Better City, Better Life

# SHANGHAI MANUAL:

## 2025

2025

SUSTAINABLE
DEVELOPMENT
GOALS

IMPLEMENTING
THE NEW
URBAN AGENDA

World
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Day October 31

BETTER CITY BETTER LIFE
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FOR A BETTER URBAN FUTURE

UN-Habitat
Bureau International des Expositions
Shanghai Municipal People's Government
Supported by Ministry of Housing
and Urban-Rural Development of the People's Republic of China

Better City, Better Life

# SHANGHAI MANUAL:

A Guide for Sustainable Urban Development
in the 21st Century · 2025 Annual Report

**UN@HABITAT**
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The Shanghai Manual, A Guide for Sustainable Urban Development in the 21st Century, reflects the longstanding partnership between the United Nations Human Settlements Programme (UN-Habitat), the Bureau of International Expositions and the Shanghai Municipal Government. Building on the World Cities Day 2025 theme of "People-centred smart cities", the 2025 edition contributes to the global repository of inspiring urban initiatives that place people at the heart of digital transformation and promote digital equity.

The 2025 Manual arrives at a pivotal moment. As urbanization and digital transformation accelerate worldwide, cities face unprecedented opportunities to use technology to advance people-centred smart city development. Yet without a strong focus on equity, inclusion and human rights, digital innovation risks widening existing inequalities and further marginal-izing vulnerable groups – especially the more than 1.1 billion people living in informal settlements and slums. With an estimated 2.8 billion people affected by different forms of housing inadequacy worldwide, tackling the global housing crisis is thus positioned at the core of the UN-Habitat Strategic Plan 2026-2029.

Through the adoption of a people-centred smart city approach, UN-Habitat recognizes the scale and potential for digital technologies to advance adequate housing for all and accelerate sustainable urbaniza-tion. A people-centred approach ensures that tech-nology expands opportunity, safeguards rights, and strengthens resilience. It places inclusion, cultural identity, and social well-being at the core of innova-tion, enabling cities to harness digital tools in ways that reflect local realities while advancing global sustainability. By putting people first, smart cities can become hubs of shared progress where digital

transitions lead to more inclusive, safe, resilient and sustainable urban futures.

Aligned with the theme of World Cities Day 2025, this year's edition of the Shanghai Manual focuses on people-centred smart cities and underscores the need to place urban residents at the centre of smart city transformations. It presents more than 25 global case studies and policy considerations for urban leaders, offering lessons to guide digital transitions grounded in inclusion and human rights. The Manual highlights policies, frameworks and innovative actions that promote digital inclusion, protect human rights, strengthen transparency and accountability, and support environmental sustainability. From Kampala's digital platforms for sanitation service delivery in Uganda, to digitized cultural heritage in Ghent in Belgium, digital inclusion programmes in Belo Horizonte in Brazil, and India's Smart Cities Mission, the report illustrates how technology can be deployed effectively in diverse contexts when people are at the forefront.

Through the 2025 Shanghai Manual, UN-Habitat reaffirms its commitment to supporting cities worldwide in leveraging technology as a tool for inclusive urban transformation – connecting innovation with the everyday lives of people and communities, while addressing key challenges such as the global housing crisis. By showcasing exemplary initiatives, the Manual offers insight into adaptable strategies, practical interventions and replicable models that are driving people-centred urban change through digital technology in today's complex environment.

I encourage policymakers, practitioners, and partners to draw on the knowledge shared in this Manual and apply its lessons within their own urban contexts. I trust it will serve both as a guide and as an inspiration for bold action toward adequate housing and sustainable urbanization.

Anacláudia Rossbach

United Nations Under-Secretary-General

and Executive Director of UN-Habitat

Cities are not just places where people live and work; they are the stage on which the future of society is shaped. As urban populations grow and technology becomes increasingly embedded in daily life, the challenge is to ensure that progress serves people, communities, and the planet alike. The concept of "smart cities" offers immense potential, but its true success depends on innovation being at the service of human needs, inclusivity, and resilience.

This vision is rooted in the legacy of Expo 2010 Shanghai, whose theme, "Better City, Better Life", underscored the central role of cities in shaping humanity's future. Building on that foundation, the 2025 edition of the Shanghai Manual, titled "People-centered Smart Cities", explores how cities around the world are integrating new technologies in ways that strengthen social bonds, empower citizens, and foster sustainable growth.

From artificial intelligence to data-driven services, cities are experimenting with tools that improve quality of life, enhance governance, and enable more equitable access to opportunities. Yet the application of technology is not enough; to be of value it must amplify human potential, support local culture, and build inclusive communities.

This perspective resonates with the vision of Expo 2025 Osaka Kansai, which this year saw the international community gather under the theme of "Designing Future Society for Our Lives." Exploring human-centric approaches to the adoption of high-tech solutions, Expo 2025 Osaka Kansai highlighted innovation as a means to save, empower, and connect lives.

Echoing this vision, the 2025 edition of the Shanghai Manual demonstrates how cities are fostering these principles through concrete strategies. The

following chapters showcase real-life case studies that shed light on cities that are rethinking spaces, services, and governance to ensure inclusivity, particularly for often underrepresented populations. They also emphasise the power of collaboration, between governments, private sector actors, researchers, and communities, in enabling cities to become adaptable, resilient, and supportive of all forms of life.

By connecting technological innovation with human-centred planning, this edition of the Shanghai Manual invites city leaders, policymakers, and citizens alike to imagine and (re) build urban environments that are smart, sustainable, and socially vibrant. It is a testament to the idea that cities can be both engines of innovation and spaces where every individual can thrive.

Dimitri S. Kerkentzes

Secretary General of the Bureau International des Expositions (BIE)

# Acknowledgements

This annual report represents a collaborative effort, made possible by the contributions of many people.

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We also thank Mr. Dimitri S. Kerkentzes, Secretary General at the Bureau International des Expositions, Mr. Antoine Bourdeix and their team for their sustained support and assistance in editing and revisions of the annual report. Their efforts have allowed us to continue promoting the "Better City, Better Life" spirit of the Shanghai World Expo through the release of the Shanghai Manual and its annual report.

We also express our gratitude to our colleagues from the Ministry of Housing and Urban-Rural Development of the People's Republic of China for their positive support and valuable input in the compilation and review of the 2025 Annual Report.

We would also like to express our deep appreciation to Chen Jining, Secretary of the CPC Shanghai Municipal Committee; Gong Zheng, Mayor of Shanghai; Zhang Xiaohong, Vice Mayor of Shanghai; and Wang Weiren, Deputy Secretary of the CPC Shanghai Municipal Committee, for their support and care in preparing the annual report. We also gratefully acknowledge the valuable contributions of those who assisted in the development and coordination of this report, in particular to: Director Wang Zhen, Vice

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The Shanghai Coordination Center of World Cities Day rallied numerous expert teams to prepare this annual report. The leading experts from each team are: Dr. Wang Xin from UNEP-Tongji Institute of Environment for Sustainable Development; Professor Yu Hai from Fudan University and Associate Professor Sun Zhe from Shanghai University of Finance and Economics; Professor Zeng Gang and Associate Professor Zhu Yiwen from East China Normal University; Dr. Chen Haiyun from Tongji University; Research Fellow Ms. Shi Wen, and Ms. Sheng Yang from Shanghai Library (Institute of Scientific & Technical Information of Shanghai); Professor Peng Zhenwei and Professor Chen Chen from Tongji University; Dr. Zhu Yunjie from Shanghai Institutes for International Studies (listed in the order of chapters). Notably, Professor Yu Hai is responsible for the theme development and framework of the annual report as the chief expert. We also extend our heartfelt thanks and deep appreciation to all the authors for their outstanding contributions to this report.

Special commendation goes to our colleagues from the Development Research Center of the Shanghai Municipal Government who significantly contributed to the review of the annual report.

Lastly, we extend our thanks to China Architecture & Building Press and our translation service provider, YGYM Translation Service Co., Ltd., for their meticulous and thorough work.

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# Chapter One
## Introduction

# Introduction[1]

The rapid acceleration of digitalization is reshaping the foundations of urban life. From health and education to mobility and employment, digital technologies are redefining how cities function and evolve, demanding that urban areas adapt quickly to increase inclusion, equity and resilience in an increasingly digital world. The development of digital technologies presents the opportunity to increase the quality of life for urban citizens globally, reducing inequalities and leaving no one behind. Despite the rise of digital developments, however, approximately 2.6 billion people remain offline globally. [2] In line with the theme of "people-centred smart cities", the *Shanghai Manual: A Guide for Sustainable Urban Development in the 21st Century (2025 Annual Report)*, explores cutting-edge urban initiatives that pioneer data-driven decision-making, technology and artificial intelligence (AI) to improve urban life and support cities recovering from crises in line with sustainable urban development pathways. It showcases the 2025 Shanghai Award winning cities and presents over 25 case studies and associated policy suggestions across the core urban dimensions of society, economy, environment, culture, governance and international cooperation, to support global knowledge transfer and application among urban decision makers. It also presents a chapter dedicated to people-centred smart cities, laying out the core principles and global policy landscape that guide people-centred smart city development, as well as UN-Habitat's Smart Cities Flagship Programme.

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1　This chapter was written by UN-Habitat.

2　International Telecommunication Union. (2024). Global Internet use continues to rise but disparities remain, especially in low-income regions, ITU Media Centre. Available at https://www.itu.int/en/mediacentre/Pages/PR-2024-11-27-facts-and-figures.aspx (Accessed: 5/6/2025).

# Catalysing People-Centred Smart City Development

As urbanization accelerates and digital technologies become increasingly embedded in the fabric of urban life, the concept of the "smart city" has gained global prominence. Yet the true promise of smart cities can only be realized when technological progress serves people – addressing their needs, upholding their rights and empowering their aspirations. A people-centred approach to smart cities recognizes that technological advancement must be guided by principles of equity, participation, transparency and sustainability. Technology alone does not make a city "smart". It is how technology is applied, governed and shared that truly matters, enhancing well-being, building social cohesion and protecting human dignity, so that no one is left behind. The *Shanghai Manual* (*2025 Annual Report*) explores leading urban initiatives that embody these values, offering pathways toward more just, inclusive and resilient cities.

As defined by the United for Smart Sustainable Cities, a smart city is one that "uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that they meet the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects."[1] Around the world, digital infrastructure is increasingly intertwined with the systems that sustain urban life, from transport and energy to healthcare, education, housing and public spaces, creating new opportunities to enhance sustainability and liveability. As local governments undergo digital transformation, cities are increasingly leveraging technology to deliver public services, guide spatial planning and facilitate communication with urban residents. The boundary between the physical and digital city is dissolving. This evolving landscape demands governance models that protect human rights both online and offline, ensuring that technology serves the public good.

While digital innovations are transforming how people experience and interact with cities, much of the physical infrastructure that underpins urban life has struggled to keep pace. Rapid population growth is increasing demand for housing and infrastructure, while urban activities generate roughly 70 per cent of global greenhouse gas emissions, exacerbating inequality and threatening social cohesion.[2] Cities face mounting pressure to innovate, prompting the adoption of smart city approaches that integrate ICTs into planning and operations to improve efficiency, sustainability and quality of life.

Connectivity provides a foundation for these transformations. In 2024, approximately 83 per cent of urban residents worldwide were connected to the inter-

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1    As defined by United for Smart Sustainable Cities, the United Nations smart city platform coordinated by the Economic Commission for Europe, the International Telecommunication Union and the United Nations Human Settlements Programme.

2    IPCC, 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group Ⅱ to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H.O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.). Cambridge University Press. Cambridge, UK and New York, NY, USA. Available at https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FullReport.pdf.

net, enabling a range of smart applications.[1] Wireless sensors monitor traffic, energy consumption, air quality and water systems, while AI and cloud computing process vast streams of urban data to support predictive management. Mobile platforms enhance access to public services and enable civic engagement, and open data empowers citizens and entrepreneurs to co-create solutions. These innovations demonstrate that smart cities are most effective when technology empowers people, rather than simply automating urban systems.

Despite the potential, challenges remain. Digital systems generate enormous amounts of data but also increase vulnerabilities in cybersecurity and risk, leaving behind the most marginalized and deepening digital exclusion. A people-centred approach requires cities to strengthen cybersecurity while ensuring digital inclusivity, bridging the divide for those who remain offline. Privatization of digital infrastructure and services can limit public oversight and equitable access, undermining trust in institutions.[2] It is therefore imperative that smart cities continue to advance in security, inclusion and equity to truly serve their populations.

In order to achieve people-centred smart cities, human rights must remain at the forefront. They harness technology to improve quality of life, strengthen communities and support social, economic and environmental sustainability. Innovation is guided by participatory approaches ensuring that everyone,

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1　International Telecommunication Union. (2024). Global Internet use continues to rise but disparities remain, especially in low-income regions. Available at https://www.itu.int/en/mediacentre/Pages/PR-2024-11-27-facts-and-figures.aspx.

2　UN-Habitat. (2021). Centering People in Smart Cities. A playbook for local and regional governments. Available at https://unhabitat.org/sites/default/files/2021/11/centering_people_in_smart_cities.pdf.

especially vulnerable populations, can access digital services, skills and infrastructure. Multi-level governance and clear regulatory frameworks help ensure that technology serves cities' long-term development goals, rather than becoming an end in itself.

Therefore, in contrast to technocentric approaches to smart city development, people-centred approaches place citizens at the fore, using technology as a tool to empower communities. Achieving this requires inclusive planning, community participation and cooperative innovation that responds to local needs. Governments and public institutions play a central role, ensuring that technology not only promotes broad citizen engagement but also aligns with human rights and sustainable development frameworks, ensuring that as cities grow smarter, they also grow more inclusive, resilient and human-centred.

# 2025 Annual Report: At a Glance

In light of the convergence between urbanization and digitalization, the *Shanghai Manual* (*2025 Annual Report*, see Figure 1-1) highlights urban best practices to promote knowledge generation for the realization of people-centred smart cities. It presents outstanding urban initiatives across the six core development axes of: ① society; ② economy; ③ environment; ④ culture; ⑤ governance; and ⑥ international cooperation, showcasing exemplar case studies to provide reference for cities and urban decision makers. As a core output, each

| Theme | Objective | Chapter | Measures |
|---|---|---|---|

**2025 Shanghai Award Winning Cities**

**Accelerate sustainable urban development in line with the SDGs and New Urban Agenda.**

**Society** — Facilitate smart city design in urban communities: community–focused smart city initiatives integrate technology with social realities to address inequalities, foster participation and unlock the potential of digital solutions in urban life.

**Economy** — Smart city–driven industrial upgrading and innovation: economic development in smart cities combines digital infrastructure and industrial ecosystems with human capital, creating synergies that support economic innovation and competitiveness and inclusive urban growth.

**Environment** — Advance green, low–carbon and resilient cities: environmental aspects of people–centred smart cities integrate technology alongside ecological stewardship, promoting low–carbon living, resource efficiency and climate resilience for healthier communities.

**Ensure the ethical, inclusive and sustainable deployment of digital technologies to ensure that urban innovation contributes to equity, transparency and sustainability, leaving no one and no place behind.**

**Culture** — Embed cultural values in smart cities: smart cities reflect cultural heritage and social values where digital literacy, civic engagement and technology intersect to preserve identity, strengthen cohesion and enable inclusive participation.

**Governance** — Modernize urban management through AI: cutting–edge urban governance emphasizes integrated, data–driven decision–making, multi–stakeholder collaboration and the use of AI to enhance efficiency and citizen–centred services.

**Promote people–centred smart cities.**

**International Cooperation** — Facilitate smart city knowledge exchange across borders: people–centred smart city development benefits from international cooperation that facilitates mutual learning, shared standards and locally adapted innovation that is grounded in social needs.

**Enhance participatory and culturally responsive urban innovation that empowers communities, fosters social cohesion and reinforces the human dimension of smart city development.**

**People–Centred Smart Cities** — Design inclusive smart cities that work for people: people–centred smart city development places human well–being, equity and participation at the core of digital transformation, catalysing inclusive and equitable urban change.
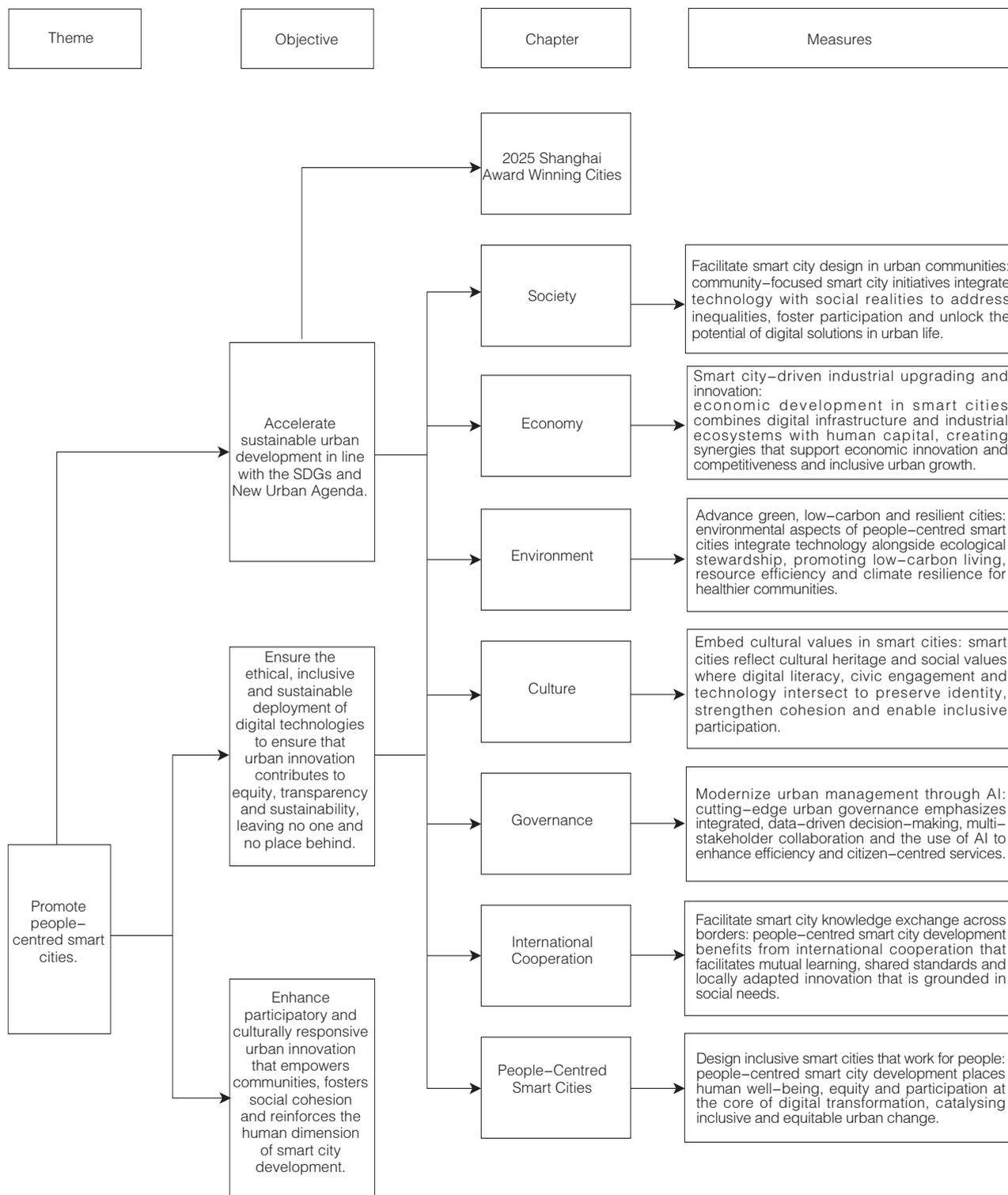
Figure 1–1　The structural and conceptual framework of the *2025 Annual Report*[1]

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1　Note that the chapter on the 2025 Shanghai Award winning cities serves as a supplementary component to the core contents of the manual.

chapter synthesises a series of actionable policy suggestions for real-world application. A specialized chapter on people-centred smart cities concludes the report.

