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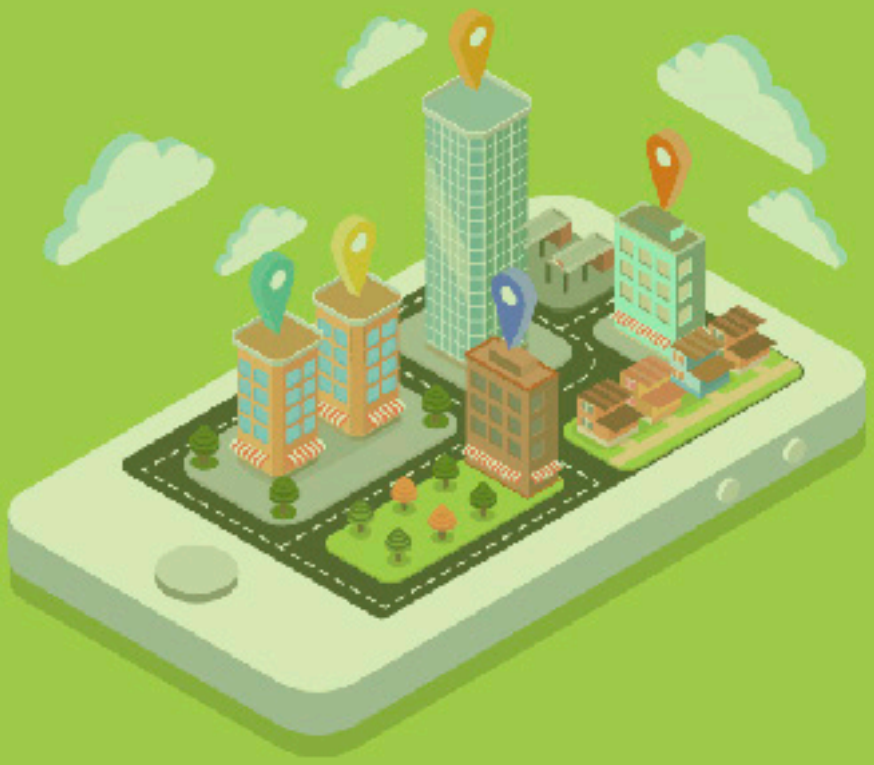

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Adaptive Socio-Technical-Ecological Systems in Smart Cities: Bridging Implementation Gaps for Inclusive Governance in the Global South

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ABSTRACT

Since Angelidou (2015) conceptualized smart cities as a conjuncture of four forces—technological, institutional, socio-economic and environmental—such initiatives have expanded rapidly, especially in the Global South. However, a decade of implementation has exposed significant gaps between policy ambitions and actual outcomes. This study reframes smart cities as adaptive socio-technical-ecological systems and examines their dynamic interactions through comparative case analysis of projects in Pune, Faridabad, Bhubaneswar (India) and Medellín (Colombia). Using official reports, audits and secondary data, findings reveal that technological determinism frequently exacerbates socio-economic exclusion and institutional fragmentation, while environmental objectives remain weakly integrated with livability and climate adaptation. The paper proposes an adaptive framework that incorporates feedback loops, contextual adaptation and equity integration. It offers practical pathways for hybrid governance, iterative policy learning and equity-focused design to advance inclusive and sustainable smart city development, with special relevance to the Global South.

INTRODUCTION

Smart city initiatives have emerged as one of the most prominent responses to the complex challenges facing contemporary urban development. Since the early 2010s, governments, private sector actors and international organisations have promoted smart cities as a means to enhance infrastructure efficiency, improve quality of life, support climate adaptation and strengthen urban governance. These initiatives typically integrate digital technologies with urban planning and management processes, promising more responsive, sustainable and liveable cities. Yet, more than a decade after their widespread adoption, particularly in the Global South, questions persist regarding their actual contribution to effective urban policy and planning.

A foundational contribution to understanding the conceptual underpinnings of smart cities came from Angelidou (2015), who argued that the smart city represents a conjuncture of four primary forces: technological, institutional, socio-economic and environmental. Published in Cities, Volume 47, Supplement, pp. 95–106, Angelidou's analysis sought to move beyond the often abstract and promotional discourse surrounding smart cities by identifying the key drivers shaping their conception and strategic development. The technological force encompasses advancements in information and communication technologies (ICT), the Internet of Things (IoT) and data analytics; the institutional force relates to governance structures, public-private partnerships and regulatory frameworks; the socio-economic force addresses issues of equity, employment, migration and livability; while the environmental force focuses on sustainability, resource efficiency, greening and climate resilience.

