration Model	Methodology	Enablers	Barriers	Key Outcomes (Categorized)
1	Kannan et al. [12]	Australia, Iran	Smart Waste Management 4.0	Quadruple Helix	Case Study	IoT, AI, big data integration, stakeholder engagement	Absence of unified frameworks	Conceptual Framework for Smart Waste Management 4.0
2	Naseem et al. [13]	Pakistan	AI & ML for COVID-19 response in LMIC	Open Data Ecosystem	Mixed Methods	AI diagnostic tools, predictive analytics	Limited resources in LMIC	Policy insights for AI in pandemic preparedness
3	Mohammadzadeh et al. [14]	Iran	Smart city technologies in healthcare	Public-Private Partnership	Qualitative	IoT, mobile apps, real-time data	Infrastructure deficiencies	Implementation framework for smart healthcare
4	Asghar et al. [15]	Pakistan	Nanomaterials for environmental remediation	Quadruple Helix	Literature Review	Advanced nanotechnology for pollution control	High costs, recycling challenges	Strategic recommendations for nanomaterial use
5	Buttazzoni et al. [16]	Canada	Equity in smart city health interventions	Urban Living Labs	Case Study	Equity-centered planning, citizen participation	Lack of integration of equity dimensions	Identification of equity gaps in interventions
6	Hassankhani et al. [17]	Iran, Japan	Smart cities for crisis management (COVID-19)	Open Data Ecosystem	Mixed Methods	Telehealth platforms, digital crisis tools	Digital divide, privacy risks	Lessons for crisis response via smart technologies
7	Obracht-Prondzyńska et al. [18]	Poland	AI-based Greencoin for climate neutrality	Smart Governance	Design Study	AI-driven citizen engagement models	Limited AI integration	Greencoin model for citizen participation
8	Balakrishnan et al. [19]	UK, Canada	Role of social media in resilience	Open Data Ecosystem	Content Analysis	Social media mobilization, community networks	Misinformation, digital inequality	Framework for enhancing resilience via social media
9	Rehman et al. [20]	Malaysia	Trust management in IoV	Quadruple Helix	Experimental	Context-aware AI trust models	Lack of standardization	Standardization strategies for IoV trust management
10	Vihman et al. [21]	Estonia	Fault-tolerant techniques in underwater sensor networks	Public-Private Partnership	Technical Review	Cross-layer fault tolerance, resilient communication	Complexity, maintenance challenges	Taxonomy of fault-tolerant methods
11	Alzahrani and Alfouzan [22]	Saudi Arabia	Augmented Reality and cybersecurity	Public-Private Partnership	Case Study	AR technologies, strong cybersecurity frameworks	Lack of integrated policies	Identification of AR application areas
12	Al-Rawashdeh et al. [23]	Malaysia, UAE	IoT adoption in smart healthcare	Quadruple Helix	Survey	IoT-enabled workflows, adoption frameworks	Privacy risks, low user adoption	Framework for IoT adoption in healthcare
13	Khajeh et al. [24]	Iran, Taiwan	Real-time IoT scheduling for smart cities	Smart Governance	Simulation	Real-time data scheduling, optimization techniques	Energy constraints, scalability challenges	Classification of IoT scheduling methods
14	Hossain et al. [25]	Bangladesh, Spain, South Korea	IoT in pregnancy care coordination	Open Data Ecosystem	Case Study	Remote monitoring, ML-enhanced IoT	Data privacy issues, interoperability gaps	IoT-enabled maternal care framework
15	Zeng et al. [26]	China	IoT sensors for sustainable cities	Quadruple Helix	Experimental	Integration of IoT sensors, multi-layered communication	Security risks, fragmented ecosystems	IoT-driven strategies for urban sustainability
16	Voorwinden et al. [27]	Netherlands	Legal & governance structures of Urban Living Labs	Urban Living Labs	Policy Analysis	Participatory governance, flexible legal frameworks	Conflicting municipal roles	Typology of legal frameworks for ULL
17	Gasco-Hernandez et al. [28]	Italy, Spain, Germany	Organizational capacity in local governments	Public-Private Partnership	Comparative Study	Strategic planning, leadership, and intergovernmental collaboration	Limited municipal resources	Framework for enhancing digital transformation capacity