The 2025 Shanghai Award acknowledges outstanding progress and achievements made by cities and municipalities globally in their implementation of the 2030 Agenda and the New Urban Agenda in regard to: delivering adequate housing for diverse needs; building people-centred smart cities together; accelerating green and resilience development that responds to climate change; and promoting effective governance for vibrant cities. The six core thematic chapters compile urban best practices within their respective domain, in which case studies are structured via three sub-sections including: ① case background which establishes the practice context and urban challenges addressed by the initiative; ② the implementation process which showcases the practice delivery process and solutions; and ③ reference experiences which operate as tools for knowledge transfer for urban development practitioners. The final chapter on people-centred smart cities reviews the current state of urban policy on people-centred smart city development and highlights the work of UN-Habitat's people-centred smart cities programme.

## 2025 Shanghai Award Winning Cities

Chapter two presents the winning cities from the Global Award for Sustainable Urban Development (2025 Third Shanghai Award). It illustrates winning initiatives from Algiers, Algeria; Bogotá, Colombia; Espoo, Finland; Incheon, the Republic of Korea; and Medina, Saudi Arabia. These practices illustrate how diverse, yet complementary approaches are helping cities globally to drive people-centred sustainable

urban development. Together, Algiers and Bogotá demonstrate the role of housing and community renewal in advancing social equity, resilience and livelihood opportunities. Espoo showcases how data-driven planning and civic participation strengthen inclusive and sustainable governance. Incheon highlights the integration of ecological restoration and clean energy transitions to achieve environmental resilience through broad-based cooperation, and Medina exemplifies the fusion of cultural heritage, ecological renewal and digital urban management to balance preservation with innovation. Together, these experiences reflect how cities across different contexts are harnessing technology, policy innovation and community engagement to build more inclusive, resilient and sustainable urban futures.

## Society

Chapter three explores the critical role of society in people-centred smart city development, highlighting how technology, including AI, can strengthen community connections, promote social inclusion and address inequities. It frames smart city design across three layers: the relational layer which responds to community needs and challenges such as digital divides and employment insecurity; the computational layer which ensures technology provides practical solutions grounded in social realities; and the visual layer which makes digital solutions accessible, understandable and participatory. Case studies illustrate how multi-stakeholder collaboration, community-driven initiatives and inclusive governance embed technology within social contexts, fostering resilience, youth engagement and equitable opportunities. The chapter underscores that

technology is most effective when applied as a social tool, enhancing human connections and empowering communities rather than driving change in isolation.

## Economy

Digital transformation is a key driving force for industrial upgrading and economic innovation. Chapter four highlights the capacity for smart city development to drive industrial upgrading and economic innovation, positioning cities as hubs of digital infrastructure, data and human capital. By integrating governance, industrial ecosystems and inclusive public services, smart cities reduce institutional barriers, foster collaboration and create feedback loops that transform data and real-world scenarios into innovation. Case studies from Changsha, Singapore; San Francisco, the United States of America; and Sèmè City, Benin illustrate how digital twins, specialized industrial zones and applied research programmes enhance competitiveness, stimulate talent development and promote inclusive growth. The chapter emphasizes that sustainable urban economic development requires aligning technology with industrial needs, institutional support and citizen engagement, enabling cities to convert innovation into tangible social and economic benefits.

## Environment

Digital infrastructure has the potential to both minimize the environmental impact of cities and help them to adapt to climate change and reduce the risk of natural hazards. Digital solutions enable cities to leapfrog outdated infrastructure systems, fast-track climate adaptation and in-build risk reduction measures from preparation through to evaluation phases. However, solutions extend further than physical hardware alone, in which data and citizen input is equally critical. To unlock their transformative potential, it is essential that digital solutions are deployed with strong ethical oversight and meaningful public participation. Chapter five explores the potential for capabilities such as smart monitoring and data analysis to mitigate environmental pollution, facilitate circular resource use, and accelerate zero-carbon development and climate resilience. It also assesses the role of data sharing and information sharing to enhance public awareness and participation on environmental sustainability actions in cities as well as the role of digital tools, including big data and geographic information technologies, to optimize the intelligent management of built systems from planning to urban disaster warning and emergency response capabilities.

## Culture

Culture plays a crucial role in shaping the sustainability and social resilience of cities in the development of smart cities. Chapter six examines the role of culture in shaping intelligent, people-centred cities, emphasizing that smart urban development relies not only on technology but on the knowledge, values and engagement of citizens. Culture, as a cornerstone of heritage and identity, informs how digital tools are applied to enhance urban life, support education, preserve heritage and foster social cohesion. Drawing on examples from Chennai, India; Seville, Spain; Suzhou, China; and Ghent, Belgium, the chapter illustrates how cities can integrate digital innovation with cultural stewardship to empower citizens,

strengthen community bonds and manage tourism and urban transformation sustainably. It underscores that successful smart cities balance technological advancement with respect for local identity, ensuring that cultural heritage becomes both a resource and a driver of inclusive, sustainable urban development.

## Governance

Equitable models of urban governance are key to ensure the development of people-centred smart cities. Chapter seven explores how AI is transforming urban governance in response to the growing complexity of global urbanization. As traditional models struggle to meet rising demands for efficiency, inclusivity and sustainability, AI emerges as a key driver of modernization – enhancing decision-making, public service delivery and collaborative governance. Drawing on case studies from Shanghai and Shenzhen in China; Espoo, Finland; Rio de Janeiro; Barcelona, Spain; India and Paris, the chapter illustrates how AI can optimize infrastructure management, promote data-driven policymaking and foster citizen-centred innovation. It emphasizes that successful smart governance requires more than technology: it depends on institutional reform, cross-sectoral collaboration, ethical oversight and public engagement. Ultimately, AI-enabled governance represents a shift toward more integrated, responsive and people-focused urban systems that advance sustainable development and equitable urban futures.

## International Cooperation

The role of regional, multilateral and cross-border cooperation among local governments, the private sector, international governmental organizations, academia and civil society remains pivotal to secure sustainable urban transitions on the global scale. Chapter eight thus unpacks the role of international cooperation in advancing people-centred smart city development, emphasizing that cities can learn from one another while adapting innovations to local contexts and citizen needs. Cross-border collaboration fosters knowledge exchange, shared standards, multi-stakeholder dialogue and coordinated technological innovation, ensuring that smart city initiatives are inclusive, equitable and aligned with the Sustainable Development Goals (SDGs). The chapter presents case studies from Chengdu and Nanning in China; and Bangkok, illustrating how international and regional partnerships can enhance urban quality of life, promote social participation and enable cities to co-create solutions that reflect local priorities, cultural identity and citizen needs.

## People-centred Smart Cities

Chapter nine explores how cities can harness digital innovation to drive equitable, sustainable and inclusive urban development. It examines the global policy and regulatory landscape shaping people-centred smart cities, highlighting both the opportunities and challenges related to digital infrastructure, data governance, human rights and environmental sustainability. The chapter presents leading global actions and frameworks that promote human-focused approaches in smart city planning and showcases successful initiatives demonstrating tangible social and environmental benefits. It also introduces

UN-Habitat's People-centred Smart Cities flagship programme and the draft *International Guidelines on People-centred Smart Cities*, which aims to guide governments and stakeholders in integrating inclusivity, equity and sustainability into urban digital transformation efforts.

# Case Selection and Principles

The case studies presented in this report show-case exemplary efforts in accelerating the development of people-centred smart cities and fostering sustainable urban development within their respective thematic areas. The cases are selected based on six primary criteria: ① acknowledgment as urban best practices; ② application of innovative urban solutions; ③ contributions towards advancing sustainable urban development; ④ contributions to promoting inclusive people-centred smart cities; ⑤ potential for adaptation and scalability across different urban contexts; and ⑥ measurable impact in advancing people-centred smart cities, see Table 1-1.

Case study selection criteria                                    Table 1-1

| Criteria | Description |
|---|---|
| Recognizable | Case studies are seen to have made outstanding contributions to sustainable urban development within their respective thematic domain, in which actions are reinforced with data-driven evidence to ensure credibility to the achievement. Case studies are therefore recognized as best practices at regional and international levels, for example: winning prizes via authoritative organizations or prestigious awards programmes; being recommended by official websites or publications; or having been critiqued by international journals (for ongoing projects this requirement is not mandatory). |
| Innovative | To address the complexities of cities, the application of innovation in urban initiatives is critical to ensure that urban development places people at the centre and realizes the SDGs at the local level. Case studies demonstrate innovative approaches in their respective contribution to advancing people-centred smart cities and, therefore, sustainable urban development. Innovations across planning, design, policy and governance spheres may include but are not limited to: infrastructure development; urban management strategies; physical planning and design; technological, digital and social innovations as well as community engagement and cooperation methods; policy approaches; and partnership building across respective thematic dimensions. |
| Sustainable | Case studies integrate principles contributing to sustainable urbanization within their respective thematic dimension supporting regenerative and sensitive urban development strategies. Case studies thus contribute to the global knowledge repository of model city practices that help drive sustainable urbanization in line with the overall theme of the report. |
| Inclusive | Case studies contribute to inclusive urban development, for example, via the incorporation and consideration of gender, age and/or under-represented/marginalized groups in regard to decision-making and actions. Cases actively facilitate social and gender equality, therefore increasing equity and inclusivity for marginalized urban inhabitants. |
| Replicable | Case studies demonstrate initiatives/strategies/models that can be replicated in different urban contexts such as different physical scales, populations, environments and cultures. In this regard, replicability may be demonstrated through scalability and transferability to diverse geographical or cultural urban settings, or ease of implementation in other cities and municipalities. |
| Contemporary | Case studies demonstrate impact on their respective domains within the last five years as exemplified through data or direct experiences. The implementation process of the practices may occur over a number of years before their results were delivered, however, cases should ultimately be up to date in regard to their positive impact and experience. |

Chapter Two
# The Best Practices of the Global Award for Sustainable Development in Cities (Shanghai Award) 2025 Winning Cities

# Introduction[1]

The world today stands at a critical juncture where accelerated urbanization intersects with global challenges. Poverty and inequality, housing shortages, climate change and governance dilemmas are severely testing the resilience and inclusiveness of cities. How to advance social transformation and achieve sustainable development while meeting basic livelihood needs has become a shared challenge for all humanity.

UN-Habitat remains steadfast in its conviction that cities embody humanity's vision for dignity, security and development. By advancing inclusive urban design, improving public services and infrastructure, and enhancing climate resilience, cities can become powerful engines for reducing poverty, narrowing inequality and enhancing well-being. Consequently, both the 2030 Agenda for Sustainable Development and the New Urban Agenda place cities at the heart of global strategy, explicitly committing to "no one should be left behind". This vision is not merely a declaration of values but a call to action, requiring continuous implementation through policy innovation and practical exploration.

Born from this vision, the Global Award for Sustainable Urban Development (Shanghai Award) was established. Jointly created by UN-Habitat and the Shanghai Municipal People's Government, the Shanghai Award centres on the core concept of Building a Sustainable Urban Future for All. It aims to recognize and promote innovative, systematic and replicable urban practices worldwide. As a global platform, it not only recognizes outstanding practices but also fosters policy dialogue, experience exchange and knowledge sharing, encouraging cities to become leaders in positive change.

The 2025 Shanghai Award continues the theme of Building a Sustainable Urban Future for All, focusing on four key areas: affordable housing that meets diverse needs; building people-centred smart cities; achieving green, low-carbon and resilient development; and promoting dynamic and efficient governance. This year, 85 applications from 33 countries across 5 continents were received, covering urban cases from diverse regions and stages of development. Following a rigorous evaluation process, an international panel of experts selected five representative winning

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1    The authors of this chapter are affiliated with Tongji University, including Wang Xin, Wu Jiang, Chen Xun, Li Zhuoqun, Lian Guoliang and Tan Siqi. The content herein is primarily supplemented by and summarized from the online application materials submitted by cities applying for the Shanghai Award. Unless otherwise specified, all images and data originate from the application materials of the respective cities.

cities based on criteria including impact, innovation, sustainability and adaptability.

Algiers, Algeria, significantly improved its public health conditions and social equity by relocating tens of thousands of families from unstable housing into well-equipped new communities through large-scale housing relocation and community renewal, enhancing urban resilience and sustainable development. Bogotá, Colombia, employed flexible housing subsidy mechanisms and public-private partnerships (PPPs) to provide decent housing for vulnerable groups. This approach simultaneously enhanced community environments and generated employment, fostering a more equitable and resilient urban fabric. Espoo, Finland, emphasized data-driven approaches and citizen participation in smart city development. By improving public transportation accessibility and sustainability, it has advanced people-centred urban planning and governance models. Incheon, the Republic of Korea, has advanced its energy transition centred on a hydrogen economy while integrating river ecological restoration. This approach has not only improved urban environmental quality but also strengthened environmental governance capabilities through extensive public and corporate participation. And Medina, Saudi Arabia, has combined ecological restoration, cultural heritage preservation and urban renewal. Utilizing digital platforms for effective urban management, it has enhanced resilience, promoted biodiversity recovery and stimulated local economic development.

These practices collectively demonstrate that despite differing developmental stages, economic conditions and social contexts, cities worldwide are responding innovatively to global challenges, showcasing diverse pathways to achieving sustainable development goals. Through institutional innovation, technological application and social mobilization, cities are becoming core forces in promoting equity, enhancing resilience and safeguarding well-being.

The choices cities make today will shape humanity's future. The Shanghai Award advocates for and honours the pioneers who dare to lead transformation with long-term vision and pragmatic action, driving global exchange and cooperation toward a more inclusive, equitable, green and resilient urbanization process.

# Algiers, Algeria Housing Resettlement and Urban Renewal

Algiers is advancing social inclusion, environmental resilience and digital governance simultaneously through large-scale housing programmes and smart city innovations, establishing itself as a model for sustainable urban development.

## 1. Development Context

### Overall Urban Development Situation

Algiers serves as the political, economic and cultural centre of Algeria. Situated on the Mediterranean coast, it is a major port and transportation hub in North Africa, see Figure 2-1. The city of Algiers has a population exceeding 3 million with its metropolitan area nearing 5 million residents, representing nearly 10 per cent of the national population, underscoring its pivotal urban significance. Economically, Algiers Port serves as



Source: Available at https://simple.wikipedia.org/wiki/Algiers.

Figure 2–1   Panoramic view of Algiers

the nation's largest commercial port, handling primary exports of oil, natural gas and mineral resources. Leveraging its oil and gas reserves, Algiers has become the economic hub of Algeria, contributing a substantial 40 per cent to the country's gross domestic product (GDP), see Table 2-1. As the capital, Algiers hosts the vast majority of the central government institutions, headquarters of the principal state-owned enterprises, key financial institutions and offices of foreign companies. This high concentration of resources continues to attract job seekers and migrants from across the nation.

Algiers basic city data    Table 2–1

| No. | Index | Data | Notes |
| --- | --- | --- | --- |
| 1 | Population | 3,283,000 | |
| 2 | Municipal administrative area size | 1,190 km$^2$ | |
| 3 | Built–up area size | 500 km$^2$ | |
| 4 | GDP per capita | USD 14,600 | |

## Primary Challenges Encountered

Algiers faces multiple challenges stemming from rapid urbanization, including the widespread existence of informal settlements, housing shortages, aging infrastructure, environmental pollution and climate change-induced issues such as floods and land degradation. The city must address social issues such as unequal access to public services, the digital divide and insufficient economic inclusion, urgently requiring systematic planning and innovative governance to achieve balanced and sustainable development.

## Overall Strategy

In recent years, Algiers has vigorously advanced urban renewal and strategic transformation with the goal of building a modern, sustainable and inclusive metropolis. Since 2016, the government has rolled out a series of development plans covering key areas such as transportation, housing, environment and digitalization. These initiatives are integrated into a long-term vision extending to 2030, systematically driving the optimization of urban structures and the enhancement of service capabilities.

## Action Strategy

In the realm of urban housing, Algiers has constructed over 84,000 social housing units through large-scale state-funded initiatives, successfully relocating more than 61,000 households from informal settlements to new communities equipped with comprehensive amenities. This effort has significantly enhanced living standards and social inclusion. The concurrently advanced Green Plan focuses on ecological restoration and environmental resilience, prioritizing the remediation of contaminated sites, expansion of urban forests and parklands, and strengthening biodiversity conservation and sustainable resource management. Additionally, the Yellow Plan is dedicated to developing a multi-modal public transportation system, improving road networks and constructing flood prevention facilities to enhance urban mobility and climate resilience. As a key driver, the Smart City Initiative comprehensively integrates AI, the Internet of Things (IoT) and big data technologies to optimize traffic, water and energy management. It promotes digital governance and public participation, fostering innovation and economic inclusion.

## 2. Feature Activities

### Launching a Large-scale Housing Resettlement Programme

Since 2014, Algiers has undertaken a massive, state-funded programme to eradicate informal settlements and rehouse affected families into newly constructed, fully serviced urban neighbourhoods. As of May 2025, over 61,000 families have been resettled from precarious conditions (slums, rooftops, basements, prefabricated chalets) into decent housing units integrated with public services (schools, playgrounds, healthcare, civil protection). The programme was backed by the construction of 84,000 sustainably developed rental units incorporating green spaces and basic urban infrastructure, see Figure 2-2.

The housing resettlement programme is rooted in the national goal of achieving an occupancy rate of 4.0 persons per housing unit. It is also aligned with the SDGs, particularly those related to social equity and urban resilience, aimed at eradicating precarious living conditions, improving public health and safety, and fostering inclusive urban growth. To meet this urgent need, Algiers developed a public rental housing programme, fully financed by the state and supported by a sophisticated logistical operation. The programme included the eradication of the Hai Remli slum in Gué de Constantine – once the largest slum in Algeria – and the redevelopment of major sites such as El Karrouche and Oued El Hamiz, with a total recovery of 750 hectares of illegally occupied public land. This land has since been redeveloped into infrastructure and housing projects, including the Great Mosque of Algiers and railway expansions.

The initiative has directly addressed housing shortages and social inequality while improving public health and educational outcomes. Its success lies in rigorous coordination between the Province of Algiers, the Ministry of Housing and local councils, with a logistical model enabling relocations of up to 1,000 families in under 24 hours. The programme's adaptability is demonstrated by the ongoing development of additional housing for the remaining 23,847 families still living in slums.

Complementing the resettlement effort, Algiers has implemented multiple housing schemes tailored



Figure 2–2    Newly constructed housing in Algiers

to income levels and demographic profiles, promoting inclusivity and social cohesion. For very low-income households, the public rental housing model, backed by decree No.08-1425, provides fully subsidized units. For middle and higher-income groups, housing options include rent-to-own schemes, participatory social housing, assisted promotional housing and public promotional housing, each offering state-supported financial mechanisms such as subsidized loans, direct grants and interest rate reductions. These programmes allow families who previously lacked access to property to become homeowners under fair and supportive conditions.

Algiers has also built in resilience through post-disaster housing policies. Following catastrophic events like the Bab El Oued floods (2001) and the Boumerdes earthquake (2003), a stock of emergency housing units are now kept in reserve to accommodate displaced families. Temporary shelters are deployed swiftly, and affected properties are either rehabilitated or replaced through state-funded reconstruction. This disaster-readiness is further bolstered by the Organisation de la Réponse de SÉcurité Civile civil protection plan which coordinates emergency response across housing, safety and humanitarian services.

Beyond the construction of homes, Algiers has focused on the integration of residents into well-designed urban settings. New residential neighbourhoods have been developed with landscaped public areas, schools, markets, healthcare facilities, civil protection stations and recreational zones. These urban improvements are part of the broader Master Plan for Development and Urban Planning 2015–2035 which outlines 82 major projects, including the new city of Sidi Abdellah and revitalization of the Casbah, to modernize Algiers and accommodate growing housing demands while preserving heritage and environmental sustainability.

To ensure quality control and governance, the housing strategy involves intersectoral coordination between the Ministry of Housing, the Ministry of the Interior, the Directorate of Housing, district authorities and local councils. Regular inspections, technical committees and joint meetings are conducted to ensure accountability and transparency in implementation. Additionally, the government has enacted legal instruments to address the proliferation of illegal and unregulated housing.