This four-forces framework provided a valuable lens for strategic urban planning at a time when smart city concepts were still maturing. However, the subsequent years of implementation have revealed significant gaps between policy ambitions and on-the-ground realities. In many Global South contexts, smart city projects have encountered challenges related to institutional fragmentation, socio-economic exclusion, uneven technological access and limited integration with broader environmental and climate goals. These experiences suggest that the original conjuncture model, while insightful, requires critical reassessment and extension to account for dynamic interactions, feedback mechanisms and context-specific adaptation processes in diverse urban settings.

This article builds upon and extends Angelidou's (2015) framework by reframing smart cities as adaptive socio-technical-ecological systems. Unlike the original static conjuncture model, the proposed framework treats the four forces as interdependent subsystems connected through dynamic feedback loops, power relations, learning mechanisms and context-specific adaptation processes. This reframing is essential for addressing real-world implementation gaps in the Global South, where technological investments often outpace institutional capacity and socio-economic equity. Such an approach directly supports the aims of smart cities research by providing a robust theoretical foundation for analysing policy effectiveness and promoting inclusive, sustainable urban development. This study contributes to smart

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cities research by offering a theoretically grounded and empirically validated framework that addresses the limitations of existing models in rapidly urbanising Global South contexts.

The paper addresses the following research questions

• How have the four forces interacted in practice within smart city initiatives in the Global South?

• What implementation gaps and policy effectiveness issues (effective/ineffective/non-existent) emerge when examined through an adaptive systems lens?

• What pathways can enhance inclusive and sustainable urban governance?

To answer these questions, the article undertakes a comparative analysis of selected smart city projects in Global South contexts, with particular attention to experiences in rapidly urbanising regions of Asia and Latin America. Drawing on policy documents, implementation reports and secondary evaluations, it assesses outcomes against key themes in urban planning and policy, including infrastructure development, public-private cooperation, livability and quality of life, greening and climate adaptation, urban regeneration and governance effectiveness.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature and develops the proposed adaptive socio-technical-ecological framework. Section 3 outlines the methodology. Section 4 presents the empirical analysis of the four forces in practice. Section 5 discusses the findings and advances the theoretical contribution. The paper concludes with policy implications and directions for future research.

Theoretical Framework and Literature Review

Angelidou (2015) provided one of the earliest systematic attempts to move beyond the promotional rhetoric surrounding smart cities by conceptualising them as the outcome of a conjuncture of four distinct yet interrelated forces. In her contribution to the Current Research on Cities supplement of this journal (Cities, Volume 47, pp. 95–106), Angelidou identified these forces as: (1) technological (advances in ICT, data analytics and digital infrastructure); (2) institutional (governance arrangements, regulatory frameworks and public-private partnerships); (3) socio-economic (issues of equity, employment, livability and social inclusion); and (4) environmental (sustainability, resource efficiency, greening and climate resilience). This framework sought to replace the then-dominant abstract and often utopian image of the smart city with a more grounded strategic understanding, drawing on both the historical strand of urban futures thinking and the contemporary knowledge and innovation economy.

The four-forces model has since been widely cited and remains a valuable heuristic for analysing smart city strategies (Angelidou, 2015). However, a decade of implementation experience, particularly in the Global South, has exposed important limitations in treating these forces as relatively discrete elements converging at a particular moment. Empirical studies increasingly document persistent implementation gaps, where technological investments outpace institutional capacity, socio-economic benefits remain unevenly distributed and environmental objectives are subordinated to short-term efficiency gains (Freestone, 2025; Praharaj, 2025; Das, 2025). These realities suggest the need for a more dynamic theoretical reframing — one that conceptualises smart cities not as a static conjuncture but as adaptive socio-technical-ecological systems characterised by continuous feedback loops, power asymmetries, learning processes and context-specific adaptation mechanisms.

Evolution of Smart City Discourse Post-2015 Post-2015

scholarship has shifted from definitional debates toward critical assessments of policy effectiveness and on-the-ground outcomes. Early optimism regarding technology-driven solutions to urban challenges has given way to more nuanced critiques highlighting techno-utopian biases, corporate influence and the risk of exacerbating existing inequalities (Hollands, 2008; updated in later works such as those reviewed in Yigitcanlar *et al.*). In the Global South, smart city initiatives, often modelled on Northern templates, have frequently encountered structural barriers including weak local governance, digital divides, informal urbanism and limited fiscal capacity (Odendaal, 2019; Prasad *et al.*, 2023; Freestone, 2025).

Literature on India's Smart Cities Mission (SCM), launched in 2015 as one of the largest national programmes of its kind, illustrates these challenges vividly. Quantitative assessments of the 100 selected cities reveal significant discrepancies between planned investments and actual implementation, with many projects prioritising command-and-control technology infrastructure (e.g., Integrated Command and Control Centres) over social sustainability and inclusive governance (Praharaj, 2025; Jha). Area-based development under the Mission has shown uneven progress in integrating livability, greening and community participation (Freestone, 2025). Similar patterns emerge in other Global South contexts, where smart city projects risk reinforcing spatial and socio-economic exclusion rather than addressing the complexities of sustainable urban development (Roy & AlSayyad, 2004; updated critiques in 2023–2025 literature).