No	Author(s) & Year	Country/Region	Study Focus	Collaboration Model	Methodology	Enablers	Barriers	Key Outcomes (Categorized)
18	Dupont et al. [29]	France	Innovative PPP for smart cities (Chaire REVES)	Public-Private Partnership	Case Study	University-industry-government collaboration	Funding constraints, institutional inertia	Demonstration of PPP-driven innovation
19	Kumar et al. [30]	India, China	Urban flood management vs. Sponge City	Smart Governance	Comparative Analysis	Integrated flood management strategies	Financial limitations, low public participation	Comparative insights for Sponge City adoption
20	Vallance et al. [31]	UK	Quadruple Helix intermediary for urban innovation	Quadruple Helix	Case Study	University-anchored innovation platforms	Limited early public engagement	Insights on intermediary roles in innovation
21	Biygautane and Clegg [32]	UAE	PPP for Dubai Smart City	Public-Private Partnership	Case Study	Strong political support, legal frameworks, and private sector expertise	Funding limitations, human capital shortages	Blueprint for GCC smart city PPPs
22	Bussador et al. [33]	Brazil	DTI-BR model for smart tourism	Quadruple Helix	Case Study	ISO standards integration, participatory governance	Gaps in indicators, weak PPP collaboration	Framework for smart tourism transformation
23	Tapia-McClung [34]	Mexico	Spatio-temporal dashboard for crime analysis	Open Data Ecosystem	Design Study	Geovisual analytics, cross-agency collaboration	Data privacy concerns, limited interoperability	Prototype for public safety dashboards
24	Hardi et al. [35]	Indonesia	Interoperability in smart city governance	Smart Governance	Policy Analysis	Cross-sector collaboration, national strategy alignment	Regulatory resistance, data fragmentation	Governance framework for human security
25	Leu et al. [36]	Taiwan	Dual approach to smart city development	Public-Private Partnership	Case Study	Top-down & bottom-up synergy, strong ICT sector	Limited citizen engagement	Taiwan's dual smart city development model
26	Pianezzi et al. [37]	Japan	Culturally embedded PPPs	Public-Private Partnership	Case Study	Long-term partnerships, cultural goodwill	Over-reliance on the private sector	Insights into culturally embedded PPPs
27	Tan and Taeihagh [38]	Developing Countries	Smart city governance	Quadruple Helix	Literature Review	Regulatory reforms, citizen participation	Financial constraints, governance complexity	Systematic framework for governance in developing nations
28	Gupta [39]	India	Smart City Mission in Gwalior	Public-Private Partnership	Case Study	Citizen engagement, policy-driven redevelopment	Debt financing, land acquisition	Recommendations for non-metro smart cities
29	López-Pérez et al. [40]	Spain	Smart mobility & climate	Triple Helix	Case Study	Science-park anchored collaboration, sustainability planning	Stakeholder conflicts, funding gaps	Pilot model for integrating mobility & climate initiatives
30	Parygin et al. [41]	Russia	Quadruple Helix for territorial development	Quadruple Helix	Case Study	Social monitoring, gamification for public input	Low civic engagement, adoption barriers	Participatory development tools using the innovation helix

3.2. Quality Appraisal of Included Studies

To ensure the credibility of the synthesized findings, a quality appraisal was conducted using an adapted Critical Appraisal Skills Programme (CASP) checklist.

Table 2 presents the results of this appraisal. The majority of studies (n = 18) achieved a high-quality rating (≥80%), characterized by strong methodological rigor, clearly stated objectives, and transparent data reporting. The remaining studies (n = 12) were rated as moderate quality due to limited empirical validation, contextual constraints, or small sample sizes. Importantly, no studies were excluded on the basis of poor quality, as all met the minimum inclusion threshold (≥70%).

