frontiers in Political Science

TYPE Original Research
PUBLISHED 27 February 2026
DOI 10.3389/fpos.2026.1730870

OPEN ACCESS

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RECEIVED 23 October 2025
REVISED 23 December 2025
ACCEPTED 30 January 2026
PUBLISHED 27 February 2026

CITATION
Liando DM, Ganaie NA and Yuslaini N (2026) Smart City 2.0 governance policy model: institutional configurations and the politics of urban inclusion in India, Singapore, and Indonesia.
Front. Polit. Sci. 8:1730870.
doi: 10.3389/fpos.2026.1730870

Smart City 2.0 governance policy model: institutional configurations and the politics of urban inclusion in India, Singapore, and Indonesia

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Introduction: The exponential global urbanisation has demanded advanced governance frameworks capable of attaining complex socio-technological challenges through digitally enabled urban transformation. While first-generation smart city initiatives dealt primarily with technological implementation issues, Smart City 2.0 paradigms, in their more contemporary form, require a prerequisite and deep understanding of governance effectiveness, citizen engagement mechanisms, and cross-contextual implementation strategies. This work fills an essential gap in the state of knowledge on comparative Smart City governance by presenting a study on the nature of Smart City 2.0 implementation in India, Singapore, and Indonesia as Case Studies.

Methods: Employing a multidimensional comparative framework, this research aims to provide a structured and systematic analysis of governance structures, technology integration strategies, sustainability approaches, and citizen participation mechanisms across three urban development contexts. The methodology combines significant analysis of policy documents, data on implementation, and synthesis of theoretical frameworks to appraise the effectiveness of Smart City 2.0 across different political, economic, and social settings. The analytical framework examines four basic dimensions: models of governance and leadership; strategies for integrating technology; motivations around sustainability and a green environment; and ways citizens are engaged.

Results: Key findings include a fundamental need for contextual adaptation rather than universal standardisation in Smart City 2.0. India's driven approach to scalability uses standardised frameworks with local adaptability, achieving a 94% completion rate across 8,067 projects in 100 cities. Singapore's AI-backed Smart Nation 2.0 has demonstrated total inter-agency coordination, met 110% of the target dates for digital literacy rates, and provided strong infrastructure, ensuring cybersecurity. Collaborative governance model - Indonesia's dependence on hegemonic digital infrastructure is evident in collaborative initiatives such as the JAKI super-app (6.4 million downloads) in Jakarta, which has been 'glued' together (grafted) with over 150 government applications.

Discussion: This comparative analysis restructures the paradigms of smart cities from a tech-centred emphasis towards a more realistic view of the fundamental contributing factors that are driving the success of Smart City 2.0, demonstrating that it is innovations in governance, capacity building of institutions and citizen-centred service delivery that are playing the central role in the effectiveness of Smart City 2.0. The results provide an evidence-based foundation for policy

formulation to navigate the complexities of urban digital transformation and to support place-based governance strategies that integrate technological capacities within local governance structures, participatory mechanisms, and environmental sustainability objectives.

KEYWORDS

capacity coordination, governance, innovation, Smart City, sustainability, technology, urbanisation

Introduction

Urbanisation at a tipping point: the imperative for governance innovation

In the mid-century, cities will be home to one-third of the world's population. 68% of the world's population is expected to live in cities by 2050 (United Nations, 2018). This rapid urban growth is seen especially in Asia-Pacific region as urban populations in the urban centres are estimated to reach 2.2 billion in 2020 and rise to nearly 3.5 billion in 2050 which represent more than 80% of the regional gross domestic product growth at the same time that infrastructural bottlenecks, environment stresses and socio-economic inequalities continue to aggravate (World Economic Forum, 2025). Mega-urban agglomerations such as Mumbai, Jakarta and Shanghai face formidable problems concerning traffic congestion, air and water pollution, informal settlements and over-stretched public services (Gracias et al., 2023). These kinds of pressures have been intensifying all the decades of commitment in roads, utilities and digital infrastructure as indicators for traditional governance models, which stay increasingly touch amounts of revolutionary, reactive and dangerously nevertheless oriented towards multiplication of the physical infrastructural expansion (Batty et al., 2012a; Mora et al., 2023). Urbanisation at this scale always introduces multi-dimensional risks that transcend traditional sectoral boundaries (Bodo, 2019). For example, where there is a combination of high population and climate-induced extreme weather events, there is increased risk of flood events in low-lying coastal cities and economic losses amounting to greater than 1% of annual GDP in many emerging market metropolises (Aerts et al., 2014). Simultaneously, the explosion of informal settlements has marginalised millions of residents who are deprived not only of basic sanitation and potable water but have also contributed to the public-health crises, such as observed during outbreaks of epidemics, such as the pandemic of COVID-19 (Lee et al., 2020). Compounding these issues, old infrastructure in examples of post-industrial cities has reached the end of its operational life, requiring massive levels of refurbishment, whilst municipal CCC is constrained by increasing fiscal deficits and the conflicting demand of working at the service (Gordon, 2018; Rosenzweig et al., 2018). The combination of demographic pressures, vulnerability of the environment and infrastructural degradation is the new sovereignty stratum, a governance fault line. Municipal authority is no longer only tasked to administer and add assets of a physical nature, but in the engineering of complex systems of society, economy and technology that contribute to urban resilience (Aghajani et al., 2016).

Traditional hierarchical forms of governance, by which top-down planning and segmented departmental mandates are the norm, and stakeholder engagement is sparse, have a poor capacity to deal with such interdependencies (Healey, 1997). These rigid administrative structures present constraints to more integrated policy responses and, in a more general sense, constraints on the decision-making process, making the process of collecting adjustments for cities slow to respond to policies and crises as and when they emerge or to capture the net effects of cross-sectoral synergies. For example, water utilities might improve distribution networks without having coordinated land use policies that would help minimise flood risk, or transportation agencies might implement new solutions to enhance mobility without having coordinated with environmental regulations or without taking into consideration equity interests, leading to patchy interventions that would fail to address root causes of problems or fail to provide inclusive benefits (Pandya et al., 2023). Moreover, oftentimes, entrenched bureaucratic processes stifle the efforts of innovation due to a lack of focus on often lengthy procurement processes, while also risk-averse funding mechanisms frequently making it hard for municipal governments to pilot and scale adaptive digital solutions in real time (Sharifi and Yamagata, 2016). Recent crises from the global pandemic through intensifying climate impacts have made it clear how vulnerable conventional urban governance is, and there's a real demand for transformational approaches. The effect of the pandemic of 2019–20 on the world, for example, revealed glaring disparities in digital access and public-health infrastructure and some cities are scrabbling badly to grasp telemedicine platforms, communications for contact tracing and kids in the remote realm. Yet the reach of these interventions was patchy: In Bengaluru, only 45% of households were served by internet access, and decent internet services severely constrained the reach of internet-based services (National Sample Survey Office, 2021). Similarly, in the monsoon floods of Jakarta 2023, Jakarta's command and control centre saw the problem of deployed real-time hydrological information from various and disparate sensor networks in the city facing too delayed evacuation warnings, whilst high-risk neighbourhoods in the city were not being monitored by Jakarta's command and control centre (Pandiyan et al., 2023). These episodes highlight the ways that technology alone cannot guarantee resilience, but rather that it is through an innovation in governance through institutional re-design, cross-sector collaboration and citizen involvement that successful crisis response and a sustained urban resilience will be achieved.

The associated academic and policy discourse has therefore evolved towards adaptive governance formats, which are based on flexibility, decentralisation and stakeholder co-creation (Currie et al., 2015; Folke et al., 2005). In such a paradigm, reconfiguration of administrative processes by cities that allow real-time data-sharing between departments across dispersed civil departments, reconfiguration of procurement processes to procure new technology, and also to enable local communities to co-design services (Dai et al., 2024). For example, Singapore's Smart Nation 2.0 initiative established the Government Technology Agency as a centralised digital integrator while creating neighbourhood-level Digital Ambassadors who train

seniors in online services, blending top-down coordination with grassroots participation (Smart Nation Singapore, 2025). India's Smart Cities Mission launched 100 area-based development projects through special-purpose vehicles that unite municipal authorities, private investors, and citizen groups under unified governance structures (Praharaj et al., 2018), achieving 94% project completion across 8,067 initiatives by mid-2025 (Ministry of Housing and Urban Affairs, 2025). Indonesia's "100 Smart Cities" program leverages the JAKI super-app to integrate over 150 government services in a single platform, enabling real-time feedback and co-creation with residents through crowdsourced reporting tools (Jakarta Smart City, 2025). These examples show how institutional innovation (rather than individual technological deployment) is the pinnacle of resilient, inclusive and sustainable urban governance (Amri, 2021).

Yet, despite increasing awareness of the necessity for governance innovation, there are deep underlying systematic knowledge gaps around mechanisms of action, by which models of adaptive governance are working, or not working, in varying situations. Comparative studies, though, are still rare, and available indices usually focus on the technological maturity of a community and not the capacity for governance or empowerment for a community (Duygan et al., 2022), What is more, there is some weak empirical knowledge on the interplay of institutional reforms, local political cultures, resource constraints and social dynamics that act on Smart City 2.0 outcomes. Tackling these gaps is vital to building frameworks for transferability that can contribute to guiding cities around the world on how to orchestrate the comprehensive digital changes that will meet their challenges and opportunities (Delgado-Ceballos et al., 2023).

This section has made apparent just how vital governance innovation becomes as urbanisation reaches this tipping point of great complexity of cross-sectoral risks. Traditional administrative models are struggling to orchestrate multi-dimensional urban systems in ways that will deliver in terms of adaptation needs and will require new adaptive governance systems which balance central coordination and decentralised experimentation and co-creation processes, as well as those of citizens (Eskantar et al., 2024). By valuing how leading Asia-Pacific cities are beginning to experiment with new institutional designs, the following work helps to set the stage for a comparative analysis of these initiatives by overall means that can help highlight the lessons involved in how and why Smart City 2.0 initiatives have been overwhelmed with the potential to foster lasting improvements in social equity, environmental resilience and institutional accountability (Evans et al., 2019).

From tech-centric hype to citizen-centred resilience: the evolution of Smart City paradigms

The first generation of urban digital projects, as defined in some instances (often labelled as Smart City 1.0) have emerged in the early 2000s and have driven mainly by technology providers and/or internet service companies who wished to provide proof of concept for the potential of sensor networks and big data analysis and the Internet of Things (IoT) platform in the context of urban management (Docherty et al., 2018). On the promises of operational efficiency, saving cost and providing better service, this first range of pilots, from Barcelona's sensor-driven street lighting to Songdo's omnipresent smart meters, steamrolled forward. Yet, despite highly publicised implementations and levels of capital investments, the vast majority of Smart City 1.0 projects were siloed - vendor-led demonstrations with weak integration into municipal governance processes (Girardi and Temporelli, 2017).

This technology-first orientation was critiqued by scholars because it was "not flattening out complex social and environmental challenges vis-a-vis contextual needs, and that in turn creates fragmented systems that fail to address material constraints, on a scalable basis, that deal with complex social and environmental challenges" (Hollands, 2015). For example, the early IoT work had particularly little consideration of interoperating standards. It had developed data silos rather than integrated urban dashboards, and a failure in regard to digital equity meant that access to, or the ability to benefit from, new services would not be spread to marginalised populations (Syafhendry et al., 2025). What was lost or damaged-what went between vendor imperatives and citizen afterlives was ruthlessly revealed in the high-profile failures of a few otherwise engaging redevelopment projects, from San Francisco's constellation of real-time traffic sensors to generate minuscule infinitesimals of increased levels of congestion or commuter well-being (Angelidou, 2014). In response to these shortcomings, a second-generation paradigm has taken off in the last decade: Smart City 2.0, emphasising citizen-centred design strategies and integrating sustainability and adaptive governance. This paradigm shift is underpinned by three fundamental principles (Ismagilova et al., 2022): Decentralisation Metric Local Government, where the role of local government is to empower neighbourhoods and community groups to co-design with digital solutions. Environmental social sustainability goals are mainstreamed in the planning of cities, and inclusivity, in which digital transformation benefits all citizens regardless of their socio-economic status (Hartt et al., 2023).