Limitations of the Original Conjuncture Model

While Angelidou's (2015) framework effectively highlighted the multi-dimensional nature of smart city formation, it paid relatively limited attention to:

• Dynamic interactions and feedback mechanisms among the four forces over time.

• Context-specific adaptation processes, particularly in rapidly urbanising developing-world settings.

• Power relations and political economy dimensions of public-private cooperation.

• Long-term policy reflection on effectiveness, including cases of ineffective or non-existent planning responses.

These gaps align with Cities' emphasis on analysing urban development and management as reflections of planning policies—effective, ineffective or absent—and on promoting appropriate policies across developed and developing worlds.

Proposed Adaptive Socio-Technical-Ecological Systems Framework

This article advances a refined theoretical framework that builds directly upon Angelidou (2015) while addressing its limitations. Smart cities are reconceptualised as adaptive socio-technical-ecological systems in which the four forces operate as interdependent subsystems connected through feedback loops (see Figure 1). Adaptation occurs through learning mechanisms, institutional adjustments and iterative policy responses that respond to emergent outcomes and external pressures such as climate change, migration and economic shifts.

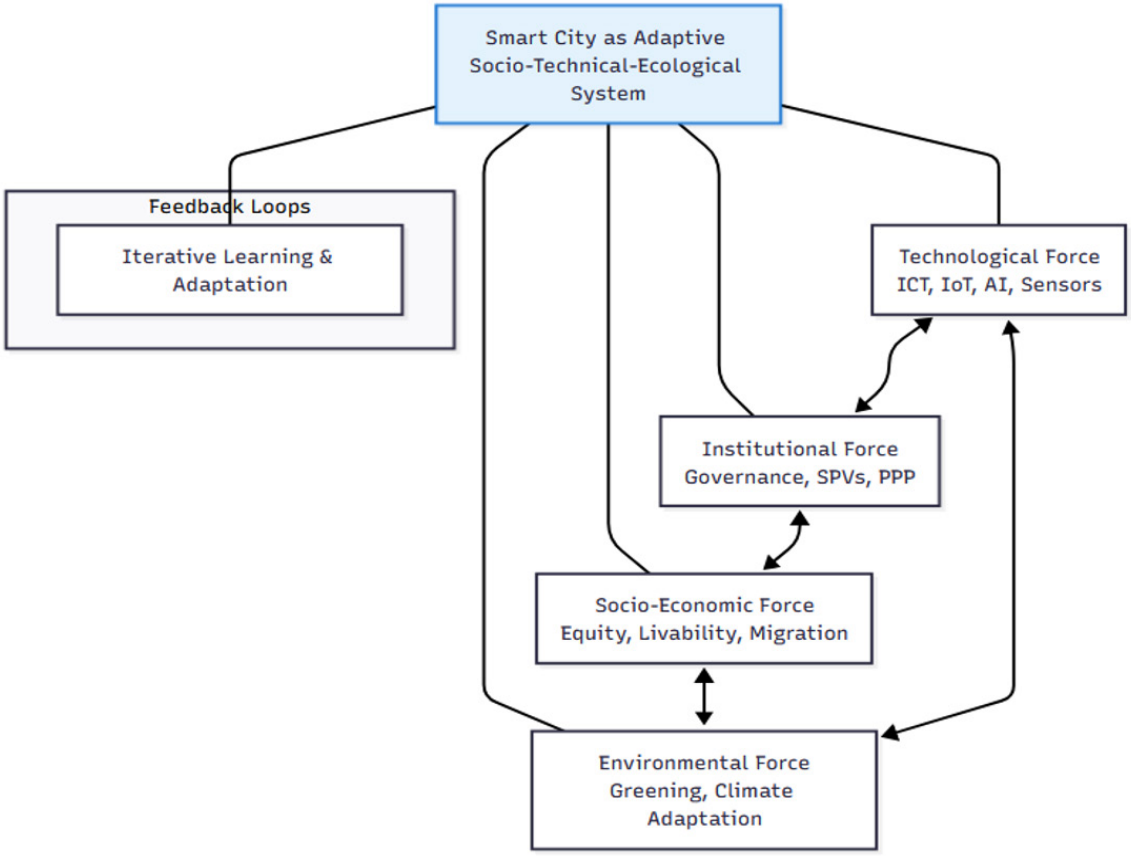

Figure 1: Conceptual Diagram of the Adaptive Socio-Technical-Ecological Framework for Smart Cities. Source: Developed by the author based on extension of Angelidou (2015).