Table 2.
Quality appraisal using an adapted CASP checklist (High ≥80%).

No.	Author(s) & Year	Study Design	CASP Score (%)	Quality Rating	Inclusion Decision	Key Appraisal Notes
1	Kannan et al. [12]	Empirical case study	85	High	Included	Clear methodology, strong data integration, and minor limitations in scalability
2	Naseem et al. [13]	Systematic review	80	High	Included	Comprehensive review, limited regional applicability
3	Mohammadzadeh et al. [14]	Conceptual framework	75	Moderate	Included	Well-defined framework, lacks empirical validation
4	Asghar et al. [15]	Review & conceptual analysis	78	Moderate	Included	Valuable synthesis of nanotechnology applications, cost barriers not deeply explored
5	Buttazzoni et al. [16]	Qualitative study	82	High	Included	Strong qualitative insights, small sample size
6	Hassankhani et al. [17]	Mixed-method study	84	High	Included	Combines qualitative & quantitative data, limited longitudinal assessment
7	Obracht-Prondzyńska et al. [18]	Conceptual paper	70	Moderate	Included	Innovative AI application needs empirical validation.
8	Balakrishnan et al. [19]	Case study	83	High	Included	Rich analysis of social media dynamics, context-specific
9	Rehman et al. [20]	Technical review	74	Moderate	Included	Provides taxonomy for IoV trust models, lacks field application.
10	Vihman et al. [21]	Systematic review	81	High	Included	Comprehensive review, clear classification of techniques
11	Alzahrani and Alfouzan [22]	Conceptual analysis	79	Moderate	Included	Identifies AR application areas, with minimal empirical testing
12	Al-Rawashdeh et al. [23]	Empirical study	82	High	Included	Strong IoT adoption framework, limited generalizability
13	Khajeh et al. [24]	Technical review	76	Moderate	Included	Provides an IoT scheduling taxonomy, lacks field validation
14	Hossain et al. [25]	Mixed-method study	84	High	Included	Valuable integration of IoT in healthcare, privacy risks discussed
15	Zeng et al. [26]	Conceptual framework	77	Moderate	Included	Detailed IoT sustainability strategies, need implementation data.
16	Voorwinden et al. [27]	Case study	83	High	Included	Clear typology of legal frameworks for ULL, context-bound.
17	Gasco-Hernandez et al. [28]	Empirical survey study	85	High	Included	Strong analysis of organizational capacity, small sample limitation
18	Dupont et al. [29]	Case study	80	High	Included	Innovative PPP model, limited long-term impact analysis
19	Kumar et al. [30]	Comparative analysis	78	Moderate	Included	Comparative insights into Sponge City strategies, limited citizen input.
20	Vallance et al. [31]	Case study	82	High	Included	Highlights intermediary role in innovation, early-stage project
21	Biygautane and Clegg [32]	Case study	86	High	Included	In-depth PPP evaluation in Dubai, replicability uncertain

No.	Author(s) & Year	Study Design	CASP Score (%)	Quality Rating	Inclusion Decision	Key Appraisal Notes
22	Bussador et al. [33]	Mixed-method study	83	High	Included	Integrating ISO standards into tourism innovation, data gaps remain
23	Tapia-McClung [34]	Case study	81	High	Included	Strong dashboard prototype analysis, needs longitudinal validation
24	Hardi et al. [35]	Empirical study	84	High	Included	Robust evaluation of interoperability in governance, some regulatory gaps
25	Leu et al. [36]	Case study	80	High	Included	Dual approach framework, limited grassroots engagement
26	Pianezzi et al. [37]	Qualitative study	82	High	Included	Culturally grounded PPP analysis, context-specific findings
27	Tan and Taeihagh [38]	Systematic review	87	High	Included	Comprehensive synthesis of governance in developing nations
28	Gupta [39]	Case study	78	Moderate	Included	Provides practical insights for Gwalior smart city, financing issues remain
29	López-Pérez et al. [40]	Case study	83	High	Included	Integrates mobility & climate planning, still in pilot phase
30	Parygin et al. [41]	Conceptual framework	79	Moderate	Included	Gamification and social monitoring strategies are well-described; however, they lack empirical testing.