## Advancing Oued Smar Landfill Ecological Transformation Project

In response to climate change, land degradation and urban pollution, Algiers launched the Green Plan including a flagship project to transform Oued Smar landfill, a 45-hectare uncontrolled waste dump active since 1978, into a safe and accessible urban park.

The site, once a source of widespread pollution, now serves as a model for circular economy and climate resilience, reducing greenhouse gas emissions and providing a green space for public use. The project highlights how innovation and ecological planning can revitalize degraded urban land, aligning with broader city efforts to improve air quality, expand green space and raise environmental awareness.

Through extensive work, including excavation,

landfill sealing with multi-layer barriers, installation of 127 biogas capture wells and the deployment of a leachate treatment plant with a capacity of 720 m³/day, the site has been fully rehabilitated. A 637 kW cogeneration unit now converts captured methane into electricity, powering park infrastructure and significantly reducing greenhouse gas emissions. This project, completed in phases since 2010 and scaled up after 2016, is now a national benchmark for ecological restoration and sustainable urban land use, see Figure 2-3.

In the waste management sector, Algiers has advanced the transition to a circular economy through the public entity GECETAL. In 2015, a mega composting station was established for processing green waste into organic fertilizer. By 2025, over 530 m³ of compost has been produced. Inert waste recovery has also been prioritized. A high-capacity crushing and screening platform was installed in 2016, resulting in the recycling of over 999,000 tons of demolition materials for use in road construction. Plastic bag recovery chains, including a treatment line of 250 kg/hour, were launched in 2025, ensuring recycled plastic re-enters the production cycle. The biogas-to-electricity plant at Oued Smar now powers park operations, while a planned Energy Recovery Unit will further convert residual waste into energy, compost and recyclable materials, reducing landfill volumes by up to 80 per cent, preserving land, creating green jobs and protecting public health.

## Launching the Smart City Initiative

Since 2016, Algiers has launched sustainable de-



Source: Available at http://khouryengineering.com/?project=landfill−oued−smar−algeria−solution.

Figure 2–3   Oued Smar landfill transformation project

velopment initiatives focused on technological innovation and smart city transformation, aiming to establish the capital as a regional information technology (IT) hub and an international model for smart cities. The strategy leverages national and diaspora talent, vigorously promoting the application of AI, IoT and digital technologies in urban governance. Progress

is being achieved through hosting international conferences, establishing PPPs, supporting startups and promoting digital solutions.

In April 2017, with the support of the Prime Minister and several ministers, the First Conference on Innovative Startups was held, marking a significant turning point in building Algiers' digital ecosystem, see Figures 2-4 and 2-5. The conference fostered youth technology entrepreneurship, cross-sector collaboration and several acceleration programmes, and officially launched the Algiers Smart City project, co-led by internationally recognized AI expert Dr. Riad Hartani.

Subsequently, Algiers, in partnership with private incubators, organized multiple startup conferences, leading to the rapid emergence of a cohort of high-growth local companies in fields such as e-commerce, transport, health, culture, tourism, technology and the environment. The number of incubators increased significantly, while supporting legislation such as the laws on electronic communications, e-commerce and small and medium-sized enterprises (SMEs) promotion was enacted, providing an institutional framework for innovation.

In June 2018, Algiers hosted the inaugural Smart Cities Global Technology and Investment Summit, attracting over 4,000 participants, 100 international speakers and representatives from numerous governments and corporations. The World Bank announced three major initiatives: the creation of a startup investment fund; the launch of a coding school; and the development of the Algiers Platform to support technological leapfrogging and local innovation.

Multiple concrete projects were advanced simultaneously, including the Smart City Operating System, traffic management, smart water management and energy efficiency optimization, all emphasizing industry-academia-research integration and international cooperation. These actions have significantly strengthened the capital's position as a North African



Source: Available at https://frankrayal.com/2018/07/03/algiers-smart-city-project/.

Figure 2-4　The Smart Cities Global Technology and Investment Summit



Source: Available at http://www.xinhuanet.com/english/2018-06/28/c_137285443.htm.

Figure 2-5　The Algerian Prime Minister addresses the Smart Cities Global Technology and Investment Summit

technology and innovation hub, and provided a replicable pathway and experience for smart city development in the Global South.

## 3. Learning Aspects

### Impact

In terms of social impact, through systematic housing policies and social integration programmes, Algiers has significantly enhanced the quality of life for its citizens and social inclusivity. Multiple housing schemes, tailored to income levels, have ensured access to adequate housing for diverse groups, strengthening social cohesion. The post-disaster emergency housing mechanism has also played a critical role during natural disasters, demonstrating the city's strong commitment to protecting vulnerable populations.

In terms of environmental impact, Algiers has achieved breakthroughs in ecological restoration and climate resilience building. The successful transformation of the Oued Smar landfill site has significantly reduced greenhouse gas emissions. Citywide, over 5,000 hectares of urban forests and more than 3,000 hectares of parks and green spaces have been established, substantially enhancing carbon sequestration capacity and biodiversity, see Figures 2-6 and 2-7.

Economically, the Smart City Initiative has propelled the rapid development of the city's digital economy, attracting international investment that resonates with local innovation. The adoption of a balanced public-private financing model in housing and infrastructure sectors has alleviated fiscal pressure on the government while stimulating market vitality.



Source: Available at https://www.sohu.com/picture/726541010.

Figure 2–6    Hamma Botanical Garden



Source: Available at https://www.sohu.com/picture/726541010.

Figure 2–7    Outcomes of the Green Plan implementation

## Sustainability

Through its Master Plan for Development and Urban Planning 2015–2035, Algiers has adopted a comprehensive medium to long-term development strategy aimed at transforming the capital into a sustainable, inclusive and resilient metropolis. The plan closely aligns with the objectives of the 2030 Agenda and the New Urban Agenda, integrating over 80 strategic projects spanning housing, transport, environment and heritage preservation.

Algiers has implemented the principle of people-centred development in its sustainability efforts, establishing a multi-stakeholder collaborative governance system. By leveraging smart platforms to integrate government bodies, experts, communities and other actors, it pays particular attention to the needs of vulnerable groups. Through democratic consultations and digital tools, it promotes public participation, enabling residents to become co-creators of urban governance, thereby significantly enhancing the inclusivity and sustainability of policies.

In terms of financing and investment, the long-term implementation of the city's development strategy is supported by a combination of public funding, PPPs and emerging circular economy financing models. Since 2021, housing and infrastructure projects have shifted from being primarily funded by the central government (70 per cent) to a balanced public-private financing model (50 : 50), encouraging greater private sector involvement in housing and infrastructure. Green projects are led by public enterprises that achieve cost recovery, while the Smart City Initiative has garnered support from international institutions such as the World Bank. These diversified mechanisms enhance the city's financial sustainability and foster innovative, inclusive development.

## Innovation

In the realm of policy and legislation, Algiers has institutionalized the principles of sustainable urban development through systematic legislation. In the housing sector, for example, the city has integrated slum eradication and resettlement programmes into its core urban policies, utilizing relevant laws to regularize informal housing, thereby enhancing legal clarity and urban governance effectiveness. Additionally, Algiers has established intersectoral coordination platforms and technical committees, strengthening institutional collaboration and accountability mechanisms.

Guided by its Master Plan for Development and Urban Planning, Algiers is driving sustainable growth through 82 major projects. These include developing eco-cities, preserving green spaces and constructing integrated transport networks. Its innovative approach combines data-driven slum upgrading, participatory housing schemes and the integration of climate resilience into design, such as through green space restoration and flood prevention projects, achieving a transition toward an inclusive, livable and sustainable city.

## Adaptability

The practices of Algiers offer adaptable strategies for cities facing rapid urbanization, informal settlements and infrastructure deficits. The slum eradica-

tion and rehousing programme is a replicable model for cities tackling informal housing. Its integration of updated census data, intersectoral coordination and comprehensive resettlement, including schools, healthcare and public services, demonstrates how social equity and urban development can be advanced simultaneously.

In waste management, the city's approach to circular economy practices, including composting, demolition waste reuse and biogas recovery, offers scalable solutions for cities struggling with landfill overuse and environmental degradation.

The Smart City Initiative which engaged start-ups, universities and local talents, provides a template for cities aiming to foster innovation with limited resources. Its emphasis on public-private collaboration, digital tools and citizen-centric services is especially relevant for cities seeking to modernize governance and improve service delivery.

# Bogotá，Colombia
# My City，My Home

Under the theme My City, My Home, Bogotá has vigorously promoted the development of green infrastructure and liveable housing. These efforts have not only improved the city's ecological environment but also advanced social equity, creating a favourable setting for innovation and entrepreneurship. The city provides an outstanding example of building a safe, inclusive and resilient urban environment.

## 1. Development Context

### Overall Urban Development Situation

Bogotá, Colombia's capital and a major gateway to South America, is situated on the Andean plateau, see Figure 2-8. With a permanent population approaching 8 million, its advantageous geographical location and abundant human resources have established it as the core engine driving the nation's economic and social innovation, see Table 2-2. Today, Bogotá is accelerating its transformation into one of South America's most dynamic and promising global cities through strategic initiatives focused on smart planning, green transportation, open innovation and social inclusion.

Bogotá basic city data        Table 2–2

| No. | Index | Data | Notes |
|-----|-------|------|-------|
| 1 | Population | 7,181,469 | |
| 2 | Municipal administrative area size | 1,636 km$^2$ | |
| 3 | Built–up area size of the city | 307 km$^2$ | |
| 4 | GDP per capita | USD 12,321 | |

### Primary Challenges Encountered

Despite its strong growth potential, Bogotá faces profound challenges stemming from rapid urbanization, much like many global megacities. As the nation's second most climate-vulnerable city, environmental risks cannot be overlooked. On the socio-economic front, the city still has 283,000 households living in poverty, with 32 per cent of the workforce engaged in informal employment. Additionally, over 250,000 households require urgent housing improve-

Source: Available at https://commons.wikimedia.org/w/index.php?curid=76123284.

Figure 2–8　Panoramic view of Bogotá

ments. To address these issues, Bogotá is implementing public policies to create more inclusive, resilient and secure urban spaces by enhancing infrastructure, reducing regional disparities and removing barriers faced by vulnerable groups, see Figure 2-9.

### Overall Strategy

Within the framework of the SDGs, the New Urban Agenda and the National Action Plan, Bogotá is actively advancing its sustainable development strategy. Centred on the core principles of "resilience, inclusivity and innovation", the city is committed to enhancing residents' quality of life and driving green transformation. Its objectives include achieving significant greenhouse gas emissions reductions by the end of 2025, establishing a compact and livable urban structure, and promoting social equity and inclusion through public policy.

### Action Strategy

The city's action strategy encompasses multiple dimensions including climate, land use, social development and urban governance, with progress evaluated through quantifiable indicators:

(1) Climate action: through the Climate Action Policy, Bogotá set a target of 15 per cent emissions reduction by 2024 and a 50 per cent reduction by the end of 2025, alongside achieving carbon neutrality within the same timeframe. This policy drives ecological conservation, restoration and connectivity
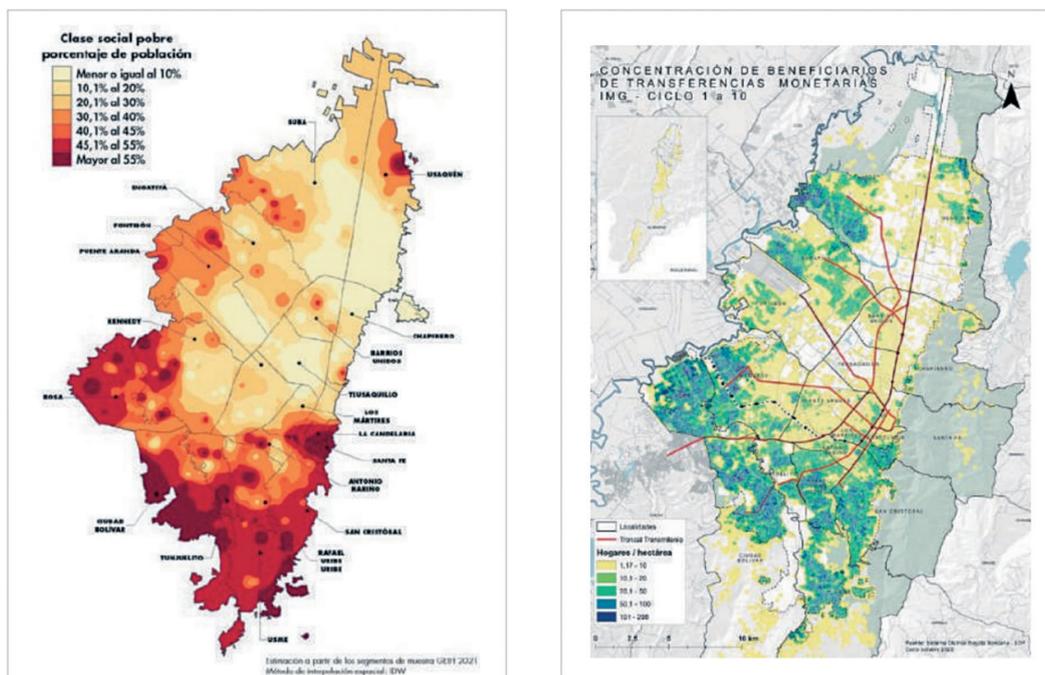
Figure 2−9    Spatial concentration of poverty in Bogotá (left) and households benefiting from policies (right)

initiatives to enhance the city's resilience to climate change.

(2) Land use and urban planning: guided by the Land Use Plan, Bogotá's urban planning emphasizes water-centred spatial organization, fostering proximity-based and care-oriented urban models. This approach promotes the rational use of natural resources and supports the development of climate-resilient habitats.

(3) Social inclusion and public spaces: human-centred local development initiatives like Safe Bogotá Walking improve housing and public service provision, enhancing living conditions and public space quality. By 2027, Bogotá aims to become a city prioritizing well-being and equal opportunities, enabling all residents to share development outcomes with fairness and dignity.

(4) Urban revitalization and governance innovation: Bogotá emphasises multi-sectoral collaboration and social co-governance. Through integrated urban projects, it seeks to balance development in established and peripheral areas, reducing residents' social, economic and environmental vulnerabilities.

## 2. Feature Activities

### Housing Programme–My House in Bogotá

The My House in Bogotá housing programme aims to meet the housing improvement needs of over 250,000 households by 2030, driving comprehensive economic and social transformation through housing, see Figure 2-10. The initiative goes beyond mere construction, emphasizing holistic improvements to the living environment. It integrates public services,
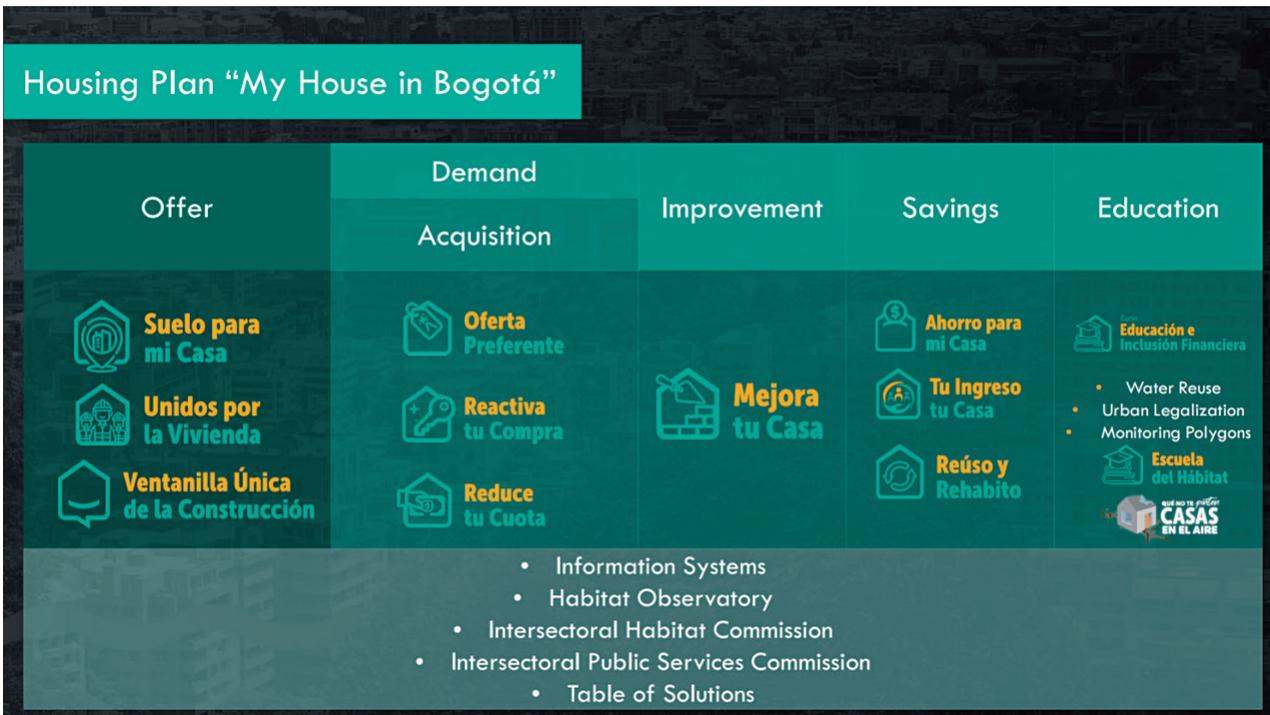
Figure 2–10　My House in Bogotá

infrastructure and social inclusion to foster a more equitable and resilient city.

Key measures include: ① tailored flexible subsidies and financing tools to support vulnerable families in accessing social housing; ② leveraging existing urban structures to increase housing supply in central areas, enhancing residents' convenience; and ③ promoting PPPs to build social housing in transit-oriented areas, closely integrated with public facilities, green spaces and employment opportunities.

The programme has commited to constructing 75,000 social housing units. Through three subsidy mechanisms — purchase, rental and improvement, combined with rural housing development and financial education training, it comprehensively supports vulnerable households earning less than four times the minimum wage (approximately USD 1,400). Between 2024 and 2027, every COP 1 trillion invested in housing construction and improvement will contribute COP 1.82 trillion to GDP and create over 40,000 direct and indirect jobs. Currently, over 43 per cent of social housing buyers have received municipal subsidies. Among the 10,000+ subsidies disbursed, 66 per cent benefited women, with 17 per cent going to female-headed households. By the end of 2025, the plan aims to distribute 24,000 subsidies cumulatively and identify 25,000 potential social housing units within designated revitalization zones.

The pilot district of San Cristóbal is projected to develop 2,717 housing units, prioritizing proximity to public services and ecological resources to foster sustainable, inclusive and neighbourhood-oriented living

patterns. Concurrently, Bogotá integrates informal settlements into the legal framework and implements improvements through mechanisms like the Human Settlements Improvement Intervention Plan. In formal urban areas, land management and cooperative development provide sites for approximately 80,000 social housing units and associated public spaces.

The Revitalize Your Neighbourhood strategy integrates housing with community governance across 20 priority districts. Through multi-departmental collaboration, community participation and investment consolidation, it not only optimizes housing supply but also promotes equitable community development and social cohesion by linking transportation, employment and green spaces — creating long-term momentum for urban renewal.

## Housing Finance and Social Support Programme–My Savings, My Home

To further alleviate housing pressures for vulnerable households, Bogotá launched the My Savings, My Home housing support programme, centred on financial subsidies and social protection. Through flexible subsidies and rental support, it provides stable, secure and sustainable living environments for low-income families, disaster-affected groups and female-headed households, see Figure 2-11. The scheme comprises:

(1) Rental support: through "solidarity renting", households unable to afford housing costs due to disasters or economic hardship receive a monthly rent subsidy of USD 67 per household for up to two months. By the end of 2022, 14,504 households had



Figure 2–11    My Savings, My Home

benefited.