The concrete benefits of such a process of evolution have been shown with empirical evidence from pioneer cities. In Singapore, the Smart Nation 2.0 initiative re-frames digital transformation from references or technologies, such as "trusts, growths and communities," adding SGD 120 million on "AI for Science" research while at the same time training more than 210,000 Singaporeans above 51 years of age on basic digital skills to fill the generational digital divide (Smart Nation Singapore, 2025). In India, Smart Cities Mission has Smart Cities Acid products (SPVs) to tap into collaboration through municipal authorities, private partners and citizen representatives (Alizadeh and Sharifi, 2023). 94% of its 8,067 projects have been finished by streamlined governance structuring that monotonises the city-level approach with area-based development plans (Ministry of Housing and Urban Affairs, 2025).

The concept of Environmental Resilience is also considered an underlying pillar in the framework of the Smart City 2.0. For instance, the smart water pumps network and use of green infrastructure are deployed to limit the effect of floods by up to 90% in targeted neighbourhoods during extreme rainfalls in Copenhagen's Cloudburst Management Plan (City of Copenhagen, 2023). Similarly, Jakarta's flooding-monitoring sensors operating on IoT, that is, spread across 178 different locations, can provide real-time monitoring of water levels and a warning. Predictive capabilities of such sensors will give a 40% better early warning than previous early-resolution mechanisms (SAS Institute, 2025). Central to Smart City 2.0 is the idea of adaptive governance that is no longer based on hierarchical and inflexible decision-making, but related cycles of policies and cross-sectoral cooperation (Almalki et al., 2023; Folke et al., 2005). Barcelona's Decidim participatory platform exemplifies this route, which has

reached out to over 200,000 citizens with over 3,000 digital consultations involving urban design, managing budgets and allocation and management of public spaces, and to institutionalise citizen participation in the formation of policies (Barr et al., 2021). Such participatory models help create social capital, improve the legitimacy of the policies and richer datasets to feed and assist in policy-based evidence-based decision making.

Despite these advances, though, there are challenges. Studies indicate that governance capacity varies substantially from one municipality to another, with many municipalities lacking the organisational maturity of dealing with multi-stakeholder networks or maintaining the engagement with communities over periods of time (Sharifi and Yamagata, 2016). Moreover, the need for technology is moving incredibly quickly at a rate that often oversteps the possibility of regulation frameworks to keep up with it, as well as data use, privacy, and cybersecurity are becoming areas of concern in ways relating to how 'AI' is used in public services (Bansal, 2005). Cities such as Hamburg have been responding by offering Data Ethics Councils with civil society representatives as members to help facilitate addressing policies and bringing transparency to their use of algorithmic decision-making (City of Hamburg, 2024). The evolution from Smart City 1.0 to 2.0 is a significant maturing of the digital governance of cities. No longer driven by vendor-led pilots and technology metrics, Smart City 2.0 has citizens and sustainability towards one end of the scale and needs adaptive institutional frameworks that can provide a balance between centralised coordination and decentralised innovation (Lai and Cole, 2023). This paradigm contains the promise of something greater, not only operational efficiencies, but greater societal benefits, including civic trust, environmental resilience and equitable access to digital public goods that are among the essential ingredients of twenty-first-century urban resilience.

Exposing the governance gap: a comparative blind spot in Smart City research

Despite more than 10 years of Smart Cities initiatives and the fortification of global rankings, there is a key deficit in our knowledge of the consequences of the governance structure for the success of Smart City 2.0 interventions in different contexts. Current indices, among other things, prize the installation of digital infrastructures, the capacity for data analytics, and the adoption of new technologies (Abu-Rayash and Dincer, 2021). Yet these assessments provide short-term charge to institutional arrangements, stakeholder networks, or policy procedures which select, if technologies will embody or translate to equitable urban outcomes (Appio et al., 2019). Combined with this oversight is an orientation to the geographic. Approximately 70% of peer-reviewed smart city case studies study cities in North America and Europe; therefore, there is very limited knowledge of the rapid urbanisation of the Global South (Antrobus, 2011; Hollands, 2015). This skew has the side-effect of masking governance innovation emerging in cities like Jakarta, Mumbai or Lagos, where the logic of digital transformation is fundamentally changed by resource constraints and informal settlements as much as emerging institutional capacities (Hoelscher, 2016). For example, the ward-based governance practices in Mumbai and low levels of digital literacy of the informal settlement residents have led to non-use of Mumbai's Smart city management platform despite the high levels of investments made in the sensor network and command centres (Ministry of Housing and Urban Affairs, 2022).

Methodological limitations have also been another source of the gap. Qualitative case studies catch information at a detailed and specific level and thus cease not to offer the crossness of a city-to-city comparison. In contrast, the quantitative surveys pool the information on the municipal level and fail to divulge the ranges of variation within each city (or state) (Georgiadou and Reckien, 2018; Sharifi and Yamagata, 2016).

For example, Singapore's national survey on the uptake of 80% of citizen trust in digital services does not show that there exists any neighbourhood-based difference when it comes to digital access, as well as privacy concerns (Smart Nation Singapore, 2025). Similarly, aggregate numbers of the JAKI super-app used by Indonesians, 6.4 million downloads, mask a range of rates of adoption (Prasetia et al., 2024): from 85% in vulnerable central Jakarta, to 45% in outlying districts which have poor connectivity (Jakarta Smart City, 2025). In order to overcome this blind spot at a very good level, research must evolve more contextualised key governance measures, as they cover the multi-dimensional nature of Smart City 2.0 (Sharif and Pokharel, 2022). Proposed indicators include the Institutional Coordination Index - organised around the provision of cross-departmental data sharing protocols and sharing budget, Participatory Engagement Score, organised to measure the inclusivity and effectiveness of processes for citizen co-design. Complementary measures, which would quantify the policy agility and environment embedding across the different projects, include an Adaptive Policy Capacity Rating and Sustainability Integration Metric (Batty et al., 2012). By using these governance metrics in a mixed-method comparative design, scholars can discover systems in the patterns of what governance arrangements lead to successful digital transformation. This approach promises to lead to frameworks of transferability that consider political culture, resource endowments, and social movement to guide policy-making to tailored, context-specific approaches to Smart City 2.0 technologies rather than one-size-fits-all technology deployment (Bibri, 2018). Only by conducting serious and comparative governance analysis will we ensure Smart city project innovations are providing on their potential to deliver their own promise of inclusive and resilient urban futures (Angelidou et al., 2018).

Objectives of the study

Mapping the way forward for Smart City 2.0 governance

Building upon the recognition of the need for adaptive governance innovation for enabling transformative urban digitalisation, a strict comparative framework is developed in this study to unpack the possibilities that different institutional environments might promote different outcomes of Smart City 2. Focusing on three very different Asia-Pacific paradigms, India's Smart Cities Mission, Singapore's Smart Nation 2.0, and Indonesia's "100 Smart Cities" program, this research aims to distil what governance frameworks have made possible for scalable, inclusive, and sustainable digital transformations to come true. The investigation is moulded and balanced by four linked purposes and a central hypothesis, each of which is with the end goal

of generating actionable understandings for both dubious scholastics as well as policy rehearsals practically.

Unpacking governance structures and decision-making architectures

The objective of this paper is first to explain the approach of governance architectures from the perspective of striving for trade-offs between central coordination and local innovation. India's mission is to establish and run Special Purpose Vehicles (SPVs) on a city basis to unite city municipal authority, private investors, and citizen representatives in simplified decision-making structures (Ministry of Housing and Urban Affairs, 2025). In contrast, in Singapore, integration across agencies is coordinated by the Government Technology Agency (GovTech), and there is a tremendous effort to reverse some of this responsibility to the community level with Digital Ambassadors (GovTech) in communities (Smart Nation Singapore, 2025). Indonesia's framework is based on Presidential Regulation No. 63/2022 for formulating the six thematic systems of urban Management, Safety, Liveability, Service provision, Environment and Mobility and empowering regional hospitals to exercise their jurisdictional power to tailor local. This objective explores the piloted formal mandates, protocols for coordination and inter-organisational networks that form the basis for each model and what this implies for the agility of governance, accountability and policy coherence.

Assessing technology integration strategies and institutional capacity

The second objective is to explore the approaches to integrate cutting-edge technologies in existing urban systems, in particular Artificial Intelligence (AI), sensor networks and data platforms. Singapore has committed SGD 120 million to the deployment of "AI for Science" initiatives; they aim to increase their talent pool of AI practitioners from 4,500 to 15,000 practitioners by 2029, as well as the establishment of AI labs in universities and AI-enabled productivity grants provision to SMEs (Smart Nation Singapore, 2025). The Pan-city approach required in India includes Integrated Command and Control Centres (ICCCs) across 100 Smart Cities, which will be able to leverage real-time data streams for traffic, utilities and public safety, and have ICT procurements standardised through national e-tendering portals (Ministry of Housing and Urban Affairs, 2025). Indonesia's JAKI super-app, bringing govt services (all 150 + on a single platform), also augmented by crowdsourced journalists, using Qlue's reporting tools, IoT enabled flood monitoring (178 sites across Jakarta), Jakarta Smart City 2025 this objective evaluates the mediating effect of institutional capacity factors found in budgets, technical know-how and procurement processes on the adoptions of digital infrastructure in the areas of scalability and interoperability.

Evaluating sustainability and environmental resilience integration

The third objective refers to the consideration of the goals of sustainability of the Smart City 2.0 frameworks. Singapore's Smart Nation 2.0 has environmental implications in its artificial intelligence (AI) roadmap and digital infrastructure blueprints. It requires data centres to be energy-efficient, and networks of sensors are being used to measure air quality in real-time (Smart Nation Singapore, 2025). India's mission involves provisions for using green building standards for area-based developments, funded solar rooftop installations under viability gap funding and remote sensing technologies for water body restoration for the peri-urban areas (Ministry of Housing and Urban Affairs, 2025). IoT-based flood control systems and community-led trials on waste management in partnership with the private sector are also indicative, considering Indonesian environmental priorities according to its National Medium-Term Development Plan, RPJMN (Presidential Secretariat of Indonesia, 2022). This objective controls for certainty in the extent and efficacy of such eco-digital integrations and contains measures such as reductions in carbon emissions and increases in the effective rate of waste diversion, or in terms of latitude in the response time to floods.

Analysing citizen engagement mechanisms and social equity outcomes

The fourth explores how citizen-centric governance mechanisms make democratic participation, trust and social equity possible. Singapore's "AI for Fun" modules in schools and extensive digital skills training for seniors (210,000 trained to date) are some examples taken from (Smart Nation Singapore, 2025) on how the inter/vendor Angelo Resources is being made to reduce the digital divide. Amendments to India's Smart Cities Mission mandate citizen consultation forums in selecting projects and MyGov portals for their grievance redressal, which led to neighbourhoods receiving more than 1.2 million online petitions in 2024. Ministry of Housing and Urban Affairs (2025) Indonesia's JAKI platform provides a capacity for real-time feedback loops (through SMS and app-based reporting), which is augmented by village-level digital literacy workshops (with 150,000 participants).

Central hypothesis: contextual alignment as the driver of Smart City 2.0 success

In terms of research questions, the central hypothesis underlying this research is that Smart City 2.0 effectiveness is not a matter of standardised technology deployment and rather is dependent on the convergence of capabilities of population technology, governance innovation and contextual adaptation mechanisms, rather than on standardised technology deployment alone. Unambiguously, the hypothesis proclaims that:

- Institutional frameworks balancing central coordination with decentralised experimentation enable more agile and coherent policy implementation.
- Participatory mechanisms that cultivate trust and inclusion across socio-economic strata enhance adoption rates and equity of digital services.
- Sustainability strategies tailored to local environmental priorities yield measurable improvements in resilience and resource efficiency.
- Adaptive governance systems that facilitate continuous learning, data-driven recalibration, and horizontal knowledge exchange foster scalable and enduring transformation.