3.3. Patterns Emerging from the Reviewed Studies

The analysis of the 30 studies reveals several notable patterns regarding forms of collaboration, research methodologies, enabling and limiting factors, and outcomes of digital collaboration in smart city initiatives.

3.3.1. Collaboration Models

Public-Private Partnerships (PPP) emerged as the most prevalent model (10 studies), underscoring their central role in leveraging private-sector expertise and resources for urban innovation. Quadruple Helix collaborations followed closely (9 studies), emphasizing the inclusion of academia and civil society alongside industry and government in co-creating urban solutions. Open Data Ecosystems (6 studies) were also prominent, reflecting the growing use of data-sharing platforms for participatory and transparent governance. Smart Governance frameworks (4 studies) and Urban Living Labs (2 studies) represent more experimental, participatory approaches, while Triple Helix collaborations (1 study) were least common. Because coding was non-exclusive, totals exceed 30 and proportions may sum to >100%.

Figure 2 visualizes these proportions, illustrating the shift from traditional PPPs toward more inclusive, multi-actor frameworks.

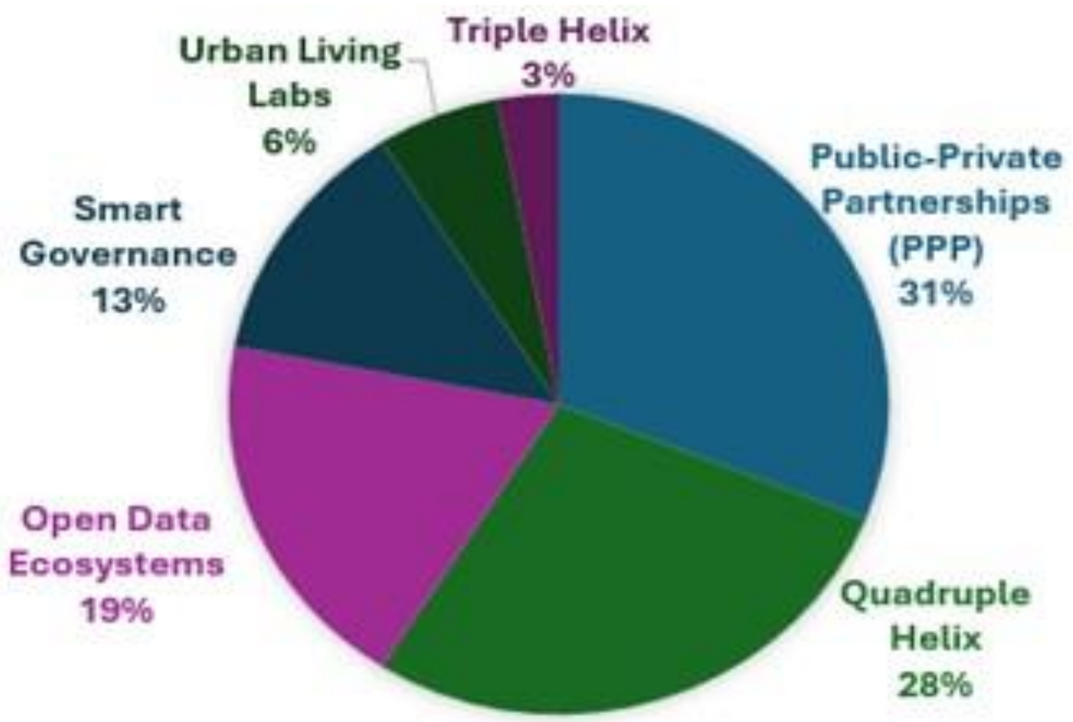

Figure 2.
Distribution of collaboration models across the reviewed studies (non-exclusive coding).