(2) Savings-for-home support: My Savings, My Home provides low-income, female-headed households (including those affected by domestic violence, conflict victims and carers) with a monthly rental subsidy of USD 165 for up to 12 months, while encouraging households to independently save USD 55 monthly to jointly achieve homeownership payments. By the end of 2022, 3,907 households had benefited.

(3) Housing access and improvement: between 2020 and 2022, 8,644 social housing purchase subsidies were allocated, alongside the completion of 2,911 urban housing improvement projects and 182 rural housing improvement projects, enhancing living con-

Figure 2–12　Nearly 30% of the built–up area consists of informal settlements

ditions for tens of thousands of residents, see Figure 2-12.

　　(4) Housing legalization and title regularization: through establishing the Social Public Curation Office, the city advanced the legalization of unauthorised dwellings meeting seismic and planning standards. By the end of 2022, 750 legalization certificates had been issued. Concurrently, 2,345 land title deeds were distributed, providing long-term, stable property rights security for households from informal settlements.

　　Through this programme, Bogotá has achieved breakthroughs in housing finance innovation and social inclusion, enhancing housing security for vulnerable households while advancing equity and sustainable development in the urban housing market.

## Sustainable Mobility and Urban Connectivity

　　The Bogotá-Cundinamarca Metropolitan Region has established a regional vision for sustainable multimodal mobility. By 2035, the city plans to complete 80 km of metro lines, 100 km of regional tramways, 154 km of high-capacity green corridors, 20 km of cable car systems, 19 km of bicycle highways with additional medium-capacity green corridors and supporting multimodal hubs.

　　To enhance system efficiency, Bogotá prioritizes: ① expanding Bus Rapid Transit stations and corridors; ② introducing over 1,400 electric buses to comprehensively advance public transport electrification; ③ constructing cable car systems covering areas with complex topography and inadequate connectivity, including Ciudad Bolívar and San Cristóbal; and ④ commencing the first metro line construction while simultaneously advancing key feeder corridors (such as Avenida 68 and Cali Boulevard).

　　Among these, the San Cristóbal cable car project exemplifies Bogotá's innovative sustainable mobility

solutions. Located in the eastern mountainous district, San Cristóbal has long faced connectivity challenges due to steep topography and unplanned development, with over 400,000 residents relying on lengthy walks or informal transport links. This project features a 2.87 km cable car line capable of transporting 4,000 passengers per hour in one direction, reducing travel time by 72 per cent and providing direct connections to the Bus Rapid Transit system, see Figure 2-13.

Beyond enhancing transport accessibility, this initiative improves access to education, employment, healthcare and cultural services through a sustainable, safe and dignified alternative mode of travel, effectively bridging social and spatial divides.

## Community-led Neighbourhood Beautification Initiative-Magical Territories Initiative

The Magical Territories initiative empowers residents as co-creators of their urban environment, fully mobilizing community engagement to foster a sense of belonging and responsibility. Through neighbourhood workshops, cultural events and on-site transformations, residents not only contribute ideas but actively participate in environmental renewal. Specific measures include: collaborative community mural painting; creating vertical green walls and pocket gardens; refurbishing small public squares; and implementing micro-upgrades to footpaths and recreational spaces. These actions breathe new life into neighbour-
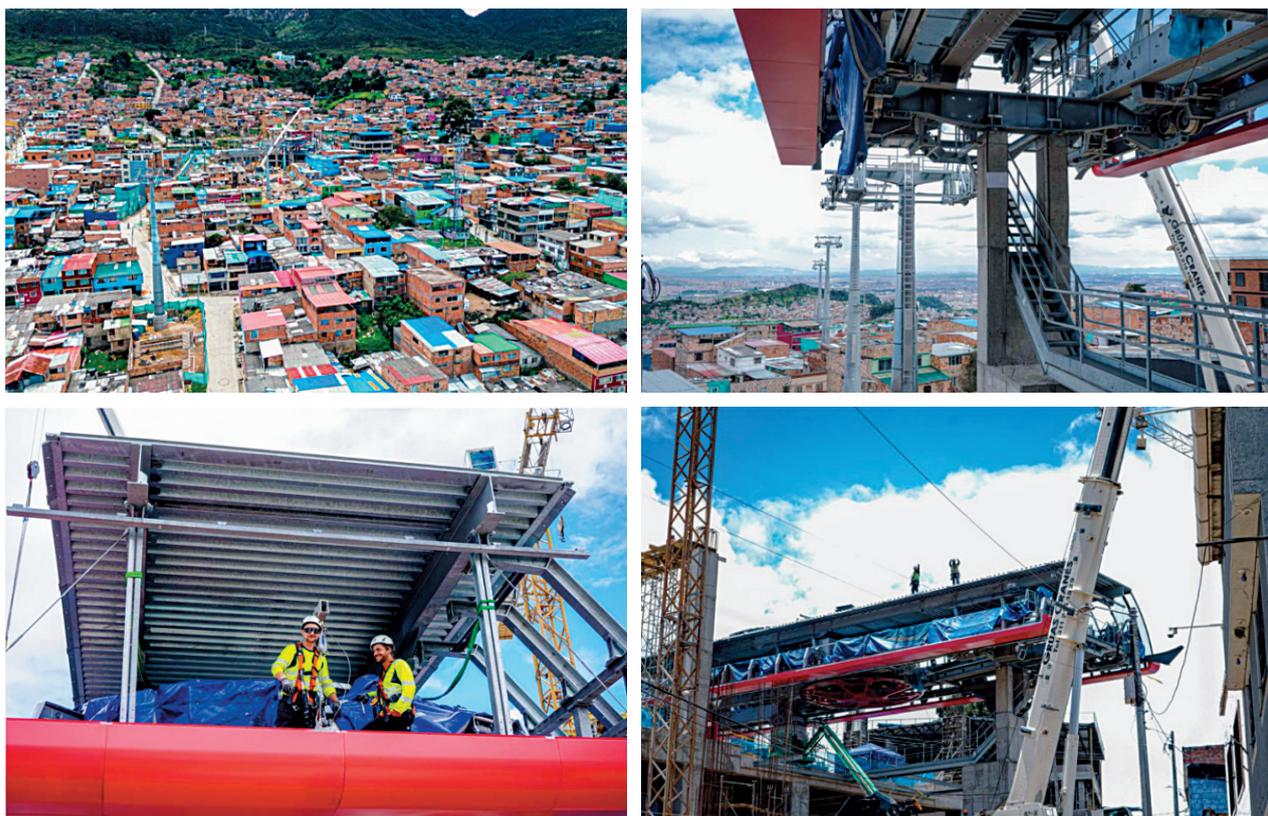


Figure 2-13    The San Cristóbal cable car project

hoods, enhancing overall aesthetics and liveability while strengthening neighbourly bonds. They foster environmental awareness and long-term stewardship of public spaces. Crucially, each transformation bears the residents' imprint, equipping them with practical skills and confidence to pursue other environmental improvements, see Figure 2-14.

## Climate Action and Ecological Conservation

In 2021, Bogotá launched its climate action policy as the core roadmap for mitigating and adapting to climate change, establishing a clear phased target to reach carbon neutrality by 2050, see Figure 2-15. At the implementation level, Bogotá introduced over 1,480 electric buses to advance comprehensive



Figure 2-14　Magical Territories
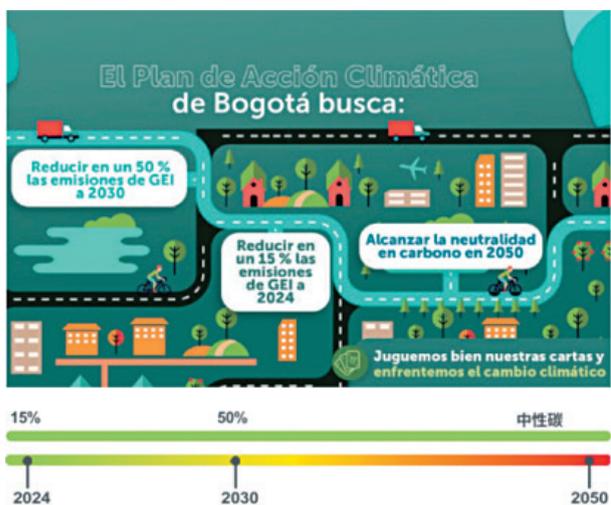
Figure 2–15   Climate Action Policy mitigation targets

low-carbon transformation of its transportation system; supported businesses in improving energy and water resource utilization; and encouraged SMEs to reduce emissions through innovative technologies. It extracts and utilizes biogas from the Doña Juana landfill, while the Salitre Wastewater Treatment Plant collects and utilizes biogas, further reducing environmental burdens.

For risk management and ecological conservation, the Institute for District Risk Management and

Climate Change is developing relocation procedures for residents in high-risk areas, and conducting diverse awareness campaigns and education to enhance community disaster preparedness and adaptation capacity. Bogotá actively promotes ecological conservation and restoration in the Eastern Mountain Range, introducing vegetation protection incentives to encourage citizen and civil society participation in ecosystem maintenance.

The citizen conservation initiative in the Vander Hammen Forest Reserve, see Figure 2-16, aims to connect the Eastern Mountain Range with the western Bogotá River, preserving its ecological corridor function for endemic species. Despite facing urbanization pressures, local communities and multiple social organizations have sustained advocacy and action — through tree-planting campaigns, ecological workshops, cultural events and multi-stakeholder alliances — engaging over 6,000 residents in conservation practices. This process has not only strengthened public awareness and responsibility toward ecosystems but also compelled governmental fulfillment of conservation commitments through social oversight



Figure 2–16   Citizen tree–planting activity in the Van der Hammen forest reserve

mechanisms. Overall, Bogotá is progressively building a future-oriented urban ecosystem characterized by low-carbon, resilient and inclusive development.

## 3. Learning Aspects

### Impact

Through the My House in Bogotá initiative, Bogotá has improved housing conditions for low-income families, created employment opportunities and narrowed community development gaps. Enhanced public spaces and essential services have strengthened community cohesion and social resilience.

Environmentally, Bogotá promotes green buildings, energy-efficient designs and rainwater harvesting, conserving millions of cubic metres of water annually and reducing carbon emissions by tens of thousands of tons. The city aims for a 50 per cent emissions reduction by 2035 and carbon neutrality by 2050. Electric cable cars, bicycle lanes and solar installations have become integrated into daily life, balancing urban development with ecological conservation and low-carbon growth.

Economically, the housing and revitalization strategy enhances land and financial management through land reuse and innovative leasing models, benefiting 1 million people and creating over 7,000 jobs in four years. The revitalization index optimizes investment allocation, while PPPs bolster investment confidence, driving green consumption and social equity.

### Sustainability

Bogotá's Revitalize Your Neighbourhood strategy, particularly its implementation in San Cristóbal, aligns with the National Action Plan and the 2030 Agenda for Sustainable Development. By formalizing informal settlements, the strategy extends public investment to roads, public spaces and social services, improving conditions in long-neglected communities. The Urban Revitalization Index continuously monitors outcomes. Simultaneously, the city employs diverse territorial management tools — including green building standards, sustainable drainage systems and risk monitoring mechanisms — to balance ecological preservation with urban development, comprehensively reducing its carbon footprint.

The revitalization strategy emphasizes service accessibility and community inclusivity. The government guides community-business co-governance, prioritizing the needs of minority groups and vulnerable populations. Through oversight committees, community service points and participatory design workshops, residents have a voice from planning to implementation, improving the environment while enhancing community cohesion and belonging.

In financing, Bogotá employs cross-departmental collaboration and PPPs to advance cable car projects and surrounding area transformations. Funding relies not only on the fiscal budget but also leverages mechanisms, land value capture and diversified investment channels to ensure sustainability and a reinvestment cycle.

At the institutional level, Bogotá incorporates ecological restoration, climate resilience and urban design into its long-term goals through the Comprehensive Territorial Plan and the Four-Year Urban

Development Plan. The Land and Infrastructure Committee strengthens cross-departmental coordination and oversight, institutionalizing revitalization outcomes. This creates a sustainable development framework combining fiscal security, social participation and institutional innovation.

### Innovation

Bogotá advances sustainable development through multiple policy and institutional innovations. The Land Use Plan establishes a 12-year blueprint balancing environmental, social and economic priorities while enhancing the city's resilience to climate and public health risks. The Safe Walking Zones Plan improves safety and well-being through public space renewal. The Eco-City and Sustainable Construction Policy comprehensively guides the green transition.

In planning and design, the city adopts the "sponge city" concept of green infrastructure and clean mobility systems to improve ecology and transportation while promoting old building reuse and green housing. Governance emphasizes collaborative co-management, and fiscal sustainability is ensured through diversified funding and inclusive financing. Through PPPs, land value capture and commercial spatial development, Bogotá has established a stable investment and financing cycle, injecting momentum into long-term urban revitalization.

### Adaptability

Through a series of forward-looking planning projects and policy practices, Bogotá has become a global model for sustainable urban development and resilience building. The integrated revitalization project along the San Cristóbal Cable Car has become an international reference for addressing similar social, economic and urban challenges. Bogotá developed the Urban Revitalization Index and the Human Settlements Management Toolkit, scientifically prioritizing investments based on analyses of social vulnerability, urban infrastructure gaps and climate risks. This approach not only enhances the precision of decision-making but also ensures the long-term benefits of revitalization projects.

Bogotá also prioritizes clean sustainable transportation, community participation and cross-agency collaboration in its practices, placing social welfare and sustainable development at the core of its policies. Through these methods, the city transforms local challenges into development opportunities, thereby strengthening community cohesion, inclusivity and urban resilience.

# Espoo, Finland
# Co-created and Shared
# Urban Governance

Espoo's emphasis on technological innovation, the participation of diverse stakeholders and the institutional guarantee of multi-level participatory mechanisms have provided significant support for sustainable development. It has a significant influence and is an exemplary role in Europe and globally.

## 1. Development Context

### Overall Urban Development Situation

From a peripheral and small town to the second largest city in Finland, Espoo is now not only a vibrant metropolis but also a city of innovation that is highly attractive to the international community, see Figure 2-17 and Table 2-3. It has been recognized as the most sustainable city in Europe (Teloos 2016, 2017), as one of the first pioneering Learning Cities in the world (United Nations Education, Scientific and Cultural Organization-UNESCO-Global Network of Learning Cities 2016) and the most intelligent community in the world (Intelligent Community Forum 2018).

Espoo is building a sustainable future through five key dimensions: ① implementing innovative solutions for transportation, construction and energy in the infrastructure sector; ② integrating courses on sustainable lifestyles into the education system; ③ providing cultural, sports, social medical facilities and other services that promote well-being in social services, and continuously maintaining comfortable and pleasant green spaces; ④ promoting sustainable transportation methods in the construction of a low-carbon environment and striving to achieve carbon neutrality by 2030;



Source: Available at https://www.bcs.org/articles−opinion−and−research/espoo−an−intelligent−city/.

Figure 2−17   Aerial view of Espoo

and ⑤ providing social assistance to families whose income is insufficient to cover basic expenses and reasonable housing.

Espoo Basic City Data          Table 2-3

| No. | Index | Data | Notes |
|-----|-------|------|-------|
| 1 | Population | 320,000 | |
| 2 | Municipal administrative area size | 528 km$^2$ | |
| 3 | Built-up area size | 100 km$^2$ | |
| 4 | GDP per capita | USD 74,300 | |

## Primary Challenges Encountered

At present, there are still people and families with financial challenges such as not being able to pay for electricity. In 2023, approximately one in five working-age adults (aged 20~64) had to compromise on food or healthcare due to lacking funds. Among Espoo residents over 20, satisfaction with quality of life has decreased since 2020.

## Overall Strategy

The Espoo Story is the city development strategy of Espoo. It has taken sustainable development as its primary principle and advocates that the city's operation should be jointly formulated and guided by residents, employees and companies. The city budget and financial plan of Espoo are all derived from this strategy. Each department and unit has developed its own "story" based on the common goals of the strategy and the term of the city council. Implementation of the strategy is reflected in all aspects of daily life. Its values emphasize a people-centred approach, encouraging innovation, advocating research and adapting to changes. Through active participation and collaboration, it ensures the smooth operation of all necessary activities. At the same time, Espoo adheres to the concept of fairness, and through transparent governance and an inclusive and equal operation mode, creates an inclusive social environment for all.

## Action Strategy

Espoo is making every effort to integrate the SDGs into all actions, making them an important part of the city's strategy, see Figure 2-18. Sustainability has become a guiding value and is fully integrated into the city's governance structure, public service system and cultural fabric. Key initiatives include:

• Sustainable project management: tools and training are being provided to city employees to incorporate sustainability into development projects.

• Data-driven decision-making: Espoo is building a knowledge base to support informed and holistic sustainability choices.

• Staff education: workshops and regular training help employees understand how their roles impact sustainable development.

Espoo also participates in international collaboration through the European Union-funded URBACT Cities for Sustainability Governance project, leading efforts among nine European cities to deepen sustainability within city governance.

## 2. Feature Activities

### My Espoo on the Map

My Espoo on the Map is a groundbreaking par-

Figure 2–18　The Espoo Story

ticipatory survey that collects residents' experiences, views and ideas through a digital mapping tool, directly influencing urban planning. It was launched in 2020 as a collaborative effort between Espoo and Aalto University to gather insights on urban functionality and development. The survey allowed residents to mark locations on a map that they found important or in need of improvement.

Conducted in both 2020 and 2024, My Espoo on the Map guides long-term strategy by integrating resident insights into city development at the start of each city council term, see Figure 2-19. The 2020 survey generated nearly 70,000 entries, especially from traditionally under-represented groups including children, youth and foreign-language speakers, see Figure 2-20. Even people with visual impairments

could fully participate in the survey, and its scale and inclusiveness were unique worldwide. At present, the survey has accumulated over 100,000 location-based entries, providing an unprecedented perspective for understanding residents' life experiences. The collected data is being used in urban planning and research, particularly within the NordGreen project at the Nordic Nordregio research centre.