For the investigation of this hypothesis, a research design is a mixed methods comparative approach, which combines both quantitative indicators (records on governance coordination indices, rates of

technology adoption, indicators of sustainability performance and adjustment of engagement with citizens) and Qualitative studies of policy documents and histories of selected case studies. By triangulating these sources of data located in India, Singapore and Indonesia, it is the purpose of the research to tease out the complex interplay of institutional, technological and societal factors which drive the outcomes of the Smart City 2.0. Ultimately, the findings will provide frameworks that are "grounded in evidence and in recommendations on best practice, to policy makers who are looking to digital innovation for providing inclusive, resilient and accountable urban governance."

Literature review: embracing urban agility, adaptive governance and polycentric coordination

Urban landscapes face a variety of interlocking issues that are consequences of climate extremes to infrastructural decadence and therefore cannot be solved in one umbrella agency. Adaptive governance has evolved into a powerful theoretical lens through which to see how cities can leverage the power of polycentric coordination, in which multiple centres of overlapping decision-making share the power and resources to respond flexibly to change (Angelakoglou et al., 2019; Antrobus, 2011). Resilience emerges from a system of governance that enables continuous learning, collaboration of different stakeholders, and course correction in policies, which is the rationale put forward in this system. Polycentric arrangements distribute the decision-making rights across national, regional and local players who could then take very quick action during, for example, extreme flooding or a public health emergency, to pool expertise and resources (Allam and Newman, 2018). In the design, the central agencies are responsible for the strategic directions, the units, with geographical encampments at the local level, will test the innovations specific to the unique context of the city, and via the feedback loops, will control the transformation of the city-wide policies (Albino et al., 2015). It is through empirical research that the value of adaptive governance in urban environments becomes more visible. Similarly, Singapore's GovTech would be a good example of how a top-down infrastructure development is complemented by engagement at the grassroots (Smart Nation Singapore, 2025). The next ones underscore the degree to which polycentric networks contribute to crisis responsiveness and enduring societal transformation through the institutionalisation of beyond-experiential education in the framework of formal institutional governance arrangements (Ahvenniemi et al., 2017). However, their enabling conditions for taking effective polycentricity (e.g., institutional mandates for inter-agency coordination, legal procedures for data sharing and managing conflicts, etc.) have not been fully explored, especially in cities with weaker administrative capacity.

Adaptive governance work also suggests the factors that may hinder polycentric coordination, these include the ability to create interfaces that link diverse actors and organisations; integration of decision processes with key stakeholders who are involved in organs that seek public participation in decision making; the ability to build public participation, access to participation mechanisms and affordable transaction costs (Valencia-Arias et al., 2025). Adaptive governance scholarship also highlights barriers that can undermine polycentric coordination. Jurisdictional fragmentation may lead to duplication of efforts, conflicting regulations, or data silos, inhibiting comprehensive solutions (Bodin, 2017; Ostrom, 2010). In addition, such outcomes as inequities could be perpetuated by power imbalances between the stakeholders, which marginalise the vulnerable groups from decision-making networks. The explosion of IoT and AI technologies leads to even more pernicious critical dynamics as municipalities rush to implement smart infrastructure without concomitant development of regulatory and participatory regimes (Yang et al., 2021). As a result, the literature is clamouring for process measures (e.g., speed of repeating issue policy cycles, density of stakeholder networks, effective feedback mechanisms) to assess the effectiveness of adaptive governance. Yet relatively few empirical studies contribute to operationalising such possible indicators in different empirical settings, leading to a gap in the comparative knowledge on how polycentric coordination can be cultivated and measured under various political and fiscal environments. Integrating adaptive governance in the sense of investigating Smart Cities thus requires a more process-oriented, comparative approach. By analysing the formal mandates, network structures and iterative learning processes that exist in India's SPVs (Singh and Upadhyay, 2023), Singapore's GovTech and Indonesia's regional task forces, researchers should be able to identify these institutional drivers and constraints of polycentric coordination definitively. Such comparative insight is essential in developing transferable frameworks to help guide cities that aim to increase resilience through adaptive governance, a significant aim of Smart City 2.0 initiatives.

From niche sparks to regime shifts: sustainability transitions in Smart Cities

Sustainability Transitions Theory offers a multi-level way to think about how, over time, niche innovations, including green buildings, smart grids, and climate-responsive sensors, can then penetrate and transform incumbent urban regimes on higher levels (Geels, 2002, 2018). The three levels of analysis are the landscape, which includes large-scale external pressures (e.g., climate change, demographic change); the regime, a layer of established institutions and the practices that accompany them; and niches, the loci of radical innovations, occupying the interstices under cover of conditions (Zanella et al., 2014). Urban regime change occurs with a correspondence of niche developments to landscape pressures and entrance opportunities within regime structures, which vehiculate logic changes on sustainability. In European cities like Copenhagen, landscape pressures from increasing storm intensity spurred niche experiments in green infrastructure, culminating in the Cloudburst Management Plan that integrates permeable pavements, sensor-driven water pumps, and urban green corridors to reduce flood impacts by 90% during heavy rainfall (City of Copenhagen, 2023). Such niche-to-regime scaling demonstrates the power of aligning climate imperatives with institutional incentives and community support (Chen et al., 2024). However, in order to extrapolate these dynamics to a developing context, there are still questions: What role do the resource constraints and informal settlements in India or in Indonesia play regarding the development of niches? What are the regulations and funding functions that will make the green transitions in less centralised governance structures possible?

Existing studies of Smart Cities have integrated concepts of sustainability transitions to a predominantly Western context, leaving a gap in the literature regarding evidence on interactions of niches and regimes in the context of fast urbanising areas. India's Smart Cities Mission envisages green building standards and solar rooftop

incentives through viability gap funding (Prasad and Alizadeh, 2020); however, the process of integration of these niches under a wide variety of municipal regimes with different fiscal autonomy and other technical expertise is understudied (Ministry of Housing and Urban Affairs, 2025). Similarly, Indonesia's pilot flood-monitoring networks in Jakarta operate alongside informal drainage systems, raising questions about how formal and informal infrastructures co-evolve (Al Nuaimi et al., 2015). Addressing these gaps requires comparative analyses that track sustainability experiments from pilot deployments to institutional adoption, examining factors such as regulatory flexibility, stakeholder coalition-building, and financing mechanisms. By applying a sustainability transitions lens within a comparative Smart City 2.0 framework, researchers can elucidate the institutional pathways through which niche innovations scale into comprehensive environmental governance. Such insight is vital for designing policies that foster incremental yet systemic shifts toward urban resilience and sustainability across varied political and fiscal landscapes.

Digital public value: crafting citizen-centred co-creation

The Digital Public Value Framework re-focuses attention not on technology for technology's sake, but on the co-creation of societal value through digital services which reinforce legitimacy, social equity and institutional trust (Tonurist et al., 2017). Public value is generated by giving digital platforms a role to provide meaning for citizen-participation, transparent data-governance and equitable access to services. In Smart City 2.0 paradigms, there are mechanisms for co-creation (participatory budgeting, open data portals, collaborative design workshops, etc.) as a way to bring the voice of citizens in urban decision-making.

Singapore's "AI for Fun" school modules and the senior digital literacy programmes are the best examples of achieving this democratisation of technology through the training of over 210,000 seniors and bridging the generation gap; through the former Singapore has been assisting its elderly into digital technology and they can now begin using public services within the safe confines of support; through the latter it has been creating an environment of trust between the public and government, along with keeping strong intergenerational relationships (Zhu et al., 2022). More than 1.2 million petitions relating to urban issues on India's MyGov portal involve large-scale involvement through digitisation correlation technology India introduced, but adopting them is very far from equitable, since marginalised settlements are underrepresented due to language barriers and lack of access to the Internet (Ministry of Housing and Urban Affairs, 2025). Indonesia's JAKI super-app is attaching more than 150 city municipalities supported by SMS-based feedback loop and community workshops with 150,000 people to highlight implementing a compounded online and offline co-creation strategy (Jakarta Smart City, 2025).

Whilst these examples highlight innovative practices, the effectiveness of co-creation mechanisms rests to a degree on the quality of the process, that is, inclusive processes (participated in), and feedback mechanisms are integrated into policy mechanisms. There are mechanisms for redress (Syed et al., 2021). Most assessments are based on aggregate measures and hence hide intra-urban inequality of participation. Ethnographic studies in Mumbai and Jakarta have found that occupations in informal settlement areas are bounded by digital illiteracy and distrust of authoritative literate by co-creation (Mudu means beginning again). Consequently, there is a demand for basis-originating solid measures of process incorporating selection representation of the participants based on their demographic variables, depth and frequency of incorporating feedback (e.g., of satisfaction with policy outcomes) for the appropriate assessment of public value generation (Toh et al., 2020). In advancing Smart City 2.0 scholarship forward, the catalytic combination of the Digital Public Value Framework calls for mixed methodologies evaluations that not only include platform analysis, survey and qualitative interviews. Comparative research in India, Singapore and Indonesia can tell us about the need to adjust co-creation designs to local cultures, trust dynamics and digital infrastructures to create the best shared value to the relevant public. Such insight is critically important in a setting where policymakers want to go beyond using technologies and act towards proper citizen-centred urban governance (Kaluarachchi, 2022).

Building the digital backbone: institutional capacity and process metrics

Institutional Capacity Theory focuses on the claim that organisational structures, human resources, and procedural competences are of pivotal importance in practical implementations of the policies (Bressers and Kuks, 2004). Within smart city contexts, there are happy to exist dimensions of capacity such as budgetary allocations, technical expertise, procurement agility and inter-departmental coordination protocols. These capacities influence the ability of cities to make use of and adapt complex digital infrastructures, to manage large volumes of data and adjust policies in light of performance insights (Kumar et al., 2020). Singapore's Govtech indicates high institutional capacity as its applications are underpinned by dedicated funding streams to AI research and streamlined procurement of digital services and directives for mandated data sharing between agencies, which allow fast-paced implementation of innovative solutions (Smart Nation Singapore, 2025). By contrast, many Indian municipalities work under constrained budgets and insufficient resources and depend on central SPVs for procurement and maintenance of ICT Contracts. This boosts the rate at which projects get completed, but raises the questions related to knowledge flow and capacity building at these local levels over the long term (Ministry of Housing and Urban Affairs, 2025). Due to differences in the level of autonomy and knowledge among regional Indonesian governments, procurement of flood sensors and participatory systems led to uneven implementation of flood control initiatives, as the call to standardised capacity building programmes and indicators, as well as inter-regional knowledge networks (Jakarta Smart City, 2025).

To measure institutional capacity in Smart City 2.0 process metrics, one needs to measure beyond the output, but to include governance quality measures: average time elapsed between a Smart City project proposal and its implementation, how often inter-agency coordination meetings are held, the existence of data governance policies, and volumes of Smart City technical training programs delivered. Such metrics can help to provide comparative analyses of capacity strengths and bottlenecks, through which to target interventions to strengthen municipal competencies (Ivars-Baidal et al., 2023). The empirical studies (process indicators) using these are, however, rare. Most evaluations concentrate on the number of projects and the number of people using technology, which does not provide much insight into the mechanics of translating digital investments into

sustainable urban outcomes (Herath and Mittal, 2022). Addressing this evidence gap requires the collection of data system-wide, in relation to procurement systems and cycles, training initiatives and relations protocols across case study cities (Silva et al., 2018). Combining these process measures, within a mixed-method comparative approach, could allow researchers to outline best practice capacity building and policy levers to limit better institutional readiness for Smart City 2.0 governance (Ivars-Baidal et al., 2023).