3.3.2. Research Methodologies

Case studies dominate the evidence base (approximately 50%), reflecting the exploratory and context-specific nature of institutional collaboration research in smart cities. Comparative and policy analyses provide cross-contextual evaluations of collaboration mechanisms, while mixed-methods and experimental designs offer integrated insights, albeit in fewer studies. Literature reviews remain a minority, suggesting an opportunity for more theory-building in this domain.

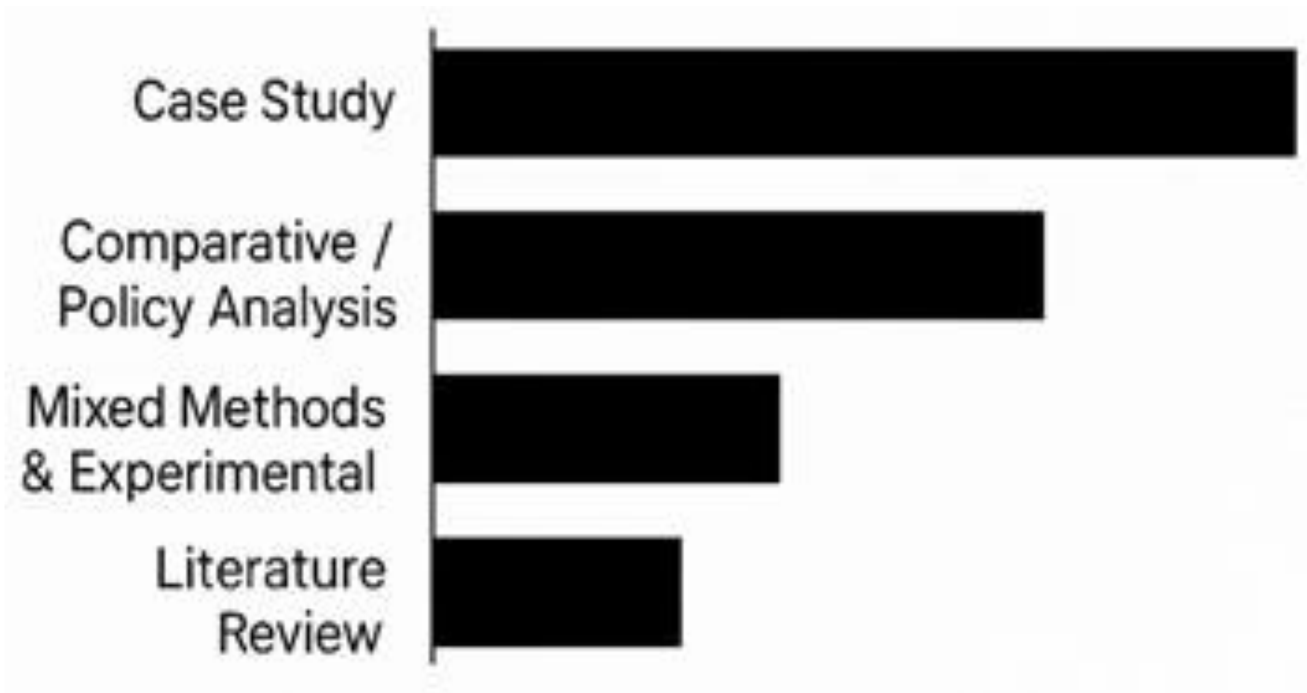

Figure 3.
Research methodologies used in the reviewed studies.

3.3.3. Enablers and Barriers

The most frequently reported enablers include:

- Deployment of advanced technologies (IoT, AI, big data) to improve efficiency and coordination.
- Strong political support and enabling legal frameworks that foster collaboration.
- Active multi-stakeholder engagement across government, academia, industry, and civil society.