## Three Dimensional City Model

In 2019, Espoo was the first European city to launch a constantly updated three dimensional (3D) city model as an open interface service, see Figure 2-21. City information modelling (CIM) integrates intelligence, rich data, visualization and real-time updates, and covers all the main elements of the urban

Source: https://www.espoo.fi/en/news/2024/11/espoo−residents−very−actively−responded−my−espoo−on−map−survey.
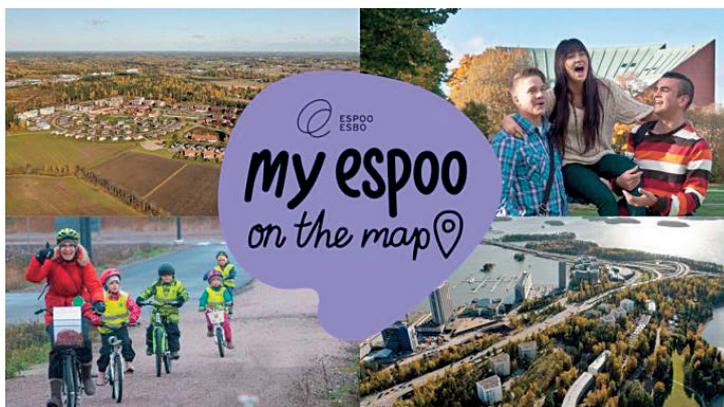
Figure 2−19    My Espoo on the Map poster



Source: https://www.espoo.fi/en/news/2024/11/espoo−residents−very−actively−responded−my−espoo−on−map−survey.
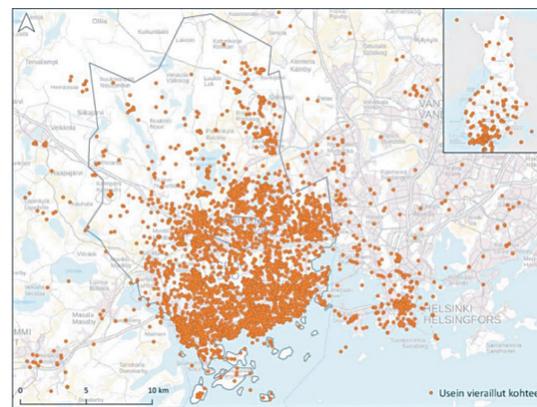
Figure 2−20    The most frequently visited places marked by children and young people in My Espoo on the Map
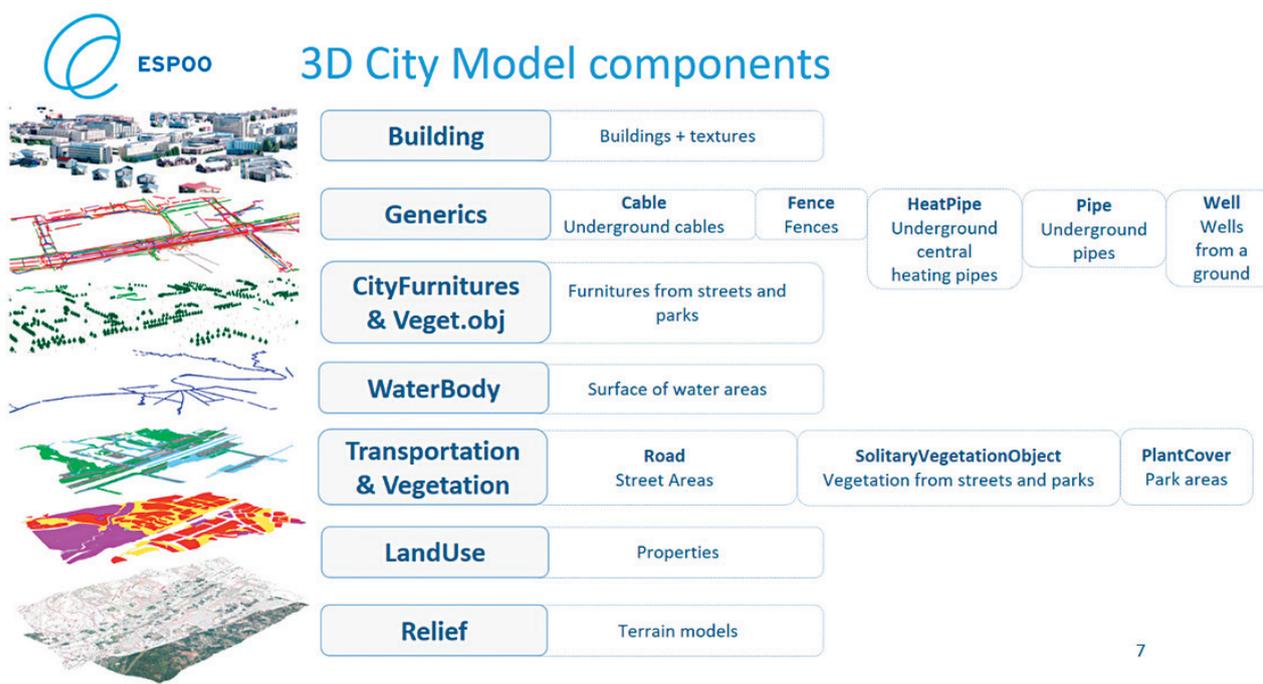


Source: Available at https://kartat.espoo.fi/3d/index_en.html.

Figure 2−21    Components of the 3D City Model

structure from land use to infrastructure, including the existing building stock of the city and the streets, parks and water systems. It can also be used to provide information on town planning, building control and landed property, and assists in planning and decision-making to more efficiently reflect the current state of the city. With its rich and diverse data system, it can support multi-dimensional analysis of the urban structure and infrastructure of Espoo. The platform can also store and share data. Through open interface services, everyone can use the real-time updated city model and provide fertile ground for the creation of

### Housing Improvment Project

In terms of affordable housing and rental housing, Espoo builds 400 new residential units every year through the municipal agency Espoon Asunnot, focusing on developing small-sized apartments in areas with growing transportation hubs. City rental apartments have a price advantage over private housing and also offer the "right-of-occupancy housing" model, which is a middle form between rental housing and owner-occupied housing – a type of nationally guaranteed housing. Once residents have received a queue number, they can apply to the owner of the building for a right-of-occupancy appartment. Once their application has been approved, they must pay an occupancy fee and monthly living expenses to the apartment owner, thus enabling residents to have a stable home. Espoo currently has approximately 6,600 completed or under-construction right-of-occupancy apartments, see Figure 2-22.

To promote balanced urban development, Espoo ensures housing caters to individuals from diverse



Source: Available at https://www.espoo.fi/en/housing−and−building/housing/right−occupancy−apartments.

Figure 2−22　Right−of−occupancy apartments in Espoo

backgrounds and circumstances. Special attention is given to residents with specific needs, such as senior citizens and people with disabilities, through supported and service housing options. Assisted living arrangements provide personalized care, helping individuals maintain independence while receiving the necessary support. The city also provides financial advice, urgent housing allocations and social services to those at risk of homelessness. This proactive strategy helps individuals build stability, reducing long-term social inequality.

Espoo integrates carbon-neutral solutions into housing initiatives. The city strives to create energy-efficient homes that align with its goal of achieving carbon neutrality by 2030. The use of low-carbon construction materials and an emphasis on eco-friendly urban design underscore Espoo's commitment to long-term sustainability. Espoo prioritizes green spaces in residential planning, ensuring neighbourhoods are not only livable but also environmentally friendly. Public transportation access is a key factor in new housing developments, reducing reliance on cars and promoting sustainable mobility. For example, a brand-new tram line was built between Espoo and Helsinki and launched in 2023, see Figure 2-23. Espoo also keeps improving its bicycling infrastructure to encourage sustainable and net-zero transportation.

### Autonomous Shuttle Bus

In Autumn 2019, Espoo and Sensible 4 launched a pilot project providing a self-driving shuttle bus in the Kera area, see Figure 2-24. The key point of the project was to offer last-mile transportation to em-
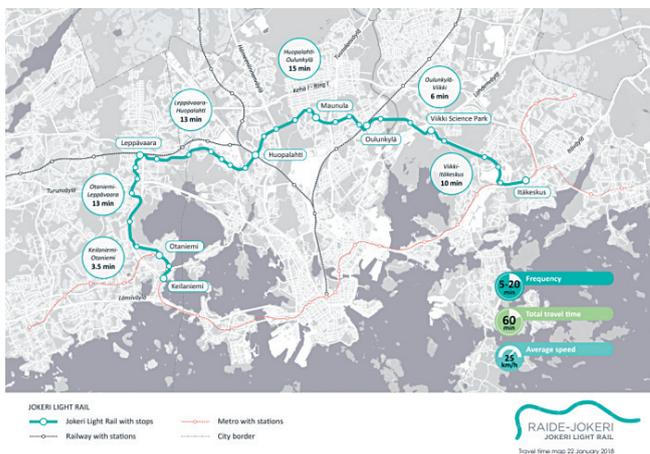
Figure 2–23    The tram route and tram between Espoo and Helsinki



Source: Available at https://sensible4.fi/gacha/.

Figure 2–24    Autonomous shuttle bus

ployees, for example, between the railway station and an office building. If successful, the project would effectively reduce the number of vehicles on the road, create a safer and more comfortable traffic environment, and provide safe, economical and sustainable transportation services for citizens.

The shuttle bus can accommodate approximately 16 people. Its circular-shaped seats are designed not only for comfort but also to encourage social interaction among passengers. This bus is also capable of adapting to various weather conditions and can even travel safely on the snow-covered roads in Finland during the winter when the temperature can drop to −28℃ .

## Reuse of Biogas

The biogas produced by Nordic energy company Gasum is made in Finland from biodegradable waste from households, agriculture and businesses, among others – and it is 100 per cent renewable. The use of biogas for transport can reduce the greenhouse gas emissions generated during the life cycle of fuel by up

Figure 2−25　IKEA gas filling stations in Espoo

to 85 per cent. The use of biogas also reduces emissions from city traffic, such as nitrous oxides and particulate matter, which significantly improves air quality in cities. Gasum owns 13 biogas plants in Finland and Sweden, and the company also buys biogas from three partner plants in Finland. The current volume of biogas produced in the metropolitan area (including Espoo) corresponds to the annual fuel demand of approximately 1,000 buses or 30,000 passenger cars.

Gasum and IKEA Finland formed a partnership in 2017 resulting in the production of renewable and low-emissions biogas from biowaste from the restaurants of IKEA stores. At the same time, gas filling stations were built next to IKEA stores for both IKEA customers and other users of gas vehicles, see Figure 2-25. More than 80 companies in Espoo have reduced their emissions by using biogas for transportation.

## 3. Learning Aspects

### Impact

My Espoo on the Map informs academic research and supports the city's master plan development up to 2060 by systematically integrating the data into decision-making. The 3D city information model serves as a baseline data model, providing a reliable basis for planning. The model is distributed through an open interface so it is also available to actors outside the city organization. This saves planning agencies time during the initial data editing phase, reduces the implementation time of development projects and improves the city budget. At the same time, the model facilitates new innovations and solutions, and provides a platform for testing them. This city creates a safe, inclusive and barrier-free community environment by providing safe, accessible and affordable rental housing, promoting social fairness and stability.

In terms of the environment, energy-efficient buildings, low-carbon building materials and a comprehensive recycling system reduce carbon emissions throughout the building's life cycle, and enhance the city's ecosystem services through green integration and ecological design. At the transportation level, new tram lines, improved bicycle infrastructure and the

implementation of autonomous shuttle bus pilot projects have effectively reduced reliance on private cars, lowered greenhouse gas and air pollutant emissions, and improved traffic safety and efficiency. At the energy level, the transformation of urban district heating has been achieved, and biogas utilization converts biological waste into 100 per cent renewable energy. In the transportation sector, it can reduce greenhouse gas emissions by up to 85 per cent and significantly improve urban air quality by reducing nitrogen oxides and particulate matter, see Figure 2-26.

## Sustainability

By using an ecosystem-based approach, Espoo will advance business activities, the green transition, employment and the economy while reducing emissions and enhancing well-being. In terms of sustainability, Espoo is committed to pioneering the SDGs. Espoo strives to: ① lead in achieving the 17 SDGs, setting national and international examples; ② achieve carbon neutrality, working to combat and adapt to climate change; ③ encourage sustainable lifestyles, fostering sustainability in daily life and enhancing city practices to support SDGs; ④ become a model for sustainable urban development and improve urban well-being by involving businesses and research partners in city development; and ⑤ lead sustainable innovation, serving as a research and development (R&D) hub, facilitating partnerships and European Union funding allocation. The city will stabilize ecosystem work, enhance local economic growth and encourage digitalization in sustainable solutions. In addition, Espoo, together with the Technical Research Centre of Finland, has been
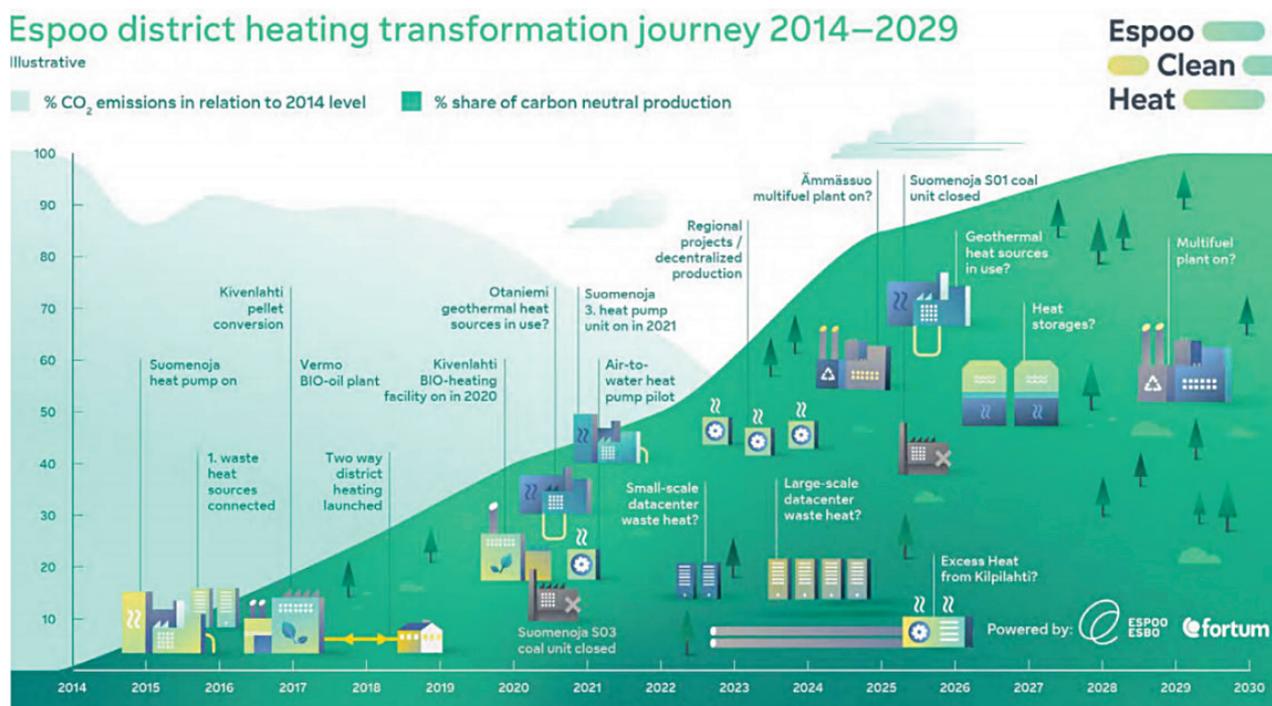


Figure 2−26   Espoo district heating transformation journey 2014‐2019

developing metrics to monitor and evaluate the implementation of the strategy within a dynamic urban environment since 2019.

In terms of financing and investment, Espoo increasingly utilizes European Union funding for sustainable development of the city together with European partners. The budget approved by the city council sets out the revenue estimates for the sectors that provide basic services to citizens.

In the aspect of institutional capacity building, Espoo has integrated the SDGs into planning, budgeting and performance monitoring, ensuring that sustainability is the foundation of how the city operates. A defining feature of Espoo's approach is its shift toward integrative public leadership. Moving away from hierarchies, the city fosters collaboration and encourages co-creation with residents and stakeholders. This nurtures innovation and inclusivity. Espoo has also embraced experimentation through pilot initiatives such as the Espoo Climate Community. This strategy helps the city retain institutional memory and build resilience over time. Espoo regularly assesses its progress through Voluntary Local Review (VLR) and other monitoring mechanisms, and actively engages with multi-level and multi-actor governance and works closely with national authorities, European networks, non-governmental organizations (NGOs), academia, businesses and citizens to design and implement sustainable urban solutions.

## Innovation

In the aspect of policy and legislation, Espoo produces a broad report on all of the city's activities each year. To support a transparent and inclusive policymaking and legislation, Espoo has also developed an online reporting tool where everyone can follow the progress of the city's actions. This includes an evaluation of the city's performance concerning the 17 SDGs of the United Nations Agenda 2030.

In the aspect of planning, city planners used insights from the My Espoo on the Map survey which highlighted key locations and ideas important to the community. The survey results were shared with residents, and a workshop on land use and traffic was held to discuss the area's development, see Figure 2-27. Participants outlined their area's current and future characteristics using maps for reference. They created a future atmospheric map, incorporating images that reflected survey responses and word clouds created based on residents' feedback.

In terms of urban governance, the Code of Conduct applies to various behaviours including the working methods of elected officials and staff, supporting the realization of a series of the SDGs. This rule supports the SDGs at large, ensuring that urban



Source: Available at https://www.ikea.com/fi/fi/newsroom/corporate−news/kaasutankkausasema−loeytyy−nyt−jokaisen−ikea−tavaratalon−laeheisyydestae−pub7c240837/?msockid=1c51333bc8a86632202d250bc97a6787.

Figure 2−27    Planners and residents jointly discuss the planning and development of the Viiskorpi−Kalajärvi area

governance adheres to strong rules in the field of health and well-being (SDG 3); eliminating gender discrimination in urban operations in the field of gender equality (SDG 5), see Figure 2-28; emphasizing fairness and transparency in areas such as decent work and economic growth (SDG 8); reducing inequality (SDG 10), just and harmonious inclusive societies (SDG 16), see Figure 2-29; and establishing fair and powerful official institutions.

In terms of financing, collaborations were established with Aalto University, the Finnish Technology Research Centre and enterprises to jointly develop growth-oriented parks, aiming to turn Espoo into the most suitable city in Northern Europe for the development of startups and growing enterprises. Espoo has created an "attractiveness programme" for businesses and experts with the aim of strengthening Espoo's revenue base by applying for national recovery and European Union funds, and working together with enterprises and research institutions to further enhance the attractiveness of the region as a destination for companies to relocate to.

## Adaptability

The Espoo Story offers construction experience for cities aiming to achieve inclusiveness, co-creation and people-oriented goals. The VLR process and the public opinion survey model provide inspiration for cities seeking to enhance their understanding of sustainable development. These solutions provide a structured and transferable framework that integrates digital mapping tools, public outreach and school co-operation, providing cities with a replicable engagement strategy.

Espoo's VLR process has been used by UN-Habitat, Nordregio and other organizations as an exemplary and participative process. Espoo has also created a virtual course on how to conduct a VLR to UN-Habitat, which is used in their Oceanic Asia area operations. In collaboration with the six largest cities in Finland and the Association of Finnish Local and Regional Authorities, this process was further developed in 2022 into an SDG Sensemaking Tool-a participatory and replicable process that can be used to localize SDG indicators
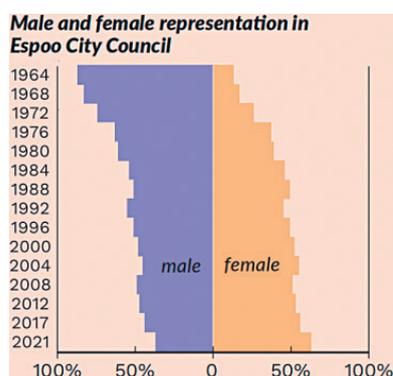


Figure 2–28   Male and female representation in Espoo City Council
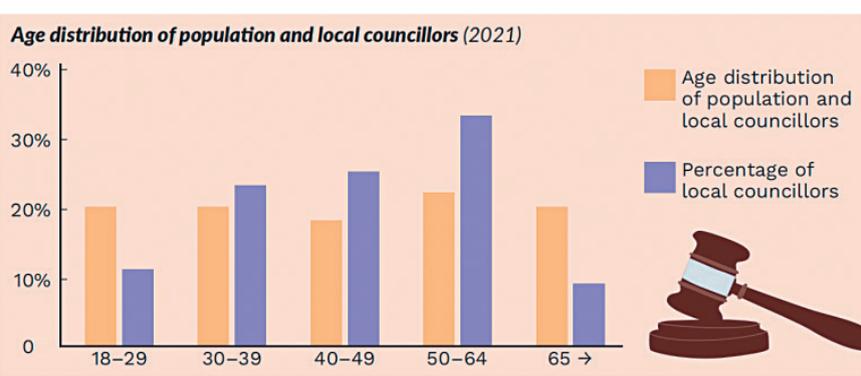


Figure 2–29   Age distribution of population and local councillors

and link them to both local goals, and global targets and indicators.

Espoo showcased the SDG Sensemaking Tool in a session at the United Nations High Level Political Forum in 2021. The tool is now used by more than 30 cities around the world. Through Eurocities, Espoo holds leadership roles in working groups focused on culture management and innovation, and entrepreneurship for 2024–2025. Espoo has been selected to implement the European Union Mission on climate-neutral and smart cities by 2030 together with other pioneers. The selected cities act as centres of experimentation and innovation for solutions that will enable all European cities to achieve the same goals by 2050.

# Incheon, the Republic of Korea
# Energy Transition toward a Sustainable Future

Incheon's results-oriented integrated approach harmonizes long-term vision with measurable outcomes, achieving a balance between environmental preservation, economic vitality and social inclusion.

## 1. Development Context

### Overall Urban Development Situation

Over the past 60 years, Incheon has grown into the second-largest economic city in the Republic of Korea,



Source: Available at https://renchuan.dayoucs.com/guanyurenchuan/renchuanjianjie/.