This framework incorporates three key extensions:

- **Feedback and Iteration**: Outcomes from one force influence others (e.g., technological deployment affecting socio-economic inclusion, which in turn shapes institutional responses).
- **Contextual Adaptation**: Emphasis on place-based responses suited to Global South realities, including informal settlements, resource constraints and multi-level governance challenges.
- **Equity and Sustainability Integration**: Explicit integration of urban politics, quality of life and climate adaptation as cross-cutting concerns rather than secondary dimensions.
- The framework supports rigorous assessment of policy effectiveness by evaluating how well initiatives reflect and respond to past and present urban conditions.

Scope and Contribution

This theoretical development directly supports the aims of Cities by providing an interdisciplinary platform for analysing urban planning and policy. It addresses core topics including smart cities and regions, urban governance, public-private sector cooperation, infrastructure, livability, greening, climate adaptation and the complexities of creating sustainable cities. By focusing on implementation realities in the Global South, the paper contributes to the promotion of appropriate urban policies that move beyond techno-centric approaches toward more inclusive and adaptive governance models.

MATERIALS AND METHODS

This study adopts a qualitative comparative case study approach to examine the implementation of

smart city initiatives through the lens of the proposed adaptive socio-technical-ecological systems framework. Comparative case analysis is particularly suited to investigating complex urban policy phenomena where context plays a central role, allowing for the identification of patterns, variations and causal mechanisms across diverse settings while maintaining analytical depth (Yin, 2018). The methodology aligns with Cities' emphasis on rigorous, interdisciplinary assessment of planning policy effectiveness in both developed and developing worlds.

Case Selection

Four smart city projects were selected for in-depth analysis using purposive sampling based on three criteria: (1) representation of Global South contexts with rapid urbanisation pressures; (2) variation in scale, governance models and implementation maturity; and (3) availability of sufficient policy documents, official reports and secondary evaluations post-2015. The selected cases are:

- **Pune Smart City**: (India) – A large metropolitan initiative under India's national Smart Cities Mission (SCM), noted for relatively advanced Integrated Command and Control Centre (ICCC) deployment and area-based development projects.
- **Faridabad Smart City**: (India) – A rapidly growing satellite city near Delhi, offering insights into area-based development challenges and social sustainability gaps (Freestone, 2025).
- **Bhubaneswar Smart City**: (India) – An early-adopter city with emphasis on pan-city solutions and heritage-sensitive regeneration, allowing examination of cultural and livability dimensions.
- **Medellín, Colombia**: (as a contrasting Latin American case) – Recognised for innovative social urbanism approaches integrated with digital elements, providing comparative perspective on public-private cooperation and equity-focused governance in a different regional context.
- These cases enable examination of interactions among the four forces in diverse institutional and socio-economic settings while focusing primarily on Global South realities, consistent with the journal's aim to promote appropriate urban policies in developing worlds. India dominates the selection because its Smart Cities Mission represents one of the world's largest national-scale experiments, with documented implementation data up to 2023–2025 (Praharaj, 2025; Government of India reports.

Table 1: Overview of Selected Case Studies

Case City	Country	Population (approx.)	Key Smart City Focus Areas	Implementation Status (as of 2023–2025)	Primary Data Sources
Pune	India	7.5 million	ICCC, mobility, utilities, ABD	High progress in tech infrastructure; moderate in social integration	SCM portal, city SPV reports, Praharaj (2025)
Faridabad	India	1.8 million	Area-based redevelopment, greening	Significant gaps in social sustainability and community engagement	Freestone (2025), local evaluations
Bhubaneswar	India	1.2 million	Heritage regeneration, pan-city solutions	Mixed outcomes in livability and governance	Official SCM documents, secondary analyses
Medellín	Colombia	2.5 million	Social innovation, digital inclusion	Strong equity emphasis; variable tech integration	Academic case studies, city reports

Source: Compiled by the author from Smart Cities Mission reports (Government of India, various years), Freestone (2025), Praharaj (2025) and city-level evaluations. Population figures are approximate based on recent estimates

Data Collection and Sources

Data were drawn exclusively from authentic, publicly available sources to ensure transparency and replicability:

- **Primary policy and implementation documents**: Smart City Proposals (SCPs), Special Purpose Vehicle (SPV) annual reports, Integrated Command and Control Centre evaluations and Ministry of Housing and Urban Affairs (MoHUA) progress dashboards (2015–2025).
- **Official evaluations:** Parliamentary standing committee reports (e.g., Lok Sabha, 2024), Comptroller and Auditor General (CAG) performance audits (e.g., Karnataka report, 2025) and state-level reviews.
- **Secondary academic and grey literature**: Peer-reviewed articles on post-2015 implementation (Angelidou, 2015; Praharaj, 2025; Freestone, 2025; Odendaal, 2019), focusing on gaps in fund utilisation, project completion rates and equity outcomes.
- **Quantitative indicators**: Project completion percentages, fund utilisation rates (often below 50% in early phases despite ambitious targets) and sector-wise investment breakdowns (core infrastructure vs. technology-heavy projects).
- No primary fieldwork (e.g., interviews) was conducted for this study; reliance on secondary sources maintains objectivity while allowing critical synthesis of verified implementation realities.
- All data used in this study are secondary and derived from publicly available official sources. No new primary data were generated. Details of data sources, including specific reports and dashboards, are provided to ensure

reproducibility. Code or scripts used for qualitative thematic analysis can be made available upon reasonable request.