Conversely, key barriers include:

- Fragmented governance structures and regulatory misalignments.
- Resource constraints, including financial and human capital shortages.
- Technical challenges, particularly those related to interoperability, data privacy, and system integration.

These factors are visualized in Figure 4, which highlights the most recurring enablers and barriers across the studies.

Figure 4.
Frequency of reported enablers and barriers.

3.3.4. Outcomes

The reviewed studies predominantly produce conceptual and implementation frameworks (around 60%), offering structured guidance for digital collaboration in smart cities. Around 20% present prototypes or digital tools, while another 20% provide policy insights and recommendations, demonstrating an applied orientation toward actionable urban innovation.

3.4. Summary of Key Findings

In sum, the evidence highlights a paradigm shift toward more inclusive, multi-actor collaboration frameworks, with PPPs remaining foundational but increasingly complemented by Quadruple Helix and data-driven models. While advanced technologies and strong governance support collaboration, fragmentation, resource limitations, and technical barriers remain persistent challenges. Conceptual contributions dominate the literature, signaling the need for greater empirical testing and evaluation of collaborative models in practice.

4. Discussion

This systematic review synthesized findings from 30 peer-reviewed studies to answer the research questions regarding the forms, enablers, barriers, and outcomes of institutional digital collaboration in smart city initiatives.

4.1. Forms of Institutional Digital Collaboration in Smart Cities

Addressing RQ1, the review confirms that Public-Private Partnerships (PPPs) remain the most widely adopted model, appearing in one-third of the reviewed studies. This aligns with prior scholarship highlighting PPPs as a central mechanism for mobilizing private-sector resources and expertise for complex urban projects [29, 32]. However, the strong representation of Quadruple Helix collaborations (28%) signals a shift toward inclusive, multi-actor frameworks that integrate academia and civil society alongside industry and government, enabling co-created urban solutions [33]. Open Data Ecosystems further illustrate the increasing importance of data-driven collaboration for participatory governance, while Smart Governance frameworks and Urban Living Labs reflect experimental, adaptive approaches to city-making. Triple Helix models, though historically prominent, appear less suited for addressing the complexity of contemporary urban innovation challenges.

4.2. Enablers and Barriers of Collaboration

For RQ2, the review identifies three major enablers:

1. Integration of advanced technologies IoT, AI, and big data improves efficiency and supports evidence-based decision-making [26].
2. Strong political commitment and supportive legal frameworks, essential for institutionalizing collaborative practices [35].
3. Active multi-stakeholder engagement fosters legitimacy and shared ownership, especially in Quadruple Helix and Urban Living Labs [27].

Conversely, fragmented governance structures and regulatory misalignments emerged as critical barriers [35]. Resource constraints, including financial and human capital shortages, particularly constrained projects in developing contexts [13, 39]. Technical barriers, such as interoperability gaps, cybersecurity risks, and data privacy issues, further inhibited scalability [25].

4.3. Contributions to Innovation and Governance

Regarding RQ3, the review shows that 60% of studies delivered conceptual or implementation frameworks, offering structured pathways for collaboration in smart city projects. Examples include frameworks for Smart Waste Management 4.0 [12] and digital transformation in governance [35]. Prototypes and digital tools accounted for 20%, while another 20% presented policy insights to inform implementation. Collectively, these findings highlight that institutional collaborations not only enhance technological deployment but also strengthen governance capacity through more adaptive, participatory, and data-driven decision-making.

4.4. Implications for Practice and Research

For practice, policymakers should institutionalize multi-stakeholder participation, especially Quadruple Helix and Open Data Ecosystem models, while investing in interoperability and capacity-building to mitigate technical and resource constraints. For research, the dominance of conceptual contributions signals the need for more empirical and longitudinal studies to evaluate the long-term effects of these collaboration models on innovation and governance.