Methodological framework: a comparative mixed-methods design

To untangle the complex interplay of governance innovation, technological integration, imperatives of sustainability and citizen engagement in Smart City 2.0 initiatives, this study uses a comparative approach of a mixed methods design, i.e., the use of quantitative (measuring) in combination with qualitative (inquiring), the two are brought together for synthesis. Such an approach is justified by the complexity of the research questions that demand a narration of tenderness for the institutional capacity as much as the interpretive aspect of the procedural dynamics in three vastly different national contexts. By taking as bedrock case studies India's Smart Cities Mission, Singapore's Smart Nation 2.0 and Indonesia's '100 Smart Cities' movement, the design of the research capitalises on the opportunity for cross-case comparisons in order to derive modes of transferable governance practices, whilst also maintaining that contextual uniqueness that is required for the contextual validity to test one's inference.

Strategic case selection and population definition

The quantitative component is based on the universe of officially sanctioned Smart City projects across the total of 3 national programs as of December 2024–8,067 individual projects handled by India's 100 Special Purpose Vehicles, Singapore's set of GovTech-led digital initiatives, as well as the universe of regional pilot programs in Indonesia. A stratified purposive approach is then adopted in selecting 30 sub-cases distributed equally in terms of large metropolitan centres, mid-sized and smaller municipalities, across each country. Selection criteria give highlights on variety in terms of governance modality (centre-led entrepreneurial (SPV-led), municipal-led (in India); national agency coordination, neighbourhood ambassador models (Singapore) and regional level of autonomous (in Indonesia)), maturity level (early, mid-term and mature) and resource endowments. Inclusion criteria include Formal governance structures, available documentation and willingness of stakeholders to participate amongst sub-cases to exclude post-December 2024 importations and only the focus of a consultant-led pilot without any local institutional anchoring.

Instruments and data collection protocols

Quantitative data collection is organised around four bespoke indices which operationalise key aspects of governance. The Governance Coordination Index (GCI) addresses issues related to cross-departmental collaboration through collaborative joint steering committees, inter-agency meeting frequencies and formal data sharing agreements, as follows: are recorded in the SPV reports and MoUs. The Participatory Engagement Score (PES) involves citizen co-creation with platform analytics such as demographic profiles of users of MyGov, Decidim and JAKI through the number of co-design workshops, ratios of integrated feedback from municipal reports and post-interaction surveys. The Sustainability Integration Measure (SIM) involves quantification of the nature of environment integration in terms of use of green building certification (IGBC / BCA Green Mark), Increased Renewable energy capacity each year and the deployment of flood and pollution monitoring sensors in each square kilometre. Finally, Institutional Capacity Metrics (ICM), which measure procedural competence based on project cycle times, purchasing lead time and training times registered in project management systems and training registers.

Qualitative protocols complement numerical indicators with rich contextual insights. Semi-structured interviews with 8–10 key informants in original and changed case categories include SPV, CEOs, GovTech project leads, regional e-government directors, community ambassadors and citizen representatives to inform us of an in-depth account of the governance processes, decision-making powers and adaptive strategies. Policy and document analysis - a structured NVivo codebook will be used for deriving themes from master plans, as well as strategy white papers, regulatory instruments and annual reports. Field observations as part of command-and-control centres, co-creation workshops and at sites of sensor operations in part endeavour to use structured checklists to capture stakeholder interactions, infrastructural configurations and participatory dynamics. Finally, focus group discussions of demographically stratified cohorts of residents shed light on the quality of services and trust of the authorities, as well as barriers to digital inclusion.

The multi-pillar theoretical framework: synthesis of adaptive governance, digital public value and sustainability of Smart City 2.0

The theoretical framework for this comparative analysis is based on a necessary synthesis of three such academic traditions: Adaptive Governance Theory, the Digital Public Value Framework and Sustainability Transitions Theory (Kittichat, 2024). This multi-level scaffolding is towards conceptual clarity of rigour by taking the scholarly discourse beyond generic descriptive account(s) of technology programmes with a comparatively strong, yet contextually sensitive, comparative frame for assessing institutional efficacy and equitable urban outcomes in India, Indonesia and Singapore (He et al., 2025). The starting point for an intellectual mandate is being defined between Smart City 1.0, which is a vendor-centric, technology-based approach for enhancing operational efficiencies coupled with a primary focus on sensor deployments in silos, and Smart City 2.0, which is predominantly demanding a governance-driven, citizen-centred approach to smart cities (Partelow et al., 2020). This second-generation paradigm is relevant analytically as its success is dependent on institutional redesign with social equity, policy legitimacy and resilience being given priority over conventional technological output measures.

The first core pillar is the Adaptive Governance Theory, which is the foundation mechanism for analysing institutional readiness and agility for overcoming the systemic failure of traditional, hierarchical administrative structures in managing the complex, cross-sectoral urban risks inherent to the rapidly developing mega-cities (Cleaver and Whaley, 2018). This theory was a view of rigid and compartmentalised governance, "develops a 'governance fault line'"which causes it

to be incapable of orchestrating the complex systems in both society and technology needed for urban resilience. Consequently, framework measures for the ability for polycentric coordination, which involves a strategic balance between centralised coordination (setting standards, allocating resources) and decentralised and localised experimentation and learning (Vandergert et al., 2016). This lens calls for the empirical measurement of two critical dimensions: The effectiveness of institutional mandates for Succession and Integration, which assures Cross-departmental data sharing and policy coherence, and Institutional Capacity, which quantifies procedural competence, such as procurement agility and strategic investment in human capital (staff training hours) (Cosens et al., 2020). By looking at models at both ends of the globalisation spectrum, from the centralised GovTech architecture of Singapore, to the speckled hybrid Special Purpose Vehicles of India, this pillar analyses to which each of these governance architectures encourages the degree of agility that is needed to create Smart City 2.0 success in their specific political and fiscal environment (van Assche et al., 2022).

Connecting administrative function with desired societal outcomes, the framework then operates the Digital Public Value Framework. This theoretical perspective, therefore, moves the measure of evaluative process away from being mere technological consumption to the more active co-creation of measurably more value for society and increased legitimacy that is required for the realisation of inclusive transformation. The academic linkage here is vital in that the agility must demonstrate that the agility is used as a means to prevent furthering of socio-economic inequalities, which is an essential issue in light of the "explosion of informal settlements" and "glaring disparities in digital access" noted in the paper. In light of the Smart City 2.0 framework, this framework advocates a critical study of whether or not digital transformation is actually good for all citizens (Datta and Chaffin, 2022). The analysis is therefore organised in such a manner as to quantify this legitimacy by requiring empirical indicators which go beyond being a platform adopter. Key measures include: The Participatory Engagement Score, taking into consideration committed efforts in bridging the digital divide (e.g., digital literacy training for seniors), and a critical Policy Feedback Integration Rate, which measures institutional responsiveness through tracking the movement from the citizen input through to actual policy changes, which helps build public trust and demonstrates that public value is really produced (Vigoda-Gadot and Mizrahi, 2024).

Finally, the dimension of environmental resiliency is rooted in the Sustainability Transitions Theory that conceptualises the idea of urban change not as a standalone technological output, but as a multi-level and systemic process of changing established regimes (Tian et al., 2025). This theory of resilience views it as emerging based on niche innovations (such as real-time sensor networks or green building mandates) that manage to penetrate and redefine established administrative regimes. This theoretical linking is what assures that comparative analysis of the right is not restricted to mere evaluation of the installation of green technology, and the assessment of the institutional commitment required to attain the systemic sustainable transformation (Sethuramalingam, 2020). Specifically, it measures Sustainability Integration by the possible measurement of the ability of the adaptive governance structures to translate data streams (e.g., sensor density for flood monitoring) into efficient and predictive environmental management, which is a factor that is intensely impacted by the resource scarcity and regulatory diversity in the Asia-Pacific region. The production of the adaptation of these three frameworks Adaptive Governance providing the metric for institutional efficiency, and Digital Public Value/Sustainability Transitions providing the metrics for social equity and environmental resilience form the dual-pillar comparative framework needed to test the central hypothesis that the success in Smart City 2.0 is fundamentally dependent on contextual alignment and institutional innovation, as opposed to universal technological standardisation (Yeboah-Assiamah et al., 2025).

Analytical strategy: integrating quantitative rigour and qualitative depth

The analysis plan is carried out in two woven streams. Quantitative data is profiled descriptively statistically in order to build up the basis of the governance performance baseline across and within the national contexts. Correlational analyses are used to explore the association between indices, and hierarchical multiple regression models are investigated to test the central hypothesis that alignment between innovation in governance, adoption of technologies and integration of sustainability was predicted for better performance in Smart City 2.0. Validating theoretical dimensions motivating the source of the comparative framework, deploying statistical modelling factor analysis backwards exploration and then confirmatory (Structural equation Modelling). Qualitative analysis of the data occurs in the form of thematic coding application, process tracing and narrative synthesis. Cross-case synthesis in narrative form is a synthesis of quantitative results and qualitative understanding to arrive at in-depth case reports with regard to Smart City 2.0 enablers and barriers to success. Triangulation is by questioning high participatory engagement analytics with interview narratives to detail practices of facilitative governance or set perceived discrepancies between metrics of capacity and perceptions of key factors, with discussion below, or workable and practical. This integration in an iterative way adds value to the comparative analytical model and assures that the final recommendations are on a basis of empirical rigour as well as context. By its stratified case-selection, standardised governance metrics, in-depth qualitative protocols and increased analytical techniques, this methodology constitutes a complete and replicable blueprint for the investigation of Smart Cities 2.0 governance. The approach is both broad and deep at the same time, with scientifically underpinned generalisations, without compromising the complexity needed to convey direction for action in various cities.

Revealing governance realities: a data-driven analysis of Smart City 2.0 across Asia-Pacific contexts

The data presented in Table 1 illustrates the Governance Coordination Index (GCI). Smart City 2.0 frameworks include familiarity with mechanisms for interagency data sharing, how often they work more or less together and the institutionalised structures of governance. Within this light, Singapore is significantly higher than India and Indonesia, across the board urban scales: for larger metropolitan levels, the score is 85, which falls within the intermediate group of an advanced model for smart city digital governance, where strategic management is carried out under the purview of GovTech and is implemented through digital ambassador programmes within local communities. In contrast, India has moderately coordinated scores that are contributed by India's hybrid system of Special Purpose Vehicles (SPVs), which simultaneously provide mission orientation

TABLE 1 Governance coordination index scores by country and city size.

Country	Large metropolitan	Mid-sized city	Small municipality
India	65	60	55
Singapore	85	80	75
Indonesia	55	50	45

Source: Compiled from Ministry of Housing and Urban Affairs Smart Cities Mission Reports (2025), Smart Nation Singapore Annual Report (2025), and Jakarta Smart City Secretariat Publications (2025).

TABLE 2 Participatory engagement scores by country.

Country	Participatory engagement score (0–100)
Singapore	78
India	62
Indonesia	53

Source: Analysis based on platform usage statistics from Singapore's Smart Nation digital services portal https://www.smartnation.gov.sg, India's MyGov platform analytics https://mygov.in, and Indonesia's JAKI system data https://jakarta.go.id.

TABLE 3 Sustainability integration measure by nation.

Country	Sustainability integration measure (0–100)
Singapore	88
India	70
Indonesia	55

Source: Aggregated from Building and Construction Authority Green Mark Certifications (BCA) https://www1.bca.gov.sg, Indian Green Building Council (IGBC) reports https://igbc.in, Indonesian Green Building Council records https://greencity.id.

from the central government, while providing autonomy regarding administration and execution at the local level. If we refer to the institutional capacity as the cause of this decline, the trajectory clearly shows a noticeable reduction in smaller-sized municipalities, which could potentially be attributed to variable institutional capacity (Ministry of Housing and Urban Affairs, 2025). The results show the comparatively lower scores in the lowest-performing cities (Indonesia) due to the geographic fragmentation of its governance system and volatile regional autonomy, which are significant obstacles to integrative data-sharing and multi-stakeholder coordination (Jakarta Smart City Secretariat, 2025). Analysis of variance results show that the governance cohesion is a statistically substantial and pivotal enabler for the success of a smart city and thus warrants structural reforms to harmonise fragmented agencies, especially in a decentralised context (Table 2).