Analytical Approach

Data analysis followed a two-stage process grounded in the adaptive socio-technical-ecological framework developed in Section 2:

- **Within-case analysis**: Each case was examined through the four forces (technological, institutional, socio-economic, environmental), identifying interactions, feedback loops and adaptation (or lack thereof). Policy effectiveness was assessed as effective (measurable improvements in livability/infrastructure), ineffective (gaps between ambition and outcomes) or non-existent (unaddressed challenges such as digital divides or community exclusion).
- **Cross-case comparison**: Patterns and variations were identified using thematic coding and matrix displays to highlight context-specific barriers and enabling conditions for adaptive governance.

This approach ensures rigorous evaluation of urban development as a reflection of planning policies, directly supporting Cities' core aims. Limitations include potential bias in official reporting and the challenge of accessing granular, real-time outcome data in some Global South contexts. These are mitigated through triangulation across multiple independent sources and explicit acknowledgement of data constraints.

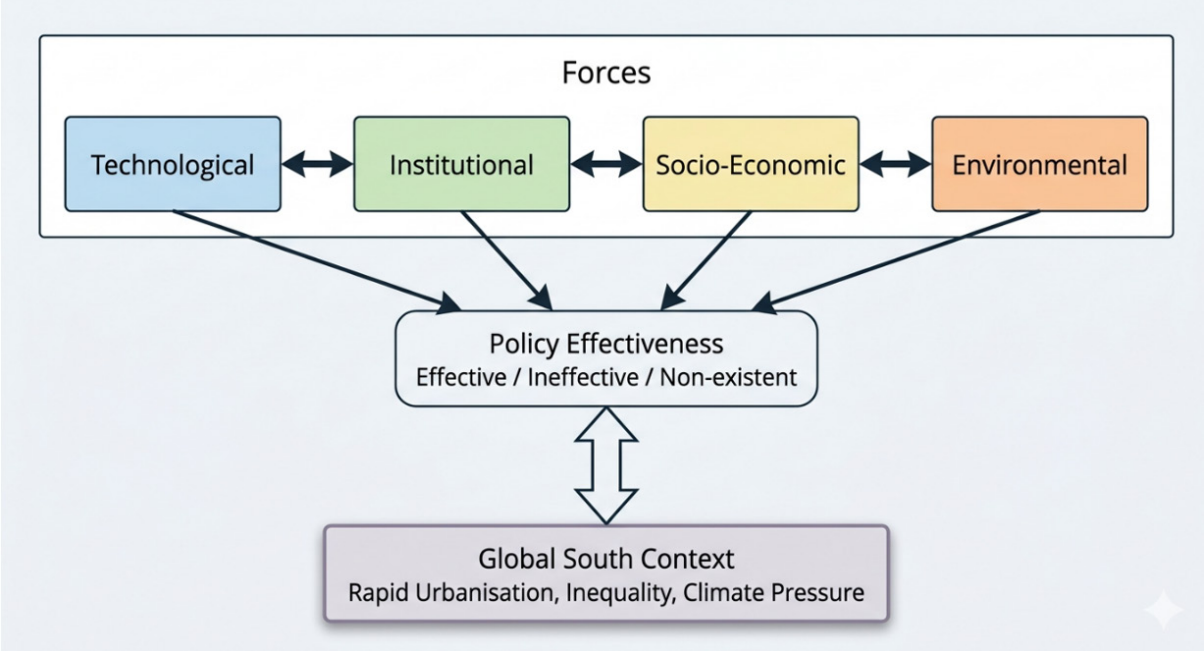

Figure 2: Analytical Framework for Assessing the Four Forces. Source: Developed by the author based on extension of Angelidou (2015).

All figures and tables will be submitted as separate editable files per Cities Guide for Authors guidelines, with high-resolution graphics (minimum 300 dpi for images) and editable text for tables.

Empirical Analysis: The Four Forces in Practice

This section examines the interactions among the four forces identified by Angelidou (2015) — technological, institutional, socio-economic and environmental — across the selected Global South smart city cases. Analysis draws on verified official reports, parliamentary evaluations and peer-reviewed assessments (Government of India, 2024; Freestone, 2025; Praharaj, 2025; Lok Sabha Standing Committee, 2024). Findings reveal persistent implementation gaps, with technological advancements often advancing ahead of institutional capacity and socio-economic integration, resulting in uneven policy effectiveness.