4.5. Limitations

This review is limited by its focus on peer-reviewed sources, potentially excluding valuable insights from grey literature. Additionally, the wide geographic diversity of the studies warrants caution in generalizing results across socio-political contexts.

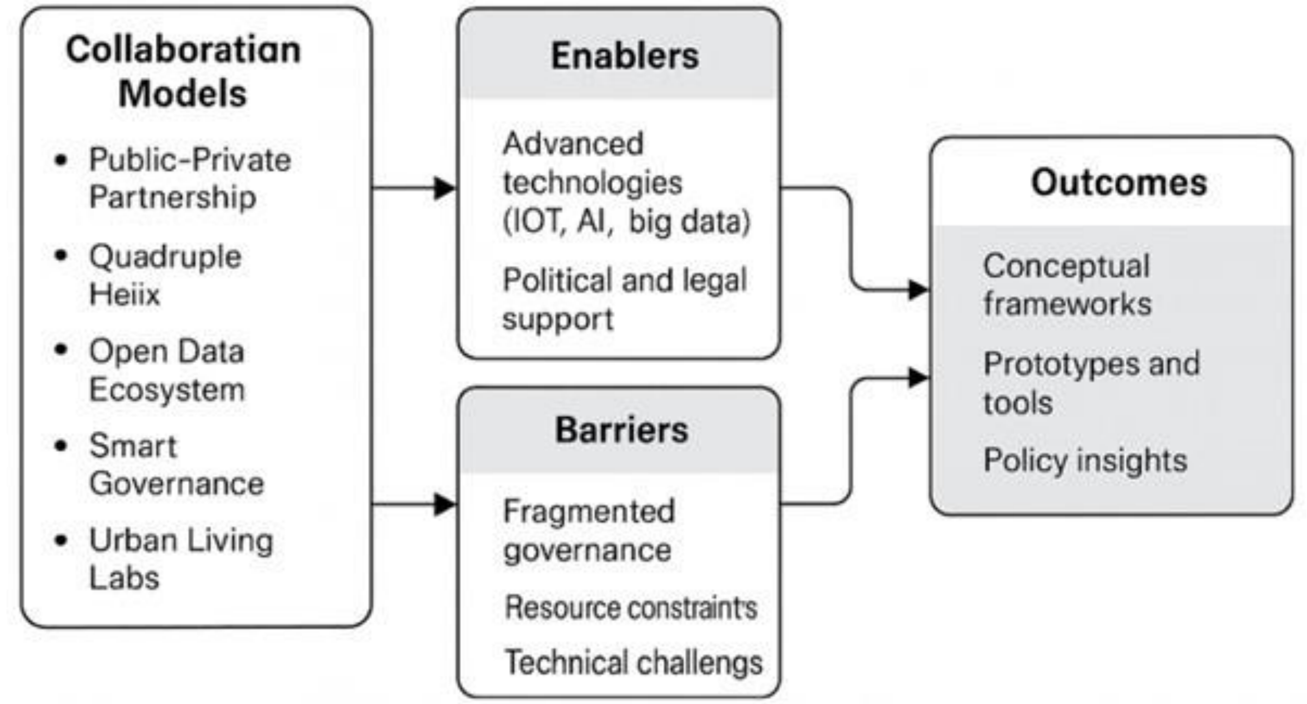

Figure 5.
Conceptual model linking collaboration models, enablers, barriers, and outcomes.

5. Conclusion

This systematic review demonstrates a paradigm shift from traditional PPPs toward more inclusive, multi-actor collaboration frameworks in smart city initiatives. Advanced technologies, strong governance support, and active stakeholder participation emerge as key enablers of successful collaboration, while fragmented governance, resource shortages, and technical challenges persist as significant barriers. The findings underscore the dual role of these collaborations: not only advancing technological innovation but also enhancing urban governance through participatory, evidence-based decision-making. Future research should emphasize comparative and longitudinal studies to assess the scalability and long-term impact of these collaborative frameworks, ensuring that smart city initiatives deliver both innovation and inclusivity.

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