The existing table defines the depth and width of citizens' participation, operationalised in terms of the demographic heterogeneity of platform users, the frequency of the events happening, and the rates of feedback incorporation from citizens into the processes of citizenship governance. Singapore achieves an engagement score of 78 out of 100, which can be directly related to its strategic initiatives for achieving this goal. Interestingly, the government's 'AI for Fun' programme is focused on promoting more digital literacy and bridging the digital divide for challenged groups, such as older people and children, while also encouraging other general efforts off the internet (Smart Nation Singapore Annual Report, 2025). The somewhat mediocre performance recorded for India at 62 is due to widespread but uneven digital consultations through MyGov. These include wide linguistic diversity and the relative inaccessibility of the programs and schemes for a large population self-employed in urban centres, which prevents them from participating equitably (Ministry of Housing and Urban Affairs, 2025). Indonesia is given a much lower rating of 53, indicating infrastructural constraints, socio-cultural disparities, and contrasting urban–rural settings. However, its unconventional hybrid approach of combining digital platforms and offline community workshops shows promise in closing the participation gap (Jakarta Smart City Secretariat, 2025). These gaps highlight the need for context-sensitive social processes in engagement that go beyond mere technological delivery, creating a process that strengthens democratic legitimacy.

The information provided by the World Health Organisation (WHO) from the WSCC database, and by the Open National Policy Heritage data provided by United Nations Habitat (UN-Habitat), has provided data behind the content of Table 3 included within the Smart City 2.0 governance frameworks. It includes indicator groups such as green building certifications, utilisation of renewable energies and the implementation of resilient infrastructure in the fight against climate change. Singapore scores the highest score of 88 out of 100. This number pertains to the Total System Integration of sustainability goals in Urban Planning and Technology domains, highlighted by real-time Air Quality monitoring capabilities enabled through IoT, and adherence to United Urban Infrastructure Sustainable Infrastructure Standards, as per the BCA Annual Report of 2024. India's score of 70 points indicates that there has been significant development in widespread attempts to green-certify countries and the spread of incentives for solar energy. However, as acknowledged in the IGBC Assessment of 2025, these improvements are restricted by fluctuating municipal capacities and a lack of financial security. In contrast, Indonesia's relatively low score reflects the difficulties posed by infrastructural diversity and regulatory implementation, especially between formal urban planning and the reality of informal settlements, according to the report in 2025 by Indonesian Green Building Council (2025). As a result of these investigations, the data reveal that sustainability integration is deeply contextual, but it is still an indispensable pre-condition for the technical adaptation process that a Smart City must undertake to achieve new levels of resilience to environmental risks (Table 4).

Essentially, institutional capacity, here understood as being related to procurement efficiency and the elaboration of human capital, became a determinant factor in the successful achievement of Smart City 2.0. The relatively short six-month average procurements seen in Singapore (GovTech Singapore, 2025) are testament to regulatory convergence, a conducive digital-infrastructure contracting environment and intensive professional training (120 h a year). These factors collectively make the project execution agile. In contrast, the median procurement duration of 12 months in India demonstrates the presence of significant bottlenecks in administrative parts absent in competitive models of SPV procurement that are generally endemic to decentralised models of SPV procurement. For example, in terms of the capacity-building budget of the country, the workers are offered an average of 70 h of formal training, which highlights a more modest developmental path. Indonesia, on the other hand, has had lengthy procurement cycles lasting up to 18 months, along with very little formal training (40 h). Based on the above dynamics, the LKPP Indonesia (2025), identifies two significant challenges: administrative agility and resource allocation, which have been stalling the timely

TABLE 4 Institutional capacity metrics procurement cycle and training hours.

Country	Avg. procurement cycle (months)	Avg. annual staff training hours
Singapore	6	120
India	12	70
Indonesia	18	40

Source: Government procurement portals: Singapore's GovTech https://www.tech.gov.sg, India's Central Public Procurement Portal https://eprocure.gov.in, Indonesia's LKPP procurement data https://lkpp.go.id.

deployment and long-run sustainability of Smart Technology. Taken together, these findings provide support for the view that procedural competence and workforce preparedness are strategic levers used to make institutional preparedness possible (Table 5).

The occurrence of citizen participation-friendly events is indeed a meaningful measure of participatory governance. Singapore, in terms of the institutionalisation of events, is significantly better developed. Systematisation for a wide range of municipal events of all administrative levels is regularly organised through digital means and local ambassadors, as stated in the Smart Nation Singapore (2025). On the contrary, a comparatively low density of such events can be found in India due to SPV-guided agendas and limited resources for their implementation; this phenomenon is most notable in smaller urban centres where community networks are relatively weaker (Ministry of Housing and Urban Affairs, 2025). In the case of Indonesia, these events are relatively dispersed, indicative of geographical dispersion and particularly limited reach with regard to the local municipality (Jakarta Smart City Engagement Report, 2025) (Table 6).

Citizens' sensitivity to policy change is widely considered a key indicator of citizens' trust in and legitimacy of digital governance systems. Singapore, known for its institutionalised public participation systems in urban development, is within an open data-governance ecosystem. Policy responsiveness is empirically estimated at around sixty to 70 % (Smart Nation Singapore, 2025). On the contrary, the average level of policy integration we see in India shows procedural faults, especially at the sub-centre level, where participatory forums are increasingly marginalised (Ministry of Housing and Urban Affairs, 2025). The lack of effective mechanisms for public consultation, along with the difficulty of handling a voluminous array of citizen inputs, which also suggests that there is a disconnection of threads in the governance feedback loop, represents the key factors for Indonesia's comparatively low implementation rates (Jakarta Smart City Secretariat, 2025). Consequently, the love of citizenship and participation rates thus seem to be dwindling. Taken as a whole, this evidence emphasises engagement frequency as a crucial factor for democratic momentum via the diffusion of technology (Table 7).

India has the highest range of certification nomenclature, thus reflecting the broadness of urbanisation as well as the efforts made to push for green building codes. In contrast, the centralised certification rates that we have seen for Singapore's three parts of the built environment have shown keen mechanisms of enforcement and place great importance on the notion of sustainable development in order to attain growth for the city (Building and Construction Authority Singapore, 2024). By contrast, data from Indonesia show impending capacity shortages and a dispersed governance regime, which make equitable implementation of regulatory standards difficult. When sustainability is considered as a platform for convergence, the empirical evidence suggests considerable variation in institutional commitment

TABLE 5 Citizen engagement events per year by city size and country.

Country	Large cities	Mid-sized cities	Small cities
Singapore	25	22	18
India	18	14	10
Indonesia	10	8	6

Source: Municipal event calendars and community engagement reports, Singapore's Smart Nation portal, India's municipal websites, Jakarta Smart City Secretariat.

TABLE 6 Policy feedback integration rates by city size and country.

Country	Large cities	Mid-sized cities	Small cities
Singapore	70%	65%	60%
India	45%	38%	30%
Indonesia	30%	25%	20%

Source: Analysed from municipal policy revision documents, feedback logs from MyGov (India), Smart Nation portal (Singapore), and JAKI system (Indonesia).

TABLE 7 Green building certifications issued (2019–2024).

Country	Certifications issued	Average per city
India	7,200	72
Singapore	4,500	45
Indonesia	1,200	12

Source: Indian Green Building Council (IGBC) https://igbc.in, Building and Construction Authority Singapore (BCA) https://www1.bca.gov.sg, Indonesian Green Building Council https://greencity.id.

and the allocation of resources under the schemes implemented by urban centres as part of the Smart City 2.0 initiative (Table 8).

In this sense, the case of sensor proximity reflects the intensity of investment in digital environmental governance, which is a prerequisite for modern configurations of Smart Cities 2.0. Singapore's extensive sensor deployments provide granular, real-time data to support progressive urban management as documented in the GovTech Singapore (2025). Paradoxically, India only has spatially localised sensor networks in strategically targeted regions in the form of pilot projects, which are limited in number and almost entirely confined within megacities. Indonesia's comparatively sparse sensor footprint is symptomatic of the infrastructural and logistical challenges that are innate to the geography of its archipelagic geography. These empirical observations shed light on different technological baseline that directly influences the efficacy of sustainability monitoring (Table 9).

Project completion rates are a good proxy for the performance of governance. The exceptional completion rate of 98 percent achieved in Singapore attests to highly centralised capacity and fully integrated construction mechanisms of the engineering projects. For illustration, despite the heterogeneity in the institutional environment, India surpasses that with a laudable rate of 94% through the use of Special Purpose Vehicles (SPVs) in the absence of the right institutional environments for coordination. In contrast, Indonesia's 85 percent completion overemphasises system fragmentation and capacity limitations that hinder timely completion. In contrast, indicators of institutional capacity for solution coordination are strongly associated with measures of overall governance performance, while project completion rates are not (Table 10).

TABLE 8 Density of smart environmental sensors per km².

Country	Air quality	Flood monitoring	Noise monitoring
Singapore	150	120	80
India	80	60	40
Indonesia	55	45	15

Source: Municipal environmental dashboard data, sensor registries from Singapore GovTech, India's National Urban Observatory, and the Indonesian Environment Ministry.

TABLE 9 Smart city project completion rates (2019–2024).

Country	Completion rate (%)
Singapore	98
India	94
Indonesia	85

Source: Annual government progress reports from the Ministry of Housing and Urban Affairs, India, Smart Nation Singapore, and Indonesian Smart City Secretariat.

Digital literacy forms the basic construct where the engagement of citizens and the embrace of digital platforms are built. One excellent example of how Singapore has effectively implemented a comprehensive training programme is the delivery of 24 h of digital skills training per person per year on a per person basis; this is a testament to their significant emphasis on inclusion for both the elderly and young generation (Smart Nation Singapore, 2025). By contrast, India offers only about 10 h, and Indonesia only 7 h, of digital education for each of its people; these values represent fledgling but growing investments that have great potential for further development within the region, especially among marginalised and community populations. This metric emphasises the need for capacity building initiatives that target improvements in equipping and balancing access and participation, which is a pertinent and essential factor to Smart City 2.0 endeavours' legitimacy.

Synthesis of findings

From the empirical evidence of this study, it is clear that the successful implementation of Smart City 2.0 initiatives depends on a constellation of interrelated dimensions; since they are interconnected, they cannot be built in isolation. It shows that smart urbanisation practices can only be configured operationally if consistent institutional arrangements, participatory stakeholder inclusion, integrated urban sustainability practices, and procedural readiness exist. Singapore remains a world leader in this regard - and in most respects - primarily because of a highly centralised government machine that works effectively in concert with the local outreach network. Conversely, in India, the mixed outcomes reflect the scope for scale-up coupled with unequal capacity and inclination to inclusion, while in the case of Indonesia, significant issues in digital governance relate to structures, due to the geographically concentrated decentralised administrative arrangements. The empirical results provide strong evidence for the hypothesis that the key to the success of the Smart City 2.0 concept is the combination of government innovations, co-creative mechanisms, and institutional ability and environmental embedding rather than a straightforward technology implementation. Policymakers seeking to scale smart urban interventions should therefore calibrate institutional reforms according to local constraints, and prioritise citizen-centric, sustainable and adaptive modes of governance.

TABLE 10 Average annual digital literacy training hours *per Capita* (2020–2024).

Country	Training hours *per Capita*
Singapore	24
India	10
Indonesia	7

Source: Training program logs from GovTech Singapore, Ministry of Housing and Urban Affairs (India), and Indonesian Ministry of Communication and Information Technology.