Technological Force

Smart city initiatives in the selected cases have prioritized the deployment of digital infrastructure, particularly Integrated Command and Control Centers (ICCCs). By late 2024, all 100 cities under India's Smart Cities Mission had operational ICCCs, integrating CCTV, sensors and data analytics for urban management (Ministry of Housing and Urban Affairs, 2024). In Pune, the ICCC (operational since 2020) monitors traffic, utilities and emergency response across multiple stakeholders, demonstrating technological maturity in mobility and service delivery.

However, adoption has been uneven. Environmental monitoring remains limited: only 36% of ICCCs track air and noise quality, 13% monitor water quality and just 5–6% address green infrastructure or climate adaptation (NIUA, 2025). In Faridabad, technological projects faced significant delays, with 60% of 112 projects experiencing

timelines extending up to 1,506 days due to site clearance and design issues (CAG Haryana Report, 2026). Digital divides persist, with limited penetration in informal settlements and lower-income areas, constraining the force's contribution to broader livability.

Table 2: Technological Force Indicators in Selected Cases (Approximate as of 2024–2025)

Case City	ICCC Status	Key Tech Deployments	Implementation Challenges	Effectiveness Assessment
Pune	Fully operational	CCTV, SCADA for water, traffic sensors	Moderate integration with social services	Moderately effective (strong infrastructure, weak equity)
Faridabad	Operational	Area-based sensors, smart poles	60% project delays, site issues	Ineffective (delays dominate)
Bhubaneswar	Operational	Heritage-linked digital solutions	Limited scale in pan-city coverage	Mixed (heritage-sensitive but partial)
Medellín	Advanced platforms	SIATA (early warning), SIMM mobility	Low uptake in some digital inclusion apps	Moderately effective (social innovation focus)

Source: Compiled by the author from MoHUA (2024), CAG (2026), NIUA (2025) and Amar-Flórez (2016) for Medellín

Institutional Force

Institutional arrangements, primarily Special Purpose Vehicles (SPVs), have facilitated public-private cooperation but revealed fragmentation. In Indian cases, SPVs coordinated projects, yet convergence with existing municipal bodies remained weak, leading to coordination failures (Lok Sabha, 2024). Fund utilisation lagged in early phases, with many cities reporting delays in state/ULB contributions.

Faridabad's experience highlights governance challenges: lack of encumbrance-free land and inter-agency coordination caused widespread delays (Freestone, 2025; CAG, 2026). In contrast, Medellín demonstrated stronger institutional embedding through integration of smart initiatives with long-standing social urbanism policies, enabling better multi-stakeholder collaboration (Amar-Flórez, 2016; Smith *et al.*, 2023). Overall, the institutional force has been ineffective in translating national ambitions into locally adaptive governance, particularly where multi-level coordination is required.

Socio-Economic Force

Socio-economic outcomes show the largest gaps. While projects improved basic infrastructure, benefits have been unevenly distributed. Area-based development in Faridabad prioritised physical upgrades but achieved limited community engagement and social sustainability, exacerbating risks of gentrification and exclusion of informal residents (Freestone, 2025). Quality-of-life improvements (e.g., smart e-toilets, open gyms) remain localised and insufficient to address broader issues of housing affordability, migration or welfare services.

In Bhubaneswar, heritage regeneration efforts enhanced livability in targeted zones, yet pan-city equity lagged. Medellín offers a partial counter-example, where social urbanism principles (parques-bibliotecas, digital inclusion programmes) integrated socio-economic goals more explicitly, reaching low-income neighbourhoods and reducing historical exclusion (though digital uptake remains low in some communities; Smith *et al.*, 2023). Across cases, the socio-economic force reflects ineffective