Figure 2–30   Panoramic view of Incheon

see Figure 2-30, with a population of 3 million and a gross regional domestic product of USD 88 billion, see Table 2-4. Since opening its port in 1883, Incheon has laid the groundwork for modern urban development due to its proximity to China and Japan, and as a strategic location as the main gateway to Seoul, establishing itself as a geopolitical hub. Although 80 per cent of the city was destroyed during the Korean War in 1950, Incheon demonstrated its resilience through the growth of manufacturing industries in the 1960s. In 1981, it was granted the status of the third directly governed city. After the 1997 Asian financial crisis, the opening of Incheon International Airport in 2001 was a turning point that drove growth in logistics and transportation. Following the designation of the Incheon Free Economic Zone in 2003, foreign investment in the biopharmaceutical sector flourished.

Incheon basic city data      Table 2–4

| No. | Index | Data | Notes |
| --- | --- | --- | --- |
| 1 | Population | 3,021,000 | |
| 2 | Municipal administrative area size | 1,067 km$^2$ | |
| 3 | Built-up area size | 512 km$^2$ | |
| 4 | GDP per capita | USD 27,356 | 2022 |

## Primary Challenges Encountered

To establish an industrial base, Incheon has expanded its land area by 5.6 times since 1970, see Figure 2-31. However, as a coastal city, Incheon regards sea-level rise caused by climate change as a critical issue that directly threatens the survival of its citizens. In 2019, former United Nations Secretary-General Ban Ki-moon warned, "If climate change is not addressed, Incheon could be submerged by the end of this century."

As a result of the Incheon Free Economic Zone, key urban functions shifted to newly developed areas, leading to a decline in the role of the original city centre. The city's manufacturing-centred industrial structure revealed its vulnerability in reducing greenhouse gas emissions and a slowdown in economic growth further weakened local economic vitality. Meanwhile, the expansion of the city transport network centred on Seoul reduced internal accessibility within Incheon, making the improvement of public transportation infrastructure an urgent priority.

## Overall Strategy

Incheon has closely aligned the 2045 Car-



1937  1940  1944—1969  1970—1985  1986  1992  1988—2002

Over the past 100 years, Incheon has reclaimed **11,230m²** of coastal land to build its industrial base

An expansion of approximately **5.6 times**
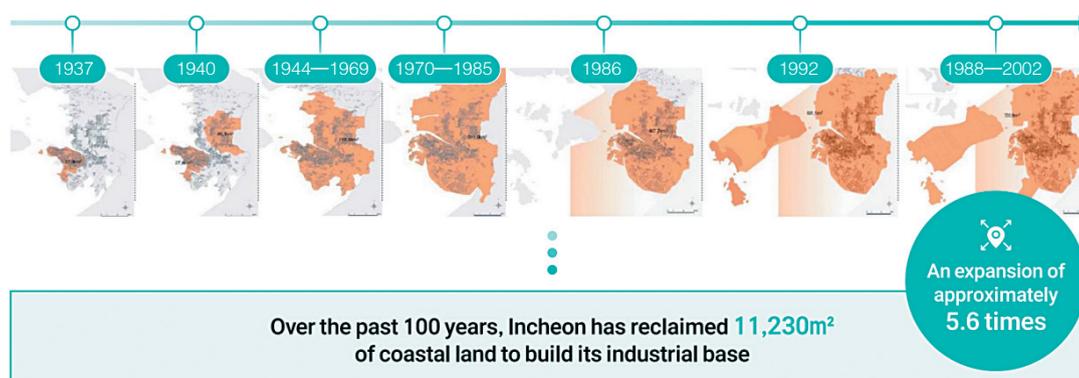
Figure 2–31   Rapid expansion of coastal land in Incheon over the past 100 years

bon-Neutral City Vision with its Incheon 2040 Urban Master Plan, establishing the goal of achieving net-zero greenhouse gas emissions by 2045, see Figure 2-32. The vision systematically outlines 154 implementation tasks across 7 key sectors, striving to strike a balance between environmental preservation, economic vitality and social inclusion.

The plan sets forth the development vision of "Incheon, a global city that is liveable in every neighbourhood," identifying carbon neutrality, ecological restoration, enhanced disaster resilience and the fostering of future-oriented strategic industries as core strategic priorities. Implementation is ensured through legislative support, diverse financing mechanisms and PPPs.

## Action Strategy

Incheon is advancing sustainable development

through three key initiatives: ① the city is developing an eco-friendly intelligent transport system (ITS). Phases 1 and 2 of the ITS project were completed by 2024, significantly enhancing traffic operational efficiency and safety; ② Incheon is actively cultivating future industries. The Songdo International Business District has one of the world's top bio-pharmaceutical production capacities, while the Cheongna area completed the world's largest liquefied hydrogen plant in May 2024, accelerating the development of the clean energy industry; and ③ Incheon is promoting ecological restoration. Building on two decades of the Stream Restoration Movement, Incheon is rehabilitating five major streams into natural ecological waterways through collaboration between citizens and the local government. The creation of water-friendly spaces and recreational facilities further enhances ur-



Figure 2-32    Incheon declares its 2045 carbon-neutral city vision

ban ecological functions and improves the quality of life for residents.

## 2. Feature Activities

Implementing the One Dollar Housing project

Incheon is implementing bold housing welfare policies to enhance quality of life and ensure residential stability in response to demographic shifts, including low birth rates and a sharp increase in single-person households. In particular, the city is advancing tailored housing policies to meet the needs of diverse social groups, with a focus on the groundbreaking low-cost rental initiative known as the One Dollar Housing project.

As of 2023, the Republic of Korea recorded a total fertility rate of 0.72, the lowest among the Organization for Economic Cooperation and Development member countries. At the same time, the number of single-person households reached approximately 10 million, accounting for 35.5 per cent of all households. This figure has more than doubled since 2016, and housing types have rapidly diversified in line with changes in family structures.

The Schwabe Index, which reflects the burden of housing costs, reached 19.7 per cent in 2021, significantly higher than the Organization for Economic Cooperation and Development average (around 15 per cent), highlighting the urgent need for a shift in housing welfare policies. In response, Incheon has steadily strengthened its institutional foundations, beginning with the establishment of the Comprehensive Housing Plan in 2009, followed by the enactment of the Basic Housing Ordinance in 2018 and the formulation of the 2030 Incheon Comprehensive Housing Plan in 2021.

Since 2024, Incheon has actively promoted tailored housing policies for different demographic groups, aiming to minimize population outflow and encourage the inflow of young people. The flagship One Dollar Housing programme provides stable housing for up to six years to newlyweds and households with newborns, at an ultra-low rent of one USD dollar per day (approximately USD 30 per month). This represents about 4 per cent of the average rent in the private sector, significantly reducing the burden of housing costs. By supplying 1,000 units annually and offering rental support of about USD 2.63 million, the programme tangibly contributes to lowering the barriers to marriage and childbirth.
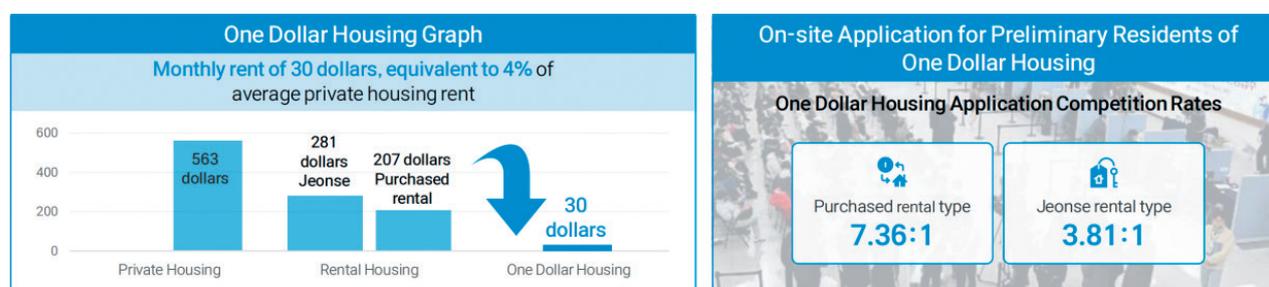


Figure 2–33　Significant rental advantage and high application competition rate of one dollar housing

Housing is provided through two types: the Purchased Lease Type and the Jeonse Lease Type. The former offers public rental housing owned by the city government, reflecting a flexible and tenant-centred approach to supply. The latter involves the city directly leasing a home selected by the applicant, with a floor area of up to 85 square metres. In March 2025, a call for applications for 500 units under the Purchased Lease Type attracted 3,681 households, resulting in a competition ratio of 7.36 to 1. In May, a call for 500 units under the Jeonse Lease Type drew 1,960 households, with a ratio of 3.81 to 1, see Figure 2-33. These numbers demonstrate strong policy demand and significant public interest, see Figure 2-34.

### Buiding an Intelligent Transport System

By 2040 and 2045, Incheon aims to strengthen its status as a global smart city by applying ITS to address traffic issues across the entire city, including the original city centre, through an integrated approach.

The gap in infrastructure between the original city centre and the new city centre has widened. The original city centre continues to rely on outdated transport infrastructure, resulting in various social costs, including chronic congestion and delays in emergency response. The car-centred system also fails to adequately ensure the safety and convenience of pedestrians, public transport users and vulnerable groups, particularly older adults, children and persons with disabilities. Incheon is promoting forward-looking transport policies by aligning the Incheon 2040 Urban Master Plan with the 2019 Incheon ITS Master Plan. In particular, it aims to ensure balanced development across the city by protecting vulnerable road users, improving public transport accessibility and establishing smart infrastructure capable of real-time response.



Figure 2–34　Applicants flood into City Hall on the first day of tenant registration for Cheonwon Housing

A key achievement is the efficient operation of the Traffic Information Centre, enabled by the completion of Phases 1 and 2 of the ITS project in 2024. Integrated management of public transport information has improved both traffic operational efficiency and citizen satisfaction. Specific outcomes achieved through system enhancements include: an increase in the fire engine response time compliance rate from 79.4 per cent to 94 per cent, see Figure 2-35; a 27.6 per cent reduction in traffic fatalities; a 14 per cent decrease in pedestrian accidents through the operation of smart crossings; improved traffic flow via the operation of smart intersections; successful apprehension of criminal suspects through the tracking of wanted vehicles, see Figure 2-36; and real-time guidance on remaining signal times via navigation systems. The use of advanced technologies has significantly enhanced both public convenience and safety, see Figure 2-37.

These efforts have been recognized both domestically and internationally. In 2020, Incheon was certified by the United Nations Office for Disaster Risk Reduction as the first Safe and Smart City role model in Asia. In 2023, the city received the Presidential Award for Proactive Administration and in 2024, Incheon was named the Top-Performing Institution in the Sustainable Transport City Assessment conducted by the Ministry of Land, Infrastructure and Transport.

## Promoting Energy Transition Centred on the Hydrogen Economy

Incheon's industrial structure is centred on manufacturing and its energy consumption is predomi-



Figure 2-35    Emergency vehicle priority signal service



Figure 2-36    Interest vehicle location tracking system



Figure 2-37    Aerial view of smart pedestrian walkway

nantly based on fossil fuels, creating a long-standing and pressing need for industrial and energy transition. The city has been focused on high-carbon industries such as automotive parts and steel, and its reliance on fossil fuels remains high due to coal and oil-based

power generation and industrial activities. This dependence has been further exacerbated by the low energy efficiency of ageing industrial facilities and buildings, contributing to increased greenhouse gas emissions. As of 2018, Incheon recorded the highest level of greenhouse gas emissions nationwide, approximately 740 million tons, of which around 75 per cent originated from power generation and industrial sectors.

In response, Incheon is advancing the Incheon 2040 Urban Master Plan alongside the 2045 Carbon-Neutral Vision to promote sustainable urban development and respond to climate change. The city's master plan identifies key priorities such as achieving carbon neutrality, strengthening disaster resilience and fostering future-oriented strategic industries. The first core strategy focuses on "innovating the industrial structure and expanding the energy transition centred on the hydrogen economy". As of 2024, Incheon had deployed 2,320 hydrogen vehicles including 480 hydrogen buses, see Figure 2-38, the highest number in the country. In May of the same year, the city completed construction of the world's largest liquefied

hydrogen plant, see Figure 2-39.

Incheon is also enhancing public awareness of environmental issues and encouraging carbon-neutral practices through citizen participation. Programmes include the Carbon-Neutral Climate Citizen Community and the Youth Supporters, while the Council for Sustainable Development serves as a communication bridge with civil society.

Incheon is strengthening international cooperation. Its collaboration with the Green Climate Fund headquartered in Songdo is expected to generate annual economic benefits of around USD 280 million and create new jobs. In 2023, Incheon co-hosted an international forum with the United Nations Economic and Social Commission for Asia and the Pacific to share its experience in transitioning to carbon neutrality.

## Implementing the Incheon Streams Restoration Project

As a major port and industrial centre in the Republic of Korea, Incheon achieved rapid economic growth during industrialization. However, the expan-



Figure 2-38　Incheon hydrogen bus



Figure 2-39　Incheon constructs the world's largest liquefied hydrogen plant

sion of industrial facilities outpaced that of environmental infrastructure, such as wastewater treatment and sewage management, leading to water pollution in the city's streams. In addition, as the city expanded rapidly, wetlands and green spaces surrounding the streams were reduced or partially degraded. As a result, the streams' natural purification functions and ecological balance declined, and the health of aquatic ecosystems gradually deteriorated. In April 2003, the Ministry of Environment announced that carcinogenic substances had been detected in the Seunggi Stream and the Gulpo Stream, further underscoring the need for restoration.

Incheon launched its Incheon Stream Restoration Task Force in September 2003 to systematically promote the stream restoration movement. This PPP involves the Incheon city government, local civil society organizations and environmental experts. The task force has implemented civic engagement programmes such as the Stream Academy, Youth Stream Camp and citizen stream stewardship activities, with several thousand participants each year, thereby establishing a system that enables citizens to take part in ecological restoration in their daily lives, see Figure 2-40. In addition, in September 2004, Incheon enacted the nation's first Stream Restoration Support Ordinance, providing an institutional foundation for stream management and restoration at the local government level. This served as the basis for a participatory decision-making framework in which citizens and experts collaboratively discussed and determined stream restoration objectives and spatial utilization approaches.

Incheon actively gathered public input through



Figure 2–40　2024 Incheon sky water citizen evaluation panel and supporters inauguration ceremony

on-site surveys for each stream, as well as through forums and public hearings, and established a network involving 155 organizations and approximately 10,000 citizens directly engaged in stream restoration and management. In particular, through the One Company, One Stream Care Campaign, a PPP model was established in which 25 companies, military units and civil society organizations collaborated to steward streams. Participating companies, in cooperation with the local government and civil society organizations, carried out a range of environmental restoration activities, such as stream clean-ups, tree planting and aquatic ecosystem management, see Figure 2-41 and 2-42. In recognition of the achievements of this active cooperation, Incheon was awarded the Minister of Environment Award in 2011.

The water quality of the Seunggi Stream improved from 3.1 parts per million of biochemical oxygen demand (Grade 3) in 2023 to 2.6 parts per million (Grade 2), as reported by the Yeonsu District Office in 2025. A policy perception survey recorded a score of 4.14 out of 5, demonstrating strong public trust and

Figure 2–41　The Incheon stream restoration project

support. In addition, according to a study by Incheon National University, the eco-friendly and accessible stream restoration project generated an estimated annual economic value of approximately USD 42 million as of 2020.

## 3. Learning Aspects

### Impact

In terms of social impact, Incheon Metropolitan City has significantly enhanced citizens' quality of life and social inclusivity through its housing and transportation policies. The One Dollar Housing programme has supplied a substantial number of high-quality rental units for newlyweds and households with newborns, effectively reducing their housing costs. This initiative has, in turn, contributed to population inflow and an increase in the birth rate, see Figure 2-43.

Following deployment of ITS, the compliance rate for emergency response times improved significantly, traffic fatalities decreased by 27.6 per cent and pedestrian accidents were reduced by 14 per cent, substantially enhancing both the safety and efficiency of urban mobility for citizens.

Regarding environmental impact, Incheon has achieved remarkable results in ecological restoration and low-carbon transition. The restoration project for the five major streams is steadily progressing, leading to a notable improvement in the environmental quality of the watercourses. The hydrogen industry ecosys-



Figure 2–42　Seunggi Stream before and after the ecological restoration project
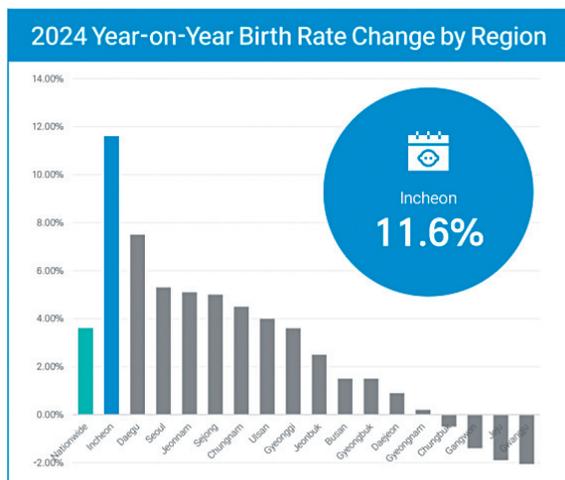
Figure 2-43    Year-on-year birth growth rate by region (2024) with Incheon ranking first nationwide
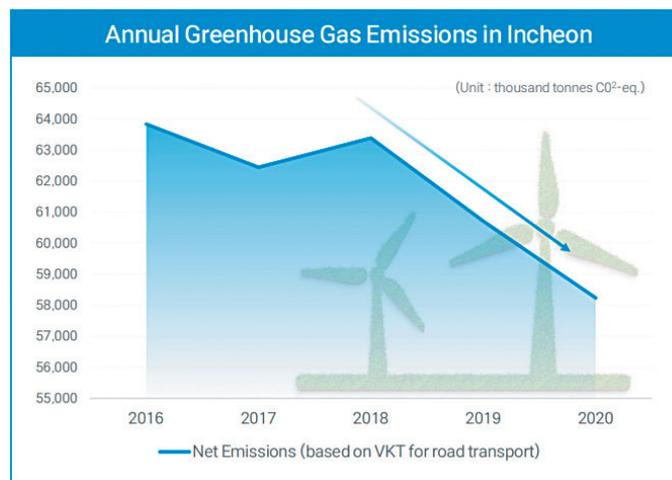


Figure 2-44    Greenhouse gas emissions have been showing a declining trend over the years

tem established by Incheon has effectively reduced greenhouse gas emissions, laying a solid foundation for achieving its 2045 carbon neutrality goal, see Figure 2-44.

In terms of economic impact, Incheon's hydrogen industry cluster and liquefied hydrogen plant have not only driven the development of the industrial chain but also enhanced employment levels. The application of ITS has yielded significant benefits. AI-based signal optimization increased travel speeds by 8.3 per cent and reduced delays by 8.7 per cent in pilot areas, generating an annual economic benefit of USD 518,000.

## Sustainability

Incheon employs the Incheon 2040 Urban Master Plan and the Global Top 10 City INCHEON Project as its core frameworks, integrating the 17 SDGs into all aspects of urban development to achieve balanced progress across social equity, environmental re-

sponsibility and economic vitality. The city's strategy has shifted from quantitative expansion to qualitative enhancement, with a particular focus on balanced development between the original city centre and newly developed areas. By improving transportation and living infrastructure, and expanding green spaces, it aims to enhance citizens' quality of life. The city is also actively developing smart ports and sustainable industries, while effectively revitalizing older urban districts through redevelopment and mixed-use renewal.

Through a people-centred approach and inter-generational policies targeting all age groups from children to the elderly, Incheon is improving the quality of life for its residents while strengthening social equity and the sustainability of welfare systems, firmly committed to building an inclusive city.

## Innovation

In terms of policy and legislation, Incheon

provides institutional guarantees for sustainable development through systematic policy and legislative innovation. By clarifying the rights and responsibilities of businesses, citizens and professional groups in environmental governance through legislation, a multi-stakeholder collaborative model was successfully built, providing a replicable example of policy and legislative synergy for other cities.