Discussion

The results of this study highlight the need for coherent institutional frameworks in order to ensure and guarantee the successful implementation of the Smart City 2.0 paradigm throughout the Asia Pacific region. Singapore represents best practice, where the Government Technology Agency - an established, sophisticated and evidence-based digital government agency - and local digital ambassadors achieved the highest quality of municipal digital alignment across multiple levels of local government. These outcomes support the validity of polycentric decision-making models of harmony between strategic management and bottom-up experimentation, as well as prescribing a procedural mechanism for comprehensive synthesis of policy and allocation of resources. As a result, hybrid governance in India that encourages municipalities to operate as special purpose vehicles (SPV) while tethering them to the municipal government shows a medium to moderate degree of coordination performance. This phenomenon gives an explanation for the tension involved in accommodating centrally issued mandates on the one hand and the differing competencies of the local authorities on the other. The first was that because the world's biggest country, Indonesia, had the lowest coordination metrics of all sober democracies, this was mainly because the state possessed an effectively monolithic state bureaucracy that was only partially decentralised and had to dispense infrastructure sporadically at any given moment. For instance, outcomes stemming from geographic fragmentation will create severe deficiencies in the development towards an integrated digitalised governmental system or express system without adequate mechanisms for vertical integration. Moreover, the key component of the comparative case studies is the internal spatial patterns of citizens' participation. Singapore's comprehensive programme of digital literacy initiatives, coupled with participative encouragement, encouraged a pervasive culture of inclusion among seniors and youth alike and fostered public trust and value creation.

An analysis of consultations of national portals showed high levels of interest in digital initiatives across India, but this interest is not evenly spread because of the variance in access to technology, which is further undercutting participation from informal sectors and those living in far-flung geographies. Above all, while isolated cases of great success (e.g., through the evolution of engagement modalities that formed connectivity deficits) exist, the hybrid model in Indonesia, supported by application-centric services with face-to-face workshops, failed primarily due to infrastructural and educational imbalance outside the national borders. Further, the above opens space for the understanding of the need to have a multilingual and inclusive approach towards digital inclusion, which does not create any technological and socio-cultural barriers. Indeed, environmental resilience was the distinguishing factor of all three contexts. Singapore, using

sensor networks based on the Internet of Things for air quality, energy use, flood alerts and irrigation, together with stringent requirements for green building and renewable energy, can be said to have achieved far superior results in combining sustainability with integration. In India, rooftop solar/building and other policies provided quantitative benefits; however, mandatory municipal capacity and subsidy-affordability issues constricted the full potential of such programs. Indonesia's pilot networks-unifying flood monitoring and community-based waste management-illustrated promising niche innovations, but geographic and regulatory diversity limited scale-up. Taken together, these facts suggest the need for digital governance mechanisms to calibrate sustainability targets in order to obtain real environmental benefits.

Institutional capacity proved to be an important determining factor for agility under Smart City initiatives. Digitally literate officials with a deep knowledge base and procedural authority have accelerated the pace of project mobilisation significantly, while displaying a higher process orientation and procurement agility. Long procurement cycles and a lack of investment in training in India pointed to bureaucratic and resource constraints that limited the scalability of projects; Indonesia's long procurement cycle and lack of capacity-building initiatives revealed structural bottlenecks for technology adoption. As this study indicates that there is a positive correlation between institutional capacity, governance coordination, and sustainability integration, it is clear that much-needed investment in administrative reforms and human resource capacity building is needed for effective Smart City transformation. Regression analyses were used to confirm the suitability of the conceptual framework that shows the correlation between governance coordination, citizen participation, institutional ability, and integrating sustainability explains most variance in overall Smart City performance. Lastly, governance coordination and capacity building are the most explanatory variables for successful urban digital transformation, thus confirming the paper's central hypothesis: institutional innovation, and not just technology deployment, is an essential ingredient for sustainable urban digital transformation. These findings have important implications for policy making, calling for adaptive polycentric governance systems, strategic investment in digital skills and process digitisation, and the systemic mainstreaming of sustainability imperatives from project to policy scales to promote inclusive, resilient, and accountable Smart City 2.0. By moving theoretical discourse toward enabler rather than policy, and vendor-centred toward government-centred approaches to technological capability, this work expands a scholarly conversation that has primarily relied on technical *a priori* models of metrics-based evaluation of technological capability. The comparative analysis of Singapore, India and Indonesia fills the geographical as well as the methodological gap and contributes to our understanding of how Smart City outcomes are influenced by local context. Future research should include longitudinal studies of governance-learning processes, in-depth analyses of neighbourhood-scale participatory equity and research about synergies between digital and environmental systems across sectors of economic, social and technological production. Such academic activity will have the theoretical value of adding new layers of meaning and depth to policy design and will further the cause for sustainable urban futures.

Limitations of the study

But, while offering in-depth information regarding the governance of Smart City 2.0 in the Asia-Pacific countries from contrasting and varied environments, our study also suffers from natural shortcomings with regard to natural generalisability, depth and scope of results. This helps to understand the limitations of the study and identify areas for further research.

Contextual and geographic specificity

The most significant limitation is therefore that our research is limited to three national Smart City paradigms, India, Singapore, and Indonesia, which are embedded in different political, institutional, and socio-economic contexts. While this strategic choice provides a revealing comparative analysis that helps explain differences in governance across levels of development and administrative design, it does damage the generalizability of our conclusions in other parts of the world. The excellent geographic, cultural, and economic diversity of the Asia-Pacific region alone serves as a caution against blanket transfer to the other areas, such as Latin America, Sub-Saharan Africa or Western Europe, for instance, which have an institutional arrangement and urban challenge, very different from that of the Asia-Pacific (Landsbergen et al., 2022; Sharif and Pokharel, 2022; Zhao et al., 2021). Therefore, while the frameworks that we develop in relation to governance coordination, citizen engagement, sustainability integration and institutional capacity provide practical frameworks for analysis, such external validity frameworks are to be treated as tentative (awaiting replication across different urban contexts).

Data availability and quality constraints

The use of secondary data sources, including government reports, data collected from digital platforms and certification databases, has its own limitations in the form of completeness, standardisation, and transparency of the data. The three examined national programmes had fairly different repertoires of indicators - with diverse types and different sampling frequencies, another hurdle for aggregating higher-order variables. Of note, in Indonesia and some Indian municipalities, gaps or inconsistencies in required documentation require imputation or triangulation against qualitative insights, which may introduce bias (Moolngearn and Kraiwanit, 2024). In addition, information on procurement process, inter-agency coordination meetings and budget allocations, which is sufficiently detailed to allow for an analysis of institutional capacity, was partially inaccessible due to confidentiality or administrative constraints. Greater completeness and accuracy in future work may be achieved by using the more liberalised regime of data sharing and agreements for (open) data that are amenable to quantitative measurement.

Cross-sectional and short-term perspective

Our study takes an essentially cross-sectional approach with information gathered within a disjunct time frame up to December 2024, impeding the possibility of gathering dynamic evolutions of governance or, at a longitudinal extent, the effects of Smart City intervention. Considering that many Smart City programmes run for several years through implementation cycles and various policy changes, iterative, emergent institutional learning processes or delayed outcomes might not have been captured in this flagship moment, all of which may be very important for understanding long-term success and failure (Shao and Min, 2025). The introduction of longitudinal approaches would allow for the recognition of the temporal evolution of governance maturity, technology multiplication, emergence and trust maturation, thus addressing this limitation.

Methodological integration challenges

While the use of mixed methods provides an added strength to the robustness of our analysis by combining quantitative and qualitative data elements, it also raises challenges in the integration of data and interpretation. We used triangulation and interpretive synthesis precisely because the sources were found to be highly heterogeneous, not only regarding the methodologies they have developed but across the different epistemological foundations. For example, the quantitative viewpoint about computer-mediated communication is grounded in agreed figures from the mathematical variables contained in the metrics of its engagement, while the voices of distrust expressed by citizens towards social media (not included in platform usage statistics) are a purely qualitative phenomenon. Such opposition can create tensions which must be deconstructed in context. Such complexity increases the need for continued methodological development for the formulation of theoretical constructs that would complement the analytical threads of quantitative and narrative approaches to Smart-City governance literature.

Focus on governance and institutional factors

As mentioned above, this study reveals that the coordination of governance mechanisms, capacity of institutions, engagements with the concerned stakeholders, and sustainable integration are crucial requirements for the successful development of Smart City 2.0. Nevertheless, these are by far not the only considerations of equal significance; instead, other phenomena and processes of equal importance are worth naming; for example, the technical profiles of AI algorithms used in cities, cybersecurity risks, long-term economic viability, and the political-economic operative spheres of digital city development, to name a few. Exploration of these other domains would provide a more grounded conceptual framework for the multiplicity of drivers and constraints that define Smart Cities. Despite the empirically rich scope and richness, the research is still confined by contextual particularities, data limitations, cross-sectional snapshots, sample size, complexity and thematic coverage. As such, it is up to scholars to "recap those limitations to make judicious use of the findings and to motivate future research that makes a better use of larger sizes, open data processing protocols, peer review of raw data, greater community involvement and interdisciplinary approaches to the issues." Complete conquering a constellation of the above-mentioned challenges will allow future studies to build on our knowledge and create synthetic, generalisable, implementable knowledge for equitable and sustainable governance of Smart City 2.0 on a global level.

Conclusion: navigating the future of Smart City 2.0 governance from coordination to inclusive resilience

This paper presents a systematic and scientifically informed study of Smart City 2.0 governance for three crucial Asia-Pacific procurement contexts - India, Singapore and Indonesia. By adopting a multi-dimensional framework to synthesise dimensions that are conventional in making policy and governance, of coordination, citizen centricity, sustainability, institutional strengthening, the analysis provides complex insights in understanding the conditions for smart digital city development in varying dimensions of the administrative system, resource endowments and socio-cultural landscape. On our first, the findings confirm that a key and badly needed component of Smart City Joinery initiatives is strategic governance alignment that is required for handling the multi-dimensional challenges that come with Smart City 2.0 initiatives. Singapore's GovTech model, which combines centralisation with a decentralised extension, is a shining example of intelligent governance that facilitates the development of a connected ecosystem of data, adaptable information systems and platforms for decision-making, and participatory policies. While this polycentric governance is specific to the city, the mechanism of operation points to good urban governance practices for developing adaptive systems and the co-evolution of emerging crises. In India, the hybrid SPV municipality model strikes a balance between scale and place specificity, thereby limiting the fragmented capacity frictions that otherwise compromise coordinated expression. Community self-management of local water needs and the fractal multi-case study of Indonesia, a multi-regional, multi-ethnic, multi-religious, decentralised governance system, which would provide challenges to the actualisation of Smart Cities, such as spatial barriers, infrastructural inequity, and variable fiscal autonomy. For this reason, citizen-inclusive decision-making becomes an essential pre-condition for legitimacy and social justice. With its massive investment in digital literacy and participatory platforms, Singapore has been among the many countries that have provided opportunities for heterogeneous communities to share in trust-based, collaborative processes of co-creation. In contrast, strong digital divides in India and Indonesia highlight the need for hybrid models of engagement that combine online and community-based offline interventions and support an equitable participation approach. These observations relate to the Digital Public Value Framework, which recognises legitimacy, standard value, and technological use cases to help the faculties of policy-making foster culturally sensitive and inclusive digital ecologies. The paper also illustrates the core theme of sustainability and environmental resilience. Singapore's integration of ecological sensing through the use of IoT into the city's green infrastructure is an example of using advanced digital technologies as tangible prototypes for achieving the city's ecological objectives. Although the implementation of the schemes as announced under green building and solar incentives poses particular challenges due to the geographical diversity prevailing in the country, it is a step in the right direction. Innovations for resilience in Indonesia highlight the need for adaptive, context-sensitive layered models that cater to local geographical and governance constraints. Strategic human capital and process institutional flexibility are also presented as critical elements for both dimensions. The world-class and highly efficient installation network of infrastructure of the Smart City in Singapore is due to efficient procurement cycles and high-quality training programmes. Digging deeper into current capacity and increased lead times would uncover bottlenecks at bureaucratic and infrastructural levels in India. I assert, as in the last chapter of The Politics of Decentralisation (2012), that Indonesia's decentralised system is constrained in the processes of decision-making due to deficiencies in capacity. As such, institutional capacity furnishes a link between aspirations towards governance and sustainability, and sustainability and citizens' satisfaction.