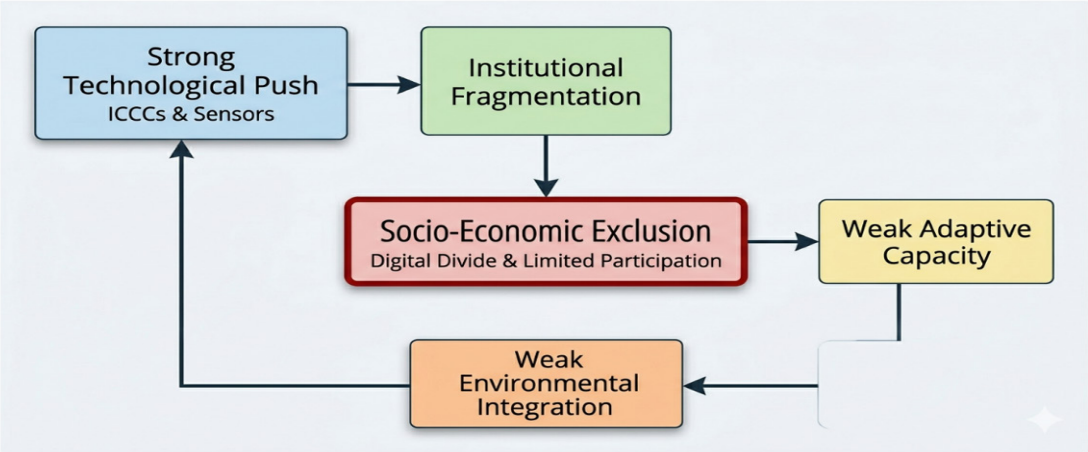

Figure 3: Interactions Among Forces – Socio-Economic Exclusion Loop. Source: Developed by the author based on case analysis and extension of Angelidou (2015).

policy translation, with techno-centric approaches often sidelining equity and inclusion.

Environmental Force

Environmental integration has been weakest. Greening and climate adaptation receive minimal attention within ICCCs (only 5–6% coverage). Investments in solid waste and stormwater remain lower than in core infrastructure (Praharaj, 2025). Pune and Bhubaneswar show some progress in mobility and heritage-sensitive greening, but Faridabad's delays limited environmental gains. Medellín's SIATA system provides early warning for environmental risks, yet broader climate resilience remains constrained by topography and inequality.

Cross-force interactions reveal that technological determinism frequently marginalises environmental and socio-economic objectives, producing non-existent or ineffective responses to sustainability complexities.

RESULT AND DISCUSSION

Discussion: Towards an Adaptive Framework for Smart City Governance

The empirical analysis presented in Section 4 reveals that, more than a decade after Angelidou's (2015) identification of smart cities as a conjuncture of four forces (technological, institutional, socio-economic and environmental), implementation in Global South contexts has been characterised by significant imbalances and limited adaptive capacity. While technological deployment — particularly Integrated Command and Control Centres — has advanced in cities such as Pune and Medellín, the institutional force has frequently struggled with coordination failures, fund mobilisation shortfalls and weak convergence with existing municipal structures (CAG Haryana, 2026; Lok Sabha Standing Committee, 2024). Socio-economic outcomes remain uneven, with area-based development often producing localised improvements at the expense of broader equity and inclusion, as documented in Faridabad (Freestone, 2025). Environmental integration has been particularly weak, with limited monitoring of greening, climate adaptation and resource efficiency within dominant technological platforms (NIUA, 2025).

These findings confirm that treating the four forces as a relatively static conjuncture is insufficient for understanding contemporary urban policy realities. Interactions among the forces frequently generate negative feedback loops: strong technological and institutional pushes can exacerbate socio-economic exclusion (e.g., digital divides in informal settlements and limited community participation), which in turn weakens long-term environmental outcomes and overall policy effectiveness. In many Indian Smart Cities Mission cases, delays in land availability, inter-departmental coordination gaps and prioritisation of visible infrastructure over social sustainability have resulted in ineffective or, in some instances, non-existent responses to the complexities of sustainable urban development (CAG reports, 2025–2026; Praharaj, 2025).