Regarding urban governance, Incheon has enhanced the inclusivity and trustworthiness of public administration through innovations in participatory governance. Its restructured institutional framework enables citizens to participate in the entire policy process, including planning, review and public relations, thereby significantly improving administrative efficiency, transparency and accountability.

### Adaptability

Incheon's innovative practices provide highly adaptable solutions for global cities facing similar challenges. Its institutional innovation model, centred on the Incheon 2040 Urban Master Plan, effectively coordinates cross-sectoral policies and can serve as a reference for cities experiencing industrial pollution and imbalanced development.

The application of technologies such as ITS and digital twins optimizes urban operations without requiring large-scale physical reconstruction, making them suitable for cities undergoing infrastructure upgrades.

The extensively established collaborative governance mechanisms involving government, businesses and citizens offer a proven approach to enhancing policy trust and social inclusivity. This is particularly applicable to industrially transitioning cities with diverse populations.

# Madinah, Saudi Arabia The Digitally Empowered Smart Holy City

Madinah has established a resilient and responsive urban management system through a comprehensive and data-driven participatory governance approach. This not only supports the implementation of the smart city strategy but also highlights the core elements of trust, inclusiveness and long-term sustainability.

## 1. Development Context

### Overall Urban Development Situation

Madinah is the second holiest city in Islam, geographically located in the western region of Saudi Arabia. It is the capital of the Medina region and holds a unique position in terms of history and culture, see Figure 2-45 and Table 2-5. Madinah's strategic location and its religious and cultural heritage provide immense opportunities for growth in tourism, education and healthcare. Currently, the city's administrative area has a permanent population of approximately 1.41 million. The city attracts over 18 million visitors each year and aims to attract more than 30 million visitors by 2030, see Figure 2-46. The city's ongoing and up-

Source: Available at https://www.saudiarabiatourismguide.com/madinah−province/.

Figure 2−45　Aerial view of Madinah



Residents:
**1,385,192**

Residents + Visitors:
**13,640,192**

Average population density:
**30.9 p/ha**

1 - 20 p/ha
21 - 60 p/ha
61 - 100 p/ha
101 - 140 p/ha
141 - 251 p/ha
252 - 350 p/ha
351 - 424 p/ha
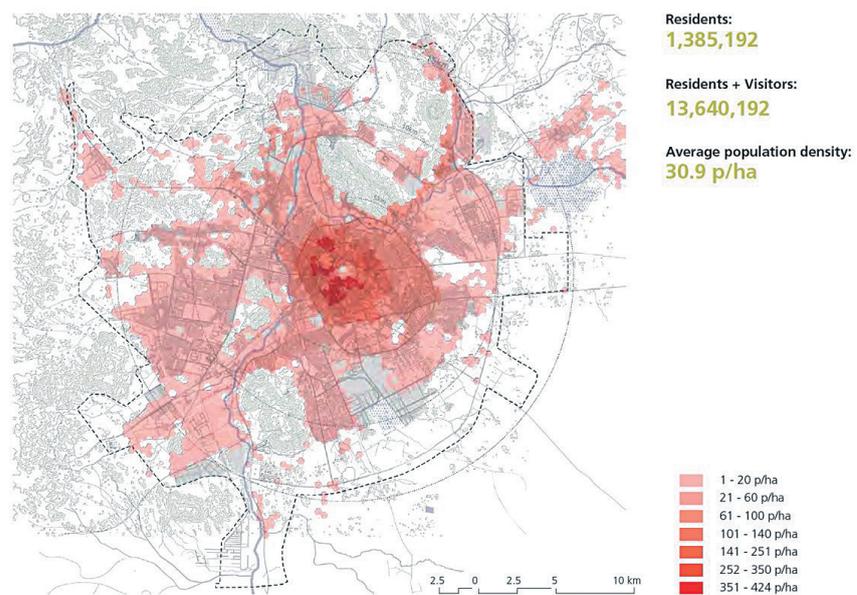
Figure 2−46　Current distribution of population density

coming mega projects aim to integrate spiritual experiences with luxury hospitality, shopping and cultural sightseeing. Efforts also include enhancing regional accessibility through improved connections with the Haramain High-Speed Railway, as well as developing a bus rapid transit system to improve urban mobility.

Madinah basic city data　　　Table 2–5

| No. | Index | Data | Notes |
| --- | --- | --- | --- |
| 1 | Population | 1,410,000 | |
| 2 | Municipal administrative area size | 682.27 km$^2$ | |
| 3 | Built-up area size | 345.12 km$^2$ | |
| 4 | GDP per capita | USD 26,571 | PPP (2023) |

## Primary Challenges Encountered

Despite its religious prominence, Madinah still faces several urban challenges, including providing adequate infrastructure and services to its growing population and the influx of pilgrims, middle grade traffic congestion, underdeveloped public transport, environmental degradation and limited access to cultural and recreational services.

## Overall Situation

Madinah's Sustainable Development Strategy is a comprehensive, multi-sectoral roadmap designed to transform the city into a smart, inclusive and resilient urban centre. Anchored in the city's "North Star" vision – to become the most tranquil, generous and dynamic smart city in the world – the strategy integrates Islamic values with global best practices in urban development. It is aligned with the SDGs, the Global Urban Monitoring Framework, the New Urban Agenda and the Saudi Vision 2030, see Figure 2-47.



Figure 2–47　Madinah smart city programme future impact

## Action Strategy

The strategy is structured around seven priority sectors: environment and agriculture; transport and mobility; business; industry and logistics; old neighbourhoods; tourism; and healthcare & well-being. Each sector is guided by a vision statement and a set of strategic objectives that promote sustainability, innovation and quality of life. For example, the transport sector aims to achieve a 20 per cent public transport mode share by 2030, while the environment sector targets becoming one of the top 50 sustainable cities for water management.

The strategy also emphasizes citizen engagement, digital transformation and PPPs. It promotes inclusive urban development by integrating old neighbourhoods into the city's economic and social fabric, enhancing access to healthcare and education, and creating vibrant public spaces. Flagship projects such as the Environmental Rehabilitation of Al-Aqiq Valley, Madinah Bus and Manarah exemplify the strategy's holistic approach combining cultural preservation, smart mobility and ecological restoration.

Multi-use projects like the Knowledge Economic City and other touristic-oriented multipurpose projects such as RUA Al Madinah; support for SMEs; affordable Housing Initiatives by SAKANI; Human-Centric Smart City Initiatives; the Haramain High-Speed Railway for inter-city connectivity and pilgrims' and tourists' good experience; Green Madinah Initiative; Renewable Energy sources; and Cultural Preservation for Heritage Sites and farms by leveraging historical and cultural sites such as Al Masjid Al Nabawi and the Khaybar fort, boost tourism and socioeconomic development.

A key enabler of the strategy is the Al Madinah Urban Observatory which monitors over 300 indicators across domains such as people, prosperity, place, governance and infrastructure.

## 2. Feature Activities

### Manarah Urban Data Platform

The Madinah Region Development Authority (MDA), in a collaborative effort with provincial authorities and over 50 organizations, has established the Manarah Urban Data Platform (UDP) – a regional spatial data infrastructure (SDI), see Figure 2-48. Designed as a unified, authoritative source of spatial and non-spatial data to promote inclusive, resilient and sustainable urbanization, Manarah enables integrated planning, real-time decision-making and cross-agency collaboration.

Before Manarah, Madinah's urban data ecosystem was fragmented and inefficient. Data was siloed across over 50 agencies with no centralized platform for integration or validation. Many datasets were outdated or lacked spatial accuracy and traditional surveying methods were slow, expensive and labour-intensive. The city lacked a regional SDI, limiting its ability to plan, assess feasibility or respond to environmental and urban challenges. Subsurface infrastructure data was inaccessible, increasing risks during construction. Heritage and agricultural zones were unmonitored and urban sprawl went undetected. Planning departments had no access to high-fidelity 3D models, and the absence of urban indicators hin-

dered benchmarking and strategic alignment.

The implementation of Manarah UDP addressed these challenges with measurable success. The platform reduced data acquisition time by over 40 per cent, established a centralized SDI used by over 50 agencies, and digitized 300,000 buildings and 18,500 businesses. It transformed fragmented data into a centralized, decision-ready system used by over 54 agencies, see Figure 2-49. It ensures sustainability by enabling environmental monitoring, heritage protection and green initiatives, see Figure 2-50. Its use of

drone mapping, 3D modelling and automated data extraction showcases strong innovation. The platform's modular, scalable architecture and integration with planning tools demonstrates its adaptability to evolving urban needs. By aligning with global standards and supporting over 300 urban indicators, Manarah empowers Madinah to plan, monitor and grow as a smart, inclusive and resilient city.

## Madinah Bus Project

The Madinah Bus project was launched as a
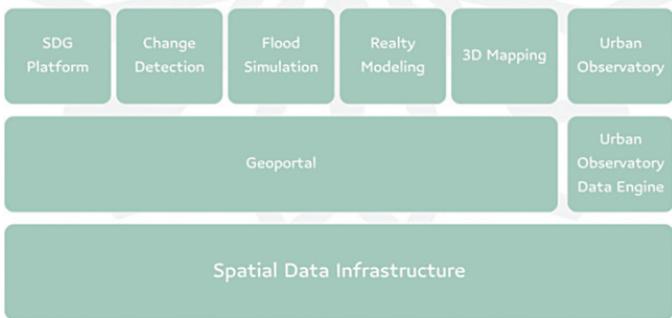
Figure 2–48　Structure of urban data portal
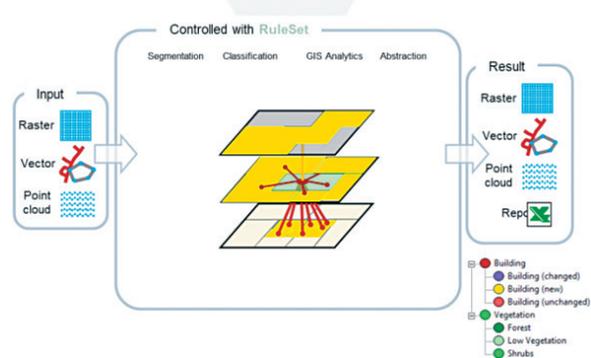
Figure 2–49　Development of eCognition ruleset for data change detection
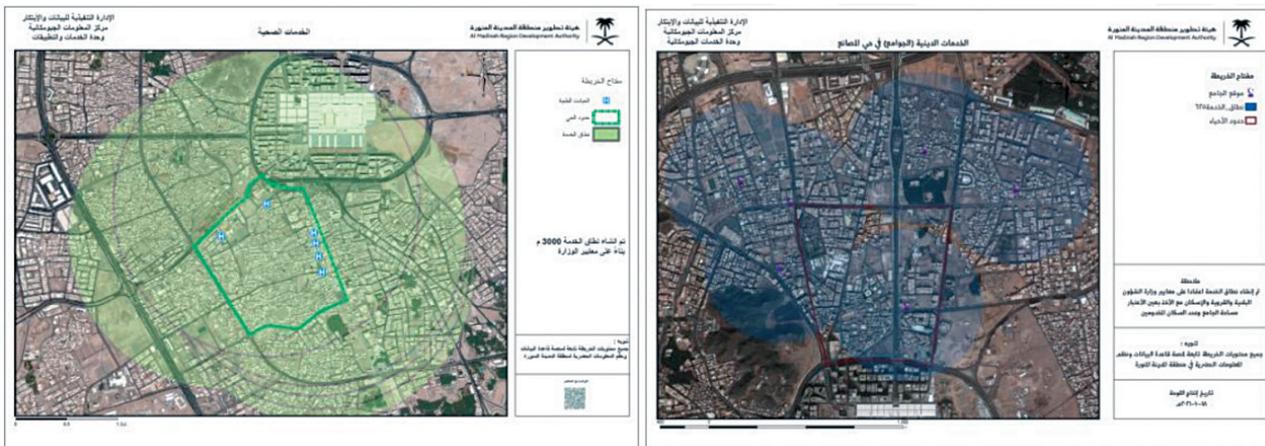
Figure 2–50　Topographic maps used for studying the modernization of historical districts

strategic initiative to address the city's growing mobility challenges, aiming to reduce traffic congestion, enhance accessibility and promote environmental sustainability through a modern and inclusive public transport system. The project began in 2015 with a shuttle service to the Prophet's Mosque and has expanded significantly over the years. By early 2025, the network had grown to 15 routes, 177 buses and 455 stops, see Figure 2-51, connecting major destinations such as the Prophet's Mosque, Quba Mosque, Prince Mohammed bin Abdulaziz Airport and the Haramain High-Speed Railway Station, see Figure 2-52. A key innovation was the introduction of the Madinah Bus mobile application, see Figure 2-53, which supports electronic ticketing, secure payments and QR code-based ride validation. The app also features real-time global positioning system (GPS) tracking, allowing users to monitor bus locations and arrival times, thereby improving trip planning and reducing wait times, see Figure 2-54. Accessibility features

were integrated to ensure usability for all, including individuals with disabilities.

### Environmental Rehabilitation of Al-Aqiq Valley

The environmental rehabilitation of Al-Aqiq Valley is a landmark project that integrates ecological restoration, cultural protection and urban renewal. Al-Aqiq Valley, mentioned in Islamic traditions and home to ancient landmarks such as the Palace and Well of Urwah ibn Al-Zubayr, is being transformed into a vibrant green corridor that enhances the city's environmental resilience and cultural identity. Through a phased approach, the valley is being rehabilitated with reforestation, water management systems, pedestrian walkways, scenic overlooks and public amenities.

Urban renewal is another pillar of the project, transforming the valley into a vibrant public green space. This includes 6 km of pedestrian and bicycling paths, public amenities like prayer areas and
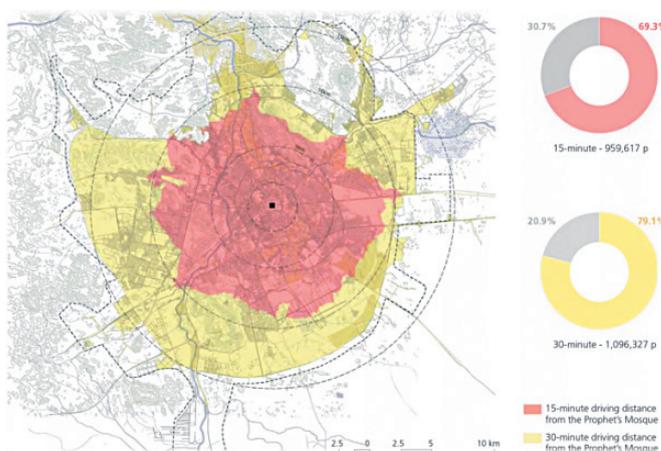


Figure 2−51    Driving accessibility to the Prophet's Mosque in Madinah and the potential for public transport development



Source: https://araburban.org/en/infohub/projects/?id=7525.
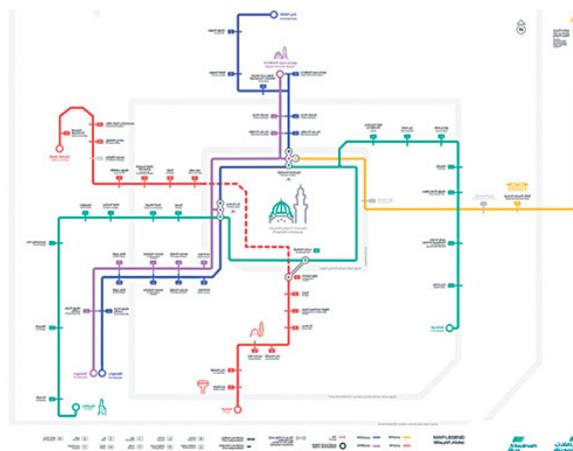
Figure 2−52    Map of the Medina Bus system

Source: https://araburban.org/en/infohub/projects/?id=7525.

Figure 2–53　Madinah bus App



Source: https://araburban.org/en/infohub/projects/?id=7525.

Figure 2–54　Madinah electric bus

restrooms, and recreational zones with native land-scaping, see Figure 2-55. Visual enhancements such as natural stone paving and scenic plazas further elevate the valley's aesthetic appeal. The project is being implemented in four strategic phases beginning with immediate environmental relief and progressing through detailed studies, infrastructure development and investment planning.

　　Economic development is embedded in the strategy through PPPs and targeted investments. Quick-win projects like the Palm Oasis Park and the Urwah Tourist Zone generate immediate returns, while long-term ventures such as eco-resorts and health centres aim to boost GDP and create jobs. Future phases will expand ecological coverage, improve hydraulic capacity and create investment zones for eco-tourism and recreation. The project also includes smart monitoring systems for water quality, waste



Source: Available at https://saudipedia.com/en/article/2097/government−and−politics/municipal−affairs−and−housing/the−environmental−rehabilitation−project−of−wadi−al−aqiq.

Figure 2–55　Environmental rehabilitation of Al–Aqiq Valley

management and visitor flows.

## Housing Improvement Project

A central focus of Madinah's housing strategy is the revitalization and integration of old neighbourhoods. To achieve this, Madinah has implemented a suite of smart planning tools and regulatory reforms. The Urban Observatory plays a pivotal role by monitoring housing indicators such as affordability, density, building compliance and flood risk. These indicators guide evidence-based policies and ensure that housing development is aligned with both local needs and global standards. The city also promotes sustainable and resilient housing design. New developments are encouraged to adopt green building principles, integrate flood mitigation measures and use smart infrastructure such as energy-efficient systems and digital permitting platforms.

Affordability is addressed through continuous monitoring of rent-to-income and home price-to-income ratios, while accessibility is enhanced by streamlining building permit processes and expanding digital services. The city's housing strategy also includes provision for vulnerable groups, ensuring that housing policies are equitable and responsive to the needs of all residents. Quantitatively, Al Madinah tracks over 40 housing-related indicators, including the percentage of the population living in affordable housing, the average cost of rent and the proportion of informal housing, see Figure 2-56.

The reality modelling application helped MDA to reduce the costs of surveying the city for ground truthing purposes. The application also helped design, perform shadow studies and develop the facility of a recent project, Qeba Plaza, built between the Prophet's Mosque and Qeba Mosque, increasing the
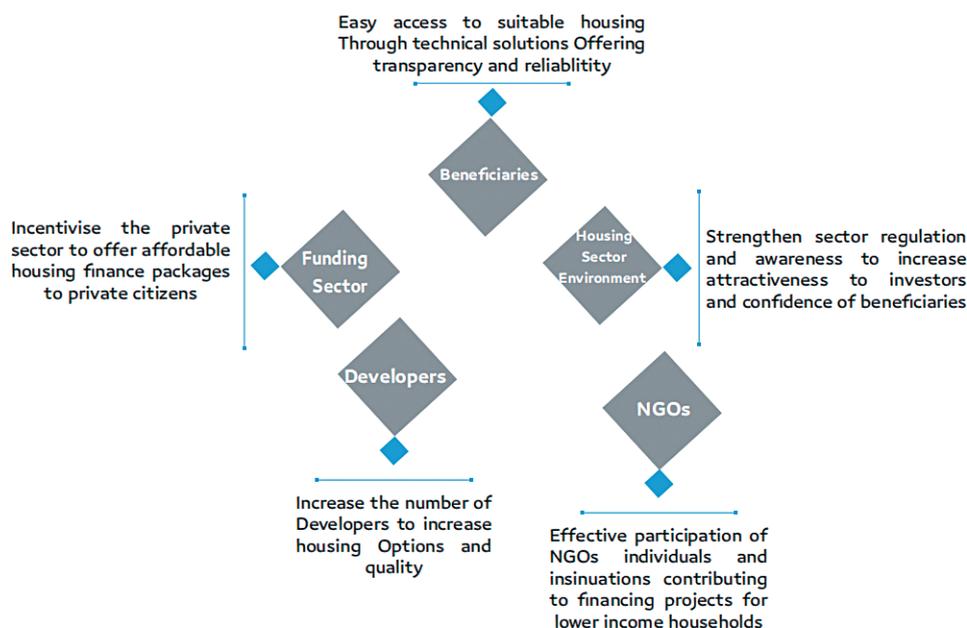


Figure 2–56    Saudi Arabia's 2020 Housing Plan

district's walkability. Similarly, plans for a building in the historical location of Housh Al Raie had a design study visualized with the reality model.