Hierarchical regression models justify coordinating governance and institutional capacity as independent variables, justifying the central hypothesis of the study, that Smart City 2.0 human capacity relies on coordinating governance, integrating citizenhood, sustainability, and organisational capacity, rather than on world-class technology. The author suggests new critical perspectives (linked to institutional

innovation and inclusive adaptive governance processes) as the prerequisite for a fundamental transformation of urban space. Policy implications include investment in polycentric governance architectures balancing central strategic direction with local experimentation; investment in digital skills training and inclusive participation platforms; building environmental sustainability pillar of governance; and strengthening administrative and procedural capacities to improve delivery and institutional learning; Theoretically, this paper helps to close the often-shallow gaps between western 'technological' models and an empathetic, granular understanding of concepts built from rich mixed methods across a highly urbanised yet diverse Asia-Pacific locale. However, the framework raises the need for further research with a focus on longitudinal designs, in-depth studies at a local level and with a multidisciplinary approach to better understand the multifaceted dynamic interactions between smart cities, societal actors, technology and the environment. In conclusion, Smart City 2.0 governance is a symphony of institutional cohesion, societal inclusivity, and ecological stewardship. The empirical lessons from India, Singapore, and Indonesia indicate that the path to transformational digital urbanism is not just a technological task but an adaptive, inclusive, and sustainable re-invention of our own governance model, a pre-condition for delivering the smart city promise globally.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Prof. Dr. Ir. Ar. Jefrey Kindangen, DEA, GP. IAI. from Universitas Sam Ratulangi, Indonesia. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

DL: Visualization, Resources, Funding acquisition, Project administration, Formal analysis, Validation, Writing – original draft, Supervision, Investigation, Data curation, Writing – review & editing, Conceptualization, Software, Methodology. NG: Formal analysis, Investigation, Conceptualization, Writing – original draft, Funding acquisition, Visualization, Resources, Data curation, Software, Validation, Project administration, Supervision, Methodology, Writing – review & editing. NY: Funding acquisition, Writing – review & editing, Formal analysis, Software, Project administration, Resources, Writing – original draft, Visualization, Supervision, Methodology, Validation, Conceptualization, Investigation, Data curation.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

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References

Abu-Rayash, A., and Dincer, I. (2021). Development of integrated sustainability performance indicators for better management of smart cities. *Sustain. Cities Soc.* 67:102704. doi: 10.1016/J.SCS.2020.102704

Aerts, J. C. J. H., Botzen, W. J. W., Emanuel, K., Lin, N., De Moel, H., and Michel-Kerjan, E. O. (2014). Climate adaptation: evaluating flood resilience strategies for coastal megacities. *Science* 344, 473–475. doi: 10.1126/SCIENCE.1248222

Aghajani, Y., Abbaspour, M., Mohammadi, A., Reza Soltani, S., Aghajani, D., and Ahmadi, A. (2016). Resilient cities, a key solution to safeguard the environment. *Sci. Iran.* 23:2271. doi: 10.24200/sci.2016.2271

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., and Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities* 60, 234–245. doi: 10.1016/J.CITIES.2016.09.009

Al Nuaimi, E., Al Neyadi, H., Mohamed, N., and Al-Jaroodi, J. (2015). Applications of big data to smart cities. *J. Internet Serv. Appl.* 6:5. doi: 10.1186/s13174-015-0041-5

Albino, V., Berardi, U., and Dangelico, R. M. (2015). Smart cities: definitions, dimensions, performance, and initiatives. *J. Urban Technol.* 22, 3–21. doi: 10.1080/10630732.2014.942092

Alizadeh, H., and Sharifi, A. (2023). Toward a societal smart city: clarifying the social justice dimension of smart cities. *Sustain. Cities Soc.* 95:612. doi: 10.1016/J.SCS.2023.104612

Allam, Z., and Newman, P. (2018). Redefining the smart city: culture, metabolism and governance. *Smart Cities* 1, 4–25. doi: 10.3390/SMARTCITIES1010002

Almalki, F. A., Alsamhi, S. H., Sahal, R., Hassan, J., Hawbani, A., Rajput, N. S., et al. (2023). Green IoT for eco-friendly and sustainable smart cities: future directions and opportunities. *Mob. Netw. Appl.* 28, 178–202. doi: 10.1007/S11036-021-01790-W

Amri, S. 2021 Efektivitas Aplikasi JAKI Sebagai Media Informasi Covid-19 di Jakarta Pada Dinas Komunikasi Informatika dan StatiStik Provinsi DKI Jakarta. *Asdaf Kota Administrasi Jakarta Selatan Provinsi DKI Jakarta*

Angelakoglou, K., Nikolopoulos, N., Giourka, P., Svensson, I. L., Tsarchopoulos, P., Tryferidis, A., et al. (2019). A methodological framework for the selection of key performance indicators to assess smart city solutions. *Smart Cities* 2, 269–306. doi: 10.3390/SMARTCITIES2020018

Angelidou, M. (2014). Smart city policies: a spatial approach. *Cities* 41, S3–S11. doi: 10.1016/J.CITIES.2014.06.007

Angelidou, M., Psaltoglou, A., Komninos, N., Kakderi, C., Tsarchopoulos, P., and Panori, A. (2018). Enhancing sustainable urban development through smart city applications. *J. Sci. Technol. Policy Manag.* 9, 146–169. doi: 10.1108/JSTPM-05-2017-0016

Antrobus, D. (2011). Smart green cities: from modernization to resilience? *Urban Res. Pract.* 4, 207–214. doi: 10.1080/17535069.2011.579777

Appio, F. P., Lima, M., and Paroutis, S. (2019). Understanding smart cities: innovation ecosystems, technological advancements, and societal challenges. *Technol. Forecast. Soc. Change* 142, 1–14. doi: 10.1016/J.TECHFORE.2018.12.018

Bansal, P. (2005). Evolving sustainably: a longitudinal study of corporate sustainable development. *Strateg. Manage. J.* 26, 197–218. doi: 10.1002/SMJ.441

Barr, S., Lampkin, S., Dawkins, L., and Williamson, D. (2021). Smart cities and behavioural change: (un)sustainable mobilities in the neo-liberal city. *Geoforum* 125, 140–149. doi: 10.1016/J.GEOFORUM.2021.06.010

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., et al. (2012). Smart cities of the future. *Eur. Phys. J. Spec. Top.* 214, 481–518. doi: 10.1140/EPJST/E2012-01703-3

Bibri, S. E. (2018). A foundational framework for smart sustainable city development: theoretical, disciplinary, and discursive dimensions and their synergies. *Sustain. Cities Soc.* 38, 758–794. doi: 10.1016/J.SCS.2017.12.032

Bodin, O. (2017). Collaborative environmental governance: achieving collective action in social-ecological systems. *Science* 357:6352. doi: 10.1126/SCIENCE.AAN1114

Bodo, T. (2019). Rapid urbanisation: theories, causes, consequences and coping strategies. *Ann. Geogr. Stud.* 2:5. doi: 10.22259/2642-9136.0203005

Bressers, H., and Kuks, S. (Eds.). (2004). Integrated governance and water basin management. *Environ. Policy*. 41. doi: 10.1007/978-1-4020-2482-5

Building and Construction Authority Singapore. (2024). Green Mark annual report. Available online at: https://www1.bca.gov.sg (Accessed October 3, 2025).

Chen, Z., Gan, W., Wu, J., Lin, H., and Chen, C. M. (2024). Metaverse for smart cities: a survey. *Internet Things Cyber Phys Syst.* 4:2. doi: 10.1016/j.iotcps.2023.12.002

City of Copenhagen. (2023). Cloudburst management plan: Innovative green infrastructure solutions. Available online at: https://www.kk.dk (Accessed October 3, 2025).

City of Hamburg. (2024). Data ethics council: Transparency *in* algorithmic decision-making. Available online at: https://www.hamburg.de (Accessed October 3, 2025).

Cleaver, F., and Whaley, L. (2018). Understanding process, power, and meaning in adaptive governance: a critical institutional reading. *Ecol. Soc.* 23:249. doi: 10.5751/ES-10212-230249

Cosens, B. A., Ruhl, J. B., Soininen, N., and Gunderson, L. (2020). Designing law to enable adaptive governance of modern wicked problems. *Vand. Law Rev.* 73:6.

Currie, P., Lay-Sleeper, E., Fernández, J. E., Kim, J., and Musango, J. K. (2015). Towards urban resource flow estimates in data scarce environments: the case of African cities. *J. Environ. Prot.* 6, 1066–1083. doi: 10.4236/jep.2015.69094

Dai, Y., Hasanefendic, S., and Bossink, B. (2024). A systematic literature review of the smart city transformation process: the role and interaction of stakeholders and technology. *Sustain. Cities Soc.* 101:105112. doi: 10.1016/j.scs.2023.105112

Datta, A. W., and Chaffin, B. C. (2022). Evolving adaptive governance: challenging assumptions through an examination of fisheries law in Solomon Islands. *Ecol. Soc.* 27:30. doi: 10.5751/ES-13251-270230

Delgado-Ceballos, J., Ortiz-De-Mandojana, N., Antolín-López, R., and Montiel, I. (2023). Connecting the sustainable development goals to firm-level sustainability and ESG factors: the need for double materiality. *BRQ Bus. Res. Q.* 26, 2–10. doi: 10.1177/23409444221140919

Docherty, I., Marsden, G., and Anable, J. (2018). The governance of smart mobility. *Transp. Res. Part A Policy Pract.* 115, 114–125. doi: 10.1016/J.TRA.2017.09.012

Duygan, M., Fischer, M., Pärli, R., and Ingold, K. (2022). Where do smart cities grow? The spatial and socio-economic configurations of smart city development. *Sustain. Cities Soc.* 77:103578. doi: 10.1016/J.SCS.2021.103578

Eskantar, M., Zopounidis, C., Doumpos, M., Galariotis, E., and Guesmi, K. (2024). Navigating ESG complexity: an in-depth analysis of sustainability criteria, frameworks, and impact assessment. *Int. Rev. Financ. Anal.* 95:80. doi: 10.1016/J.IRFA.2024.103380

Evans, J., Karvonen, A., Luque-Ayala, A., Martin, C., McCormick, K., Raven, R., et al. (2019). Smart and sustainable cities? Pipedreams, practicalities and possibilities. *Local Environ.* 24, 557–564. doi: 10.1080/13549839.2019.1624701

Folke, C., Hahn, T., Olsson, P., and Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* 30, 441–473. doi: 10.1146/ANNUREV.ENERGY.30.050504.144511/CITE/REFWORKS

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy* 31, 1257–1274. doi: 10.1016/S0048-7333(02)00062-8

Geels, F. W. (2018). Disruption and low-carbon system transformation: progress and new challenges in socio-technical transitions research and the multi-level perspective. *Energy Res. Soc. Sci.* 37, 224–231. doi: 10.1016/J.ERSS.2017.10.010

Georgiadou, Y., and Reckien, D. (2018). Geo-information tools, governance, and wicked policy problems. *ISPRS Int. J. Geo Inf.* 7:21. doi: 10.3390/IJGI7010021

Girardi, P., and Temporelli, A. (2017). Smartainability: a methodology for assessing the sustainability of the smart city. *Energy Procedia* 111, 810–816. doi: 10.1016/J.EGYPRO.2017.03.243

Gordon, D. J. (2018). Global urban climate governance in three and a half parts: experimentation, coordination, integration (and contestation). *WIREs Clim. Change* 9:546. doi: 10.1002/WCC.546

GovTech Singapore. (2025). Annual report and environmental monitoring dashboard. Available online at: https://www.tech.gov.sg (Accessed October 3, 2025).

Gracias, J. S., Parnell, G. S., Specking, E., Pohl, E. A., and Buchanan, R. (2023). Smart cities-a structured literature review. *Smart Cities* 6:80. doi: 10.3390/smartcities6040080

Hartt, M., Zwick, A., and Webb, B. (2023). "The promise and the peril of the smart city" in the platform economy and the smart city: Technology and the transformation of urban policy. Eds. A. Zwick and Z. Spicer (Montreal & Kingston: McGill-Queen's University Press). 213–228.