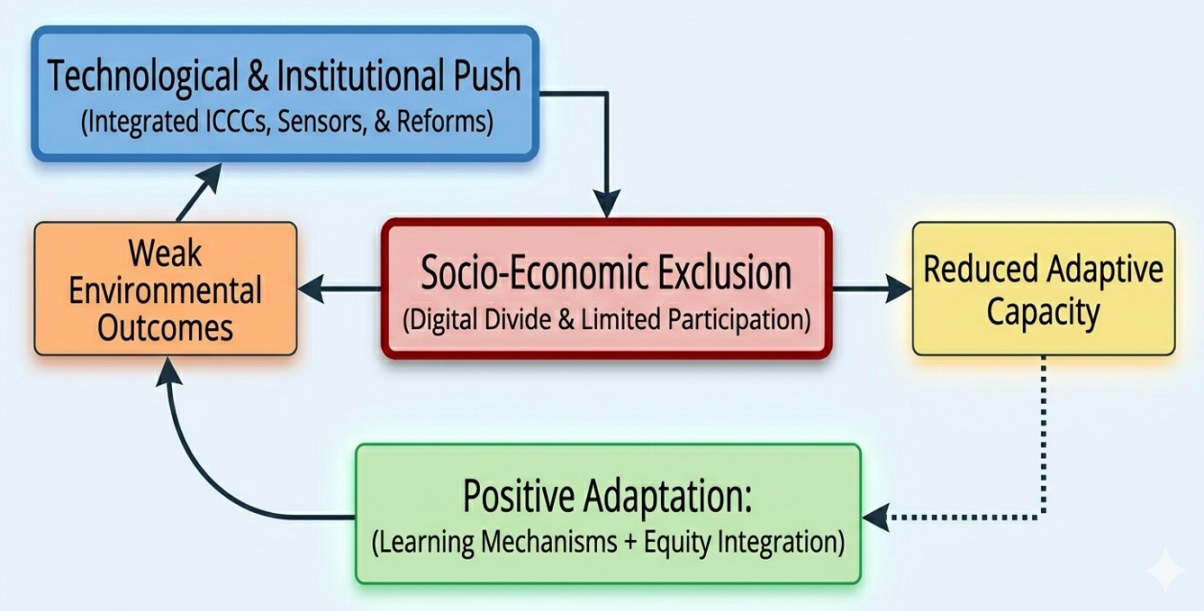

Figure 4: Negative Feedback Loops in Smart City Implementation. Source: Developed by the author based on case analysis extending Angelidou (2015).

Medellín provides a partial contrast, where integration of smart initiatives with established social urbanism principles (e.g., SIATA early warning system combined with community engagement and public space investments) has enabled somewhat stronger socio-economic and environmental linkages (Flórez, 2016; Smith *et al.*, 2023). Yet even here, digital inclusion and equity outcomes remain partial, underscoring the limits of transplanting Northern techno-centric models without deep contextual adaptation.

Reframing as Adaptive Socio-Technical-Ecological Systems

Building directly on Angelidou (2015), this paper proposes reframing smart cities as adaptive socio-technical-ecological systems. This extension introduces three critical elements absent or underdeveloped in the original conjuncture model:

- **Dynamic Feedback Loops**: Outcomes from one force continuously influence others, requiring iterative policy learning rather than linear implementation.
- **Contextual Adaptation Mechanisms**: Governance structures must incorporate place-based responses to Global South realities, including informal urbanism, multi-level coordination challenges and resource constraints.
- **Equity and Power Integration:** Explicit attention to urban politics, public participation and the distribution of benefits to prevent techno-utopian biases from reinforcing existing inequalities.

This adaptive framework aligns closely with Cities' core aims by treating urban development as a reflection of planning policies - effective when feedback enables learning and inclusion; ineffective when forces remain siloed; and non-existent when critical dimensions (e.g., climate adaptation or livability for marginalised groups) are overlooked.

Table 3: Policy Effectiveness Matrix – Four Forces vs. Adaptive Criteria

Force	Typical Implementation Pattern (Global South)	Adaptive Requirement	Policy Implication for Inclusive Governance
Technological	High investment in ICCC/ sensor infrastructure	Integrate with social & environmental data	Avoid digital determinism; prioritise equity in access
Institutional	SPV-led with weak municipal convergence	Strengthen multi-level coordination & learning	Embed community & ULB representation in decision-making
Socio-Economic	Localised benefits; gentrification risks	Prioritise inclusion & participation	Link smart projects to housing, migration & welfare policies
Environmental	Limited greening/climate integration	Mainstream adaptation metrics	Mandate cross-force environmental indicators in project design

Policy Effectiveness Matrix – Four Forces vs. Adaptive Criteria. Source: Developed by the author from case evidence (Angelidou, 2015; Freestone, 2025; CAG reports, 2025–2026).

Pathways to Inclusive Urban Governance

To operationalise the adaptive framework, several practical pathways emerge:

- **Hybrid Governance Models**: Strengthen public-private cooperation while ensuring robust representation of urban local bodies and community stakeholders in Special Purpose Vehicles.
- **Iterative Policy Learning:** Establish monitoring systems that track not only project completion but also equity, livability and sustainability indicators, feeding results back into adaptive adjustments.
- **Context-Sensitive Design:** Move beyond area-based technology projects toward integrated strategies that address neighbourhood conservation, urban regeneration and climate adaptation in informal settlements.
- **International Comparative Learning:** Global South cities can draw selective lessons from Medellín's social urbanism while avoiding wholesale adoption of Northern smart city templates.

These pathways support the promotion of appropriate urban policies in both developed and developing worlds, as emphasised by the journal.

Conclusion and Policy Implications

More than a decade after Angelidou (2015) conceptualized smart cities as a conjuncture of four forces, implementation in the Global South continues to show significant imbalances. This comparative study of projects in India and Colombia demonstrates that technological advancements often outpace institutional capacity, resulting in socio-economic exclusion and weak environmental integration. The proposed adaptive socio-technical-ecological systems framework addresses these gaps by incorporating dynamic feedback loops, contextual adaptation and equity integration.

The findings highlight the need for hybrid governance models and iterative policy learning to achieve more inclusive and sustainable smart city outcomes. Moving beyond static models toward genuinely adaptive urban governance is essential for responding to the interconnected challenges of rapid urbanisation, inequality and climate vulnerability in the 21st century.

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