## 3. Learning Aspects

### Impact

The Urban Observatory tracks over 40 indicators related to education and culture, ensuring equitable and impactful investments. Both the Medina bus system and projects such as the restoration of the Aqeeq Valley adopt universal design principles to ensure equal benefits for people with disabilities, the elderly and low-income groups.

The environmental rehabilitation of Al-Aqiq Valley is one of the most climate-impactful initiatives, restoring native vegetation, enhancing biodiversity and strengthening the valley's resilience to seasonal flooding. The Madinah Bus project has effectively reduced vehicle emissions, promoted low-carbon travel, helped improve air quality and alleviate the urban heat island effect.

The 3D models and panoramic imagery from UDP helped MDA to minimize the need for site visits, enhancing citizen confidence in the city evaluation of real estate for expropriation purposes. The regional-level city indicator data it possesses also helps investors obtain information before making investments, thus attracting foreign investors.

### Sustainability

In terms of a long-term development strategy, the Madinah Smart City Strategy is led by MDA which serves as the central coordinating body for planning, implementation and monitoring. Institutional sustainability is further reinforced through strong partnerships with over 50 government entities, NGOs, academic institutions and private sector stakeholders. These partnerships are formalized through a memorandum of understanding (MoU), joint task forces and shared data protocols. The city invests in training programmes, knowledge exchange and technical assistance to enhance the capabilities of public servants, data analysts and urban planners. Digital governance tools, such as e-platforms, mobile apps and open data portals, enhance transparency and citizen engagement. These tools not only improve service delivery but also build public trust and institutional legitimacy.

In terms of financing and investing, national funds are allocated to support the implementation of sustainable development projects through the relevant ministries within their jurisdictions. The Investment Fund supports major projects through companies such as Ro'a Al-Madina and Knowledge Economic City. PPPs are also being implemented, with collaborative arrangements between government and private entities driving the development of public services and infrastructure. The Urban Observatory plays a critical role in financial governance by tracking indicators such as capital expenditure efficiency, own-source revenue and digital service uptake.

In the aspect of institutional capacity building, Madinah invests in training programmes, workshops and partnerships with academic institutions to enhance the skills of municipal staff and stakeholders. Madinah also promotes institutional capacity building

through cooperation both domestically and internationally. For example, Madinah collaborated with the UN-Habitat-led Quality of Life Initiative to develop a Global Quality of Life Index. Madinah also collaborated with the World Council on City Data for applying the ISO 37120 Series to assess city services and quality of life for residents.

Through the above strategies and mechanisms, Madinah is gradually establishing a smart city framework that is supported by data-driven approaches, collaborative governance and sustainable investment, see Figure 2-57. This framework not only responds to the needs of residents but also lays the institutional and practical foundations for future high-quality development.

## Innovation

Madinah's Smart City Strategy introduces a new paradigm in urban governance through policy innovation that integrates data, inclusivity and sustainability. The city has also integrated sectoral policies that break down silos between transport, environment, health and culture. PPPs are institutionalized through clear guidelines and incentives, enabling co-investment in infrastructure, services and innovation. The city's regulatory environment supports startups, SMEs and social enterprises, fostering a dynamic policy ecosystem. Digital governance policies ensure transparency, data privacy and citizen engagement. Open data platforms, e-services and mobile apps are governed by policies that promote accessibility, accountability and continuous improvement. MDA built 3D mesh models and used LiDAR and panoramic imagery from the mobile mapping system to provide the basis for city signage regulations in commercial establishments.
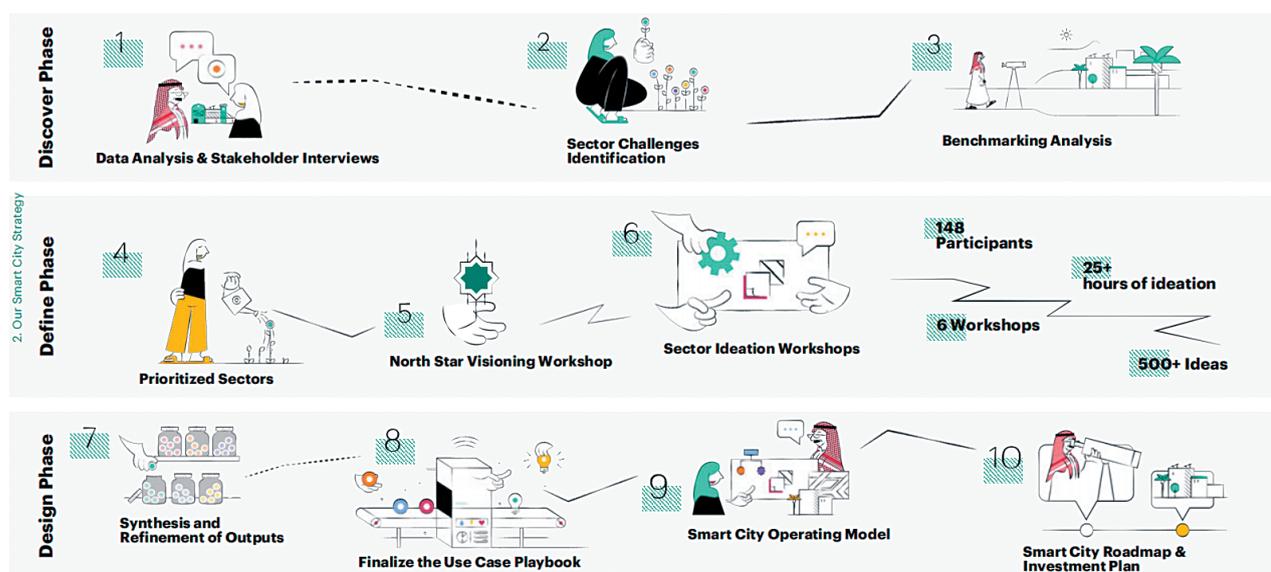


Figure 2-57    Madinah smart city programme approach

Madinah adopts a human-centred design approach that integrates tradition with modernity, technology with nature, and form with function. The Manarah Project exemplifies this approach by blending Islamic architectural elements with contemporary design. MDA performed a design study of the 14 historical districts and implemented projects which have not only provided amenities and services to residents, but also significantly reduced crime, improved build-

ing conditions and increased the living standards. The flood simulation application enabled MDA to pinpoint locations that could potentially have landslide issues and become hazardous in order to prevent development in their vicinity and avoid possible loss of life and property, see Figures 2-58 and 2-59.

The Urban Observatory Department provides real-time data and analytics to support decision-making across sectors. Its governance structure includes
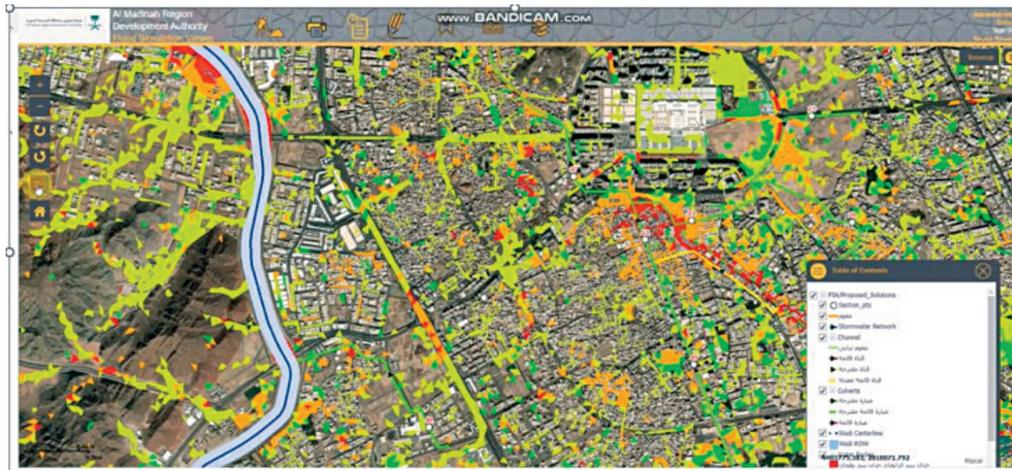


Figure 2–58　Flood simulation application shows hazardous areas and solutions



Figure 2–59　Flood simulation application shows maximum value layers and flow pattern diagram

a council, executive committee and technical teams that coordinate over 50 entities. It monitors over 300 indicators by using a combination of structured data, IoT sensors, geographic information system (GIS) mapping and real-time analytics, enabling predictive modelling, exception reporting and data-driven decision-making across sectors. The observatory's digital infrastructure supports open data platforms, dashboards and automated reporting aligned with global frameworks such as the SDGs and the Global Urban Monitoring Framework. Madinah's Smart City Strategy is driven by a strong commitment to technological innovation, leveraging digital tools and smart infrastructure to enhance urban services, improve quality of life and support sustainable development. Digital governance tools such as platforms for e-payments, open data and citizen feedback have improved efficiency and accountability. The city also tracks governance indicators such as service response times, digital infrastructure investment and public participation rates.

Madinah leverages a mix of public investment, private capital and alternative financing mechanisms to support its development plan. A key innovation is the use of PPPs to finance infrastructure and service delivery. The municipality employs performance-based budgeting, linking funding to measurable outcomes tracked by the Urban Observatory. This ensures accountability, transparency and value for money. For example, transport investments are tied to indicators such as ridership, emissions reduction and accessibility. Madinah promotes green financial tools such as sustainability-linked bonds and climate funds in ecological environment improvement

projects. Digital payment systems and unified billing platforms improve revenue collection and financial inclusion. Support for SMEs and social enterprises is facilitated through microfinance, grants and innovation funds. These mechanisms empower local entrepreneurs, especially youth and women, to participate in the city's economic transformation.

## Adaptability

Madinah's smart city model offers adaptable solutions for cities facing similar challenges, such as rapid urbanization, heritage preservation and infrastructure gaps. The Urban Observatory provides a replicable framework for evidence-based governance. Its alignment with Urban Monitoring Framework and the SDGs enables other cities to adopt global standards while tailoring indicators to local contexts.

The Urban Observatory model is being referenced in other Saudi Arabian cities. The platforms for digital health, mobility and citizen engagement have attracted interest from city councils and private sector partners where these solutions are being explored for adoption in cities with similar demographic and infrastructural profiles. Madinah fosters stakeholder collaboration through PPPs, academic partnerships and civil society engagement. These partnerships enhance implementation, ensure local relevance and support national scaling.

# Policy  Suggestions

Based on the case studies and practices of these

five exemplar cities, we find that data-driven governance, multi-stakeholder collaboration mechanisms, flexible infrastructure and green financial innovation have become key pathways for advancing sustainable urban development and enhancing resilience. We therefore propose the following recommendations to provide cities with actionable development directions:

## 1. Establish an Overarching Strategy and Strengthen the Implementation Loop

Urban development must be guided by a clear overarching strategy that provides stable direction and a long-term vision. Building upon this foundation, policy initiatives must be actionable and form a complete implementation loop through feedback, evaluation and refinement mechanisms. Integrating top-level design with grassroots implementation not only ensures consistency and continuity of action but also maintains strategic resolve in an ever-changing external environment. This interactive governance model, blending top-down and bottom-up approaches, provides the foundation and safeguards for implementing specific policies and measures.

## 2. Advancing Smart Governance and Resilient Infrastructure Development

Digital governance and intelligent infrastructure are pivotal for modern cities to mitigate risks and optimize operations. Practice demonstrates that unified data platforms and real-time monitoring systems enhance transparency, strengthen accountability mechanisms and bolster emergency management capabilities. In daily urban operations, intelligent transportation, smart healthcare and modular public service systems boost efficiency. During crises, they demonstrate high flexibility and rapid responsiveness. Cities should therefore accelerate data resource integration, information sharing and cross-departmental collaboration, embedding smart technologies into infrastructure planning to build efficient and adaptive governance systems.

## 3. Strengthening People-centred Participation Mechanisms and Social Equity

Institutionalized participation of diverse groups and equity-oriented policies are fundamental to enhancing urban cohesion. Case studies demonstrate that digital public opinion channels, community co-creation platforms and cross-cultural cooperation mechanisms all bolster the legitimacy of urban governance and public trust. Urban development strategies should prioritize social equity as a core objective, incorporating elements like housing security, educational opportunities and accessible transportation into institutional design — with particular attention to the needs of youth, women and low-income groups. By expanding participation, empowering vulnerable groups and ensuring equitable resource allocation, cities can achieve inclusive growth, extending the benefits of sustainable development to broader segments of the population.

## 4. Expanding Green Finance and Diverse Investment Channels

Long-term sustainable development requires stable and diversified financial support. Green fi-

nance instruments and PPP models are emerging as key pathways to drive urban renewal and low-carbon transformation. Introducing mechanisms like green bonds and climate funds not only enhances fiscal sustainability but also promotes circular economies and environmental restoration. Simultaneously, scientific performance evaluation systems ensure precise and efficient investment, directing resources toward areas with significant positive environmental and social benefits. By combining public investment with social capital, cities can establish more robust financing frameworks to support housing improvements, infrastructure development and ecological governance, achieving long-term balanced development.
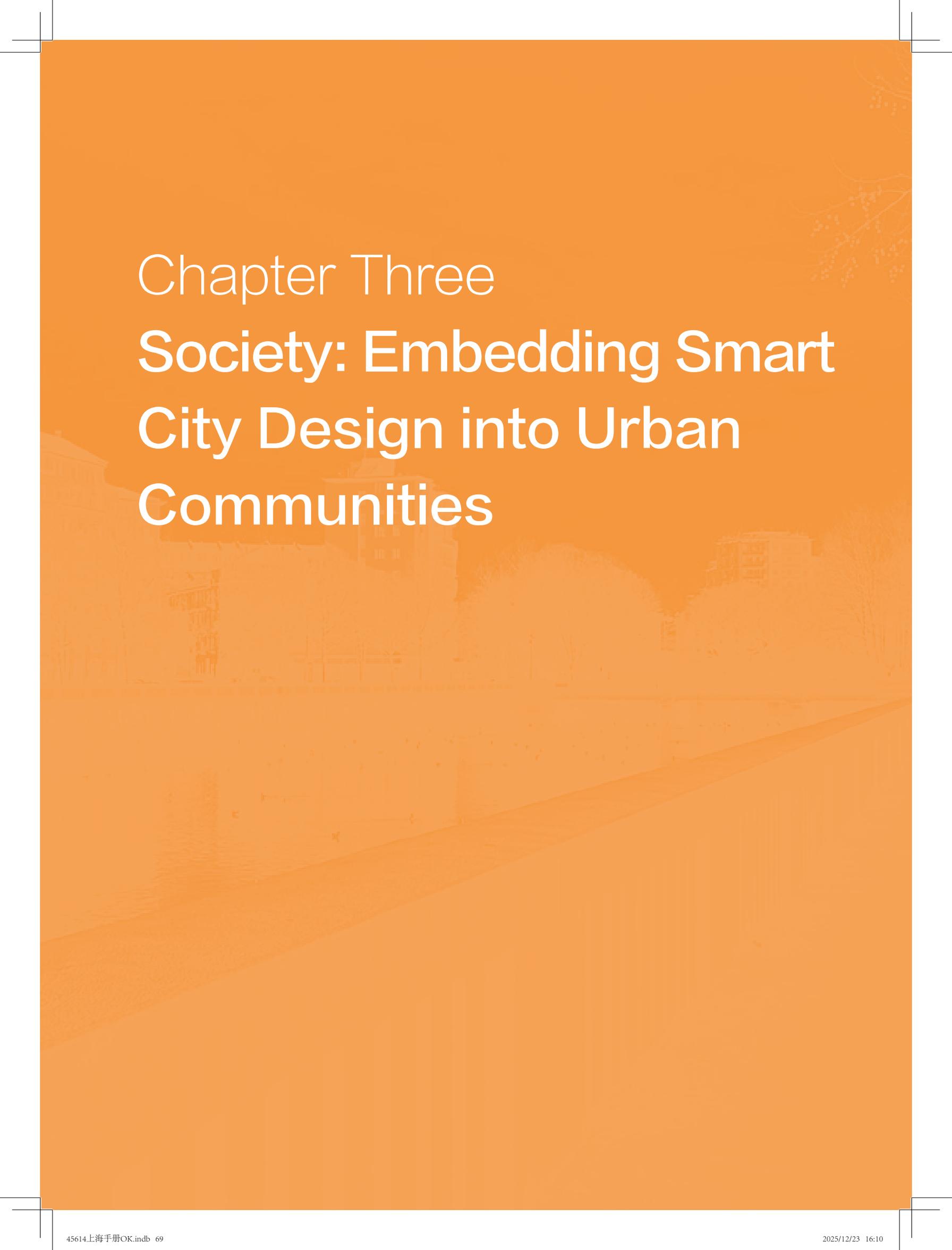
# Chapter Three
# Society: Embedding Smart City Design into Urban Communities

# Introduction[1]

The concept of people-centred smart cities situates society at the heart of urban innovation. Technology, including AI, possess the capacity to strengthen connections between urban communities and the most marginalized citizens, while also fostering social inclusion and promoting more equitable societies. This framework can be understood across three interrelated layers including: ① the relational layer; ② the computational layer; and ③ the visual layer.

Serving as a starting point, the relational layer focuses on how AI responds to community needs in a rapidly digitalizing world. Communities face both emerging challenges — such as the digital divide — and persistent issues including employment insecurity and gender inequality. The central question is how digitalization can serve as an enabler to address these issues rather than deepen them. Building on this foundation, the computational layer concerns the design of technological solutions. It promotes the notion that the primary value of technology lies in tackling the very problems it creates, bridging digital gaps and providing concrete responses to community concerns such as women's employment and youth development. Recognizing the limits of technology and embedding it in social realities—what can be considered the "socialization" of technology – ensures that digital tools remain grounded in real needs rather than a blind pursuit of speed or scale. The visual layer connects technological outcomes to social participation. Its purpose is to make digital solutions visible, understandable and accessible; and rather than presenting uniform, abstract interfaces it necessitates that technology should be communicated through diverse formats tailored to different social groups. Mobile platforms and other accessible media can enable individuals to directly perceive the benefits of technological progress while also inspiring local proposals, community-driven ideas and feedback on urban governance.

The five case studies explored in this chapter illustrate approaches that combine actions to enhance urban societies whilst also promoting the sustainable application of technology—framing digitalization as a social as opposed to technical process. In the context of addressing diverse urban challenges such as female employment security or after dark community safety, each

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1   The writing of this chapter was a joint effort by Fudan University and UN-Habitat. The Fudan University team members included Yu Hai, Sun Zhe, Zhong Xiaohua, Zou Huahua, Liu Jing, and Mao Jianyuan. The case studies for Santiago, Kampala, Belo Horizonte, and Turin, were written by UN-Habitat.

case prioritizes social needs with technology playing a supportive role. Particular attention is given to the level of social participation, for example, whether digital tools enhance youth skills or create new employment opportunities. These cases also demonstrate the value of multi-stakeholder governance. In contrast to one-way models where technology providers deliver solutions and communities passively receive them, users, local authorities and technology developers instead collaborate within shared governance frameworks. This pluralistic approach not only keeps advanced technologies close to everyday life but also builds resilience. Even when specific tools encounter setbacks, the digital literacy, collaborative networks and adaptive learning mechanisms established through such partnerships enable communities to rapidly iterate and develop new solutions.

# Reference  Cases

## Shanghai, China
## Dongming Road Metaverse Digital Community Engaging Youth in Smart Governance[1]

### Case Background

Since 2020, the Chinese government has elevated the construction of a "digital society" to a national strategic level, emphasizing the role of digital technologies in driving the modernization of social governance. In this context, the "digital community", a micro-level unit of the digital society, has emerged as a key arena where policy and practice converge. A digital community encompasses more than just upgrading infrastructure. It also represents a mechanism for reproducing social relationships mediated by technology. The integration of digital technologies is not merely a utilitarian application; it fundamentally reshapes power structures, modes of participation and social identities inherent in community