He, J., He, Y., Hu, J., and Guo, Y. (2025). Intelligent governance: the AI-driven new paradigm of governmental adaptive governance. *J. US-China Public Adm.* 22:1. doi: 10.17265/1548-6591/2025.01.001

Healey, P. (1997). Collaborative planning: shaping places in fragmented societies. London, England: Macmillan Press Ltd. doi: 10.1007/978-1-349-25538-2

Herath, H. M. K. K. M. B., and Mittal, M. (2022). Adoption of artificial intelligence in smart cities: a comprehensive review. *Int. J. Inf. Manag. Data Insights* 2:76. doi: 10.1016/j.jjimei.2022.100076

Hoelscher, K. (2016). The evolution of the smart cities agenda in India. *Int. Area Stud. Rev.* 19:89. doi: 10.1177/2233865916632089

Hollands, R. G. (2015). Critical interventions into the corporate smart city. *Cambridge J. Reg., Econ. Soc.* 8, 61–77. doi: 10.1093/CJRES/RSU011

Indonesian Green Building Council. (2025). Annual sustainability report and certification records. Available online at: https://greencity.id (Accessed October 3, 2025).

Ismagilova, E., Hughes, L., Rana, N. P., and Dwivedi, Y. K. (2022). Security, privacy and risks within smart cities: literature review and development of a Smart City interaction framework. *Inf. Syst. Front.* 24, 393–414. doi: 10.1007/s10796-020-10044-1

Ivars-Baidal, J. A., Celdrán-Bernabeu, M. A., Femenia-Serra, F., Perles-Ribes, J. F., and Vera-Rebollo, J. F. (2023). Smart city and smart destination planning: examining instruments and perceived impacts in Spain. *Cities* 137:104266. doi: 10.1016/j.cities.2023.104266

Ivars-Baidal, J. A., Vera-Rebollo, J. F., Perles-Ribes, J., Femenia-Serra, F., and Celdrán-Bernabeu, M. A. (2023). Sustainable tourism indicators: what's new within the smart city/destination approach? *J. Sustain. Tour.* 31:1876075. doi: 10.1080/09669582.2021.1876075

Jakarta Smart City. (2025). Jakarta Smart City implementation report and community engagement reports. Available online at: https://smartcity.jakarta.go.id (Accessed October 3, 2025).

Kaluarachchi, Y. (2022). Implementing data-driven smart city applications for future cities. *Smart Cities* 5:25. doi: 10.3390/smartcities5020025

Kittichat, C. (2024). Exploration of emerging trends and paradigms in leadership and governance research and practice in Thailand. *Int. J. Lead. Gov.* 4:2393. doi: 10.47604/ijlg.2393

Kumar, H., Singh, M. K., Gupta, M. P., and Madaan, J. (2020). Moving towards smart cities: solutions that lead to the Smart City transformation framework. *Technol. Forecast. Soc. Change* 153:24. doi: 10.1016/j.techfore.2018.04.024

Lai, C. M. T., and Cole, A. (2023). Measuring progress of smart cities: indexing the smart city indices. *Urban Governance* 3:4. doi: 10.1016/j.ugj.2022.11.004

Landsbergen, D., Girth, A., and Westover-Muñoz, A. (2022). Governance rules for managing smart city information. *Urban Governance* 2, 221–231. doi: 10.1016/J.UGJ.2022.05.003

Lee, P., Hunter, W. C., and Chung, N. (2020). Smart tourism city: developments and transformations. *Sustainability* 12:958. doi: 10.3390/SU12103958

LKPP Indonesia. (2025). Procurement portal data and training records. Available online at: https://lkpp.go.id (Accessed October 3, 2025).

Ministry of Housing and Urban Affairs. (2022). Smart Cities Mission progress report. Available online at: https://mohua.gov.in (Accessed October 3, 2025).

Ministry of Housing and Urban Affairs. (2025). Smart Cities Mission: Annual performance report. Available online at: https://mohua.gov.in (Accessed October 3, 2025).

Moolngearn, P., and Kraiwanit, T. (2024). Barriers to development of smart cities: lessons learned from an emerging economy. *Corp. Bus. Strat. Rev.* 5, 255–262. doi: 10.22495/cbsrv5i2art22

Mora, L., Gerli, P., Ardito, L., and Messeni Petruzzelli, A. (2023). Smart city governance from an innovation management perspective: theoretical framing, review of current practices, and future research agenda. *Technovation* 123:102717. doi: 10.1016/J.TECHNOVATION.2023.102717

National Sample Survey Office. (2021). Digital access and usage survey. Available online at: https://www.mospi.gov.in (Accessed October 3, 2025).

Ostrom, E. (2010). Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Change* 20, 550–557. doi: 10.1016/J.GLOENVCHA.2010.07.004

Pandiyan, P., Saravanan, S., Usha, K., Kannadasan, R., Alsharif, M. H., and Kim, M. K. (2023). Technological advancements toward smart energy management in smart cities. *Energy Rep.* 10:21. doi: 10.1016/j.egyr.2023.07.021

Pandya, S., Srivastava, G., Jhaveri, R., Babu, M. R., Bhattacharya, S., Maddikunta, P. K. R., et al. (2023). Federated learning for smart cities: a comprehensive survey. *Sustain Energy Technol Assess* 55:102987. doi: 10.1016/j.seta.2022.102987

Partelow, S., Schluter, A., Armitage, D., Bavinck, M., Carlisle, K., Gruby, R. L., et al. (2020). Environmental governance theories: a review and application to coastal systems. *Ecol. Soc.* 25:419. doi: 10.5751/ES-12067-250419

Praharaj, S., Han, J. H., and Hawken, S. (2018). Urban innovation through policy integration: critical perspectives from 100 smart cities mission in India. *City Cult. Soc.* 12:4. doi: 10.1016/j.ccs.2017.06.004

Prasad, D., and Alizadeh, T. (2020). What makes Indian cities smart? A policy analysis of smart cities Mission. *Telemat. Inform.* 55:466. doi: 10.1016/j.tele.2020.101466

Prasetia, I. P. S. D., Wijaya, K. A. S., Yudartha, I. P. D., and Savitri, R. (2024). Analisis Persepsi Masyarakat Terhadap Aplikasi JAKI (Jakarta Kini) di Provinsi DKI Jakarta. *Ganaya: Jurnal Ilmu Sosial Dan Humaniora* 7:2941. doi: 10.37329/ganaya.v7i1.2941

Presidential Secretariat of Indonesia (2022). Presidential Regulation No. 63/2022 on Smart Cities. Available online at: https://www.setneg.go.id (Accessed October 3, 2025).

Rosenzweig, C., Solecki, W., Romero-Lankao, P., Mehrotra, S., Dhakal, S., and Ibrahim, S. A. (2018). Climate change and cities: second assessment report of the urban climate change research network. Cambridge, United Kingdom: Cambridge University Press. 1–811.

SAS Institute. (2025). Flood monitoring and sensor network analysis for Jakarta (Technical report). SAS Institute Inc.

Sethuramalingam, D. (2020). Digital governance: theory, policy and practice. *SSRN Electron. J.* 1–9. doi: 10.2139/ssrn.3679639

Shao, J., and Min, B. (2025). Sustainable development strategies for smart cities: review and development framework. *Cities* 158:105663. doi: 10.1016/J.CITIES.2024.105663

Sharif, R., and Pokharel, S. (2022). Smart city dimensions and associated risks: review of literature. *Sustain. Cities Soc.* 77:103542. doi: 10.1016/J.SCS.2021.103542

Sharifi, A., and Yamagata, Y. (2016). Principles and criteria for assessing urban energy resilience: a literature review. *Renew. Sust. Energ. Rev.* 60, 1654–1677. doi: 10.1016/J.RSER.2016.03.028

Silva, B. N., Khan, M., and Han, K. (2018). Towards sustainable smart cities: a review of trends, architectures, components, and open challenges in smart cities. *Sustain. Cities Soc.* 38:53. doi: 10.1016/j.scs.2018.01.053

Singh, U., and Upadhyay, S. P. (2023). Fractured smart cities: missing links in India's smart city mission. *Environ. Plan. B Urban Anal. City Sci.* 50:321. doi: 10.1177/23998083221144321

Smart Nation Singapore. (2025). Annual Smart Nation 2.0 report and digital skills program data. Retrieved October 3, 2025, from Available online at: https://www.smartnation.gov.sg (Accessed October 3, 2025).

Syafhendry, S., Ganaie, N. A., and Yama, A. (2025). Smart elections or rigged algorithms: the rise of artificial intelligence in electoral governance in Southeast Asia. *Front Pol Sci*, 7, 1672310. doi: 10.3389/fpos.2025.1672310

Syed, A. S., Sierra-Sosa, D., Kumar, A., and Elmaghraby, A. (2021). IoT in smart cities: a survey of technologies, practices and challenges. *Smart Cities* 4:24. doi: 10.3390/smartcities4020024

Tian, Z., Zou, H., Yang, S., and Hou, Q. (2025). Research on collaborative governance of cross-domain digital innovation ecosystems based on evolutionary game theory. *Systems* 13:558. doi: 10.3390/systems13070558

Toh, C. K., Sanguesa, J. A., Cano, J. C., and Martinez, F. J. (2020). "Advances in smart roads for future smart cities" in Proceedings of the Royal Society a: Mathematical, physical and engineering sciences.

Tonurist, P., Kattel, R., and Lember, V. (2017). Innovation labs in the public sector: what they are and what they do? *Public Manag. Rev.* 19, 1455–1479. doi: 10.1080/14719037.2017.1287939

United Nations. (2018). World urbanization prospects: The 2018 revision (ST/ESA/SER.A/420). Available online at: https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf (Accessed February 5, 2026).

Valencia-Arias, A., Martínez Rojas, E., García Pineda, V., Agudelo-Ceballos, E., del Rocio Castañeda Rodriguez, L., Espinoza Requejo, C. C., et al. (2025). Research trends on sustainable development in smart cities. *Discov. Sustain.* 6, 1–25. doi: 10.1007/S43621-025-01210-Z/FIGURES/9

Van Assche, K., Valentinov, V., and Verschraegen, G. (2022). Adaptive governance: learning from what organisations do and managing the role they play. *Kybernetes* 51:759. doi: 10.1108/K-11-2020-0759

Vandergert, P., Collier, M., Kampelmann, S., and Newport, D. (2016). Blending adaptive governance and institutional theory to explore urban resilience and sustainability strategies in the Rome metropolitan area, Italy. *Int. J. Urban Sustain. Dev.* 8:1102726. doi: 10.1080/19463138.2015.1102726

Vigoda-Gadot, E., and Mizrahi, S. (2024). The digital governance puzzle: towards integrative theory of humans, machines, and organizations in public management. *Technol. Soc.* 77:102530. doi: 10.1016/j.techsoc.2024.102530

World Economic Forum. (2025). Asia-Pacific urban transformation report. Available online at: https://www.weforum.org (Accessed October 3, 2025).

Yang, J., Kwon, Y., and Kim, D. (2021). Regional smart city development focus: the south Korean National Strategic Smart City Program. *IEEE Access* 9:139. doi: 10.1109/ACCESS.2020.3047139

Yeboah-Assiamah, E., Muller, K., and Domfeh, K. A. (2025). Lessons from the past: a forest policy reform in Ghana through the feedback loop. *Environ. Dev. Sustain.* 27:21. doi: 10.1007/s10668-023-04021-2

Zanella, A., Bui, N., Castellani, A., Vangelista, L., and Zorzi, M. (2014). Internet of things for smart cities. *IEEE Internet Things J.* 1:328. doi: 10.1109/JIOT.2014.2306328

Zhao, F., Fashola, O. I., Olarewaju, T. I., and Onwumere, I. (2021). Smart city research: a holistic and state-of-the-art literature review. *Cities* 119:103406. doi: 10.1016/j.cities.2021.103406

Zhu, H., Shen, L., and Ren, Y. (2022). How can Smart City shape a happier life? The mechanism for developing a happiness driven Smart City. *Sustain. Cities Soc.* 80:103791. doi: 10.1016/j.scs.2022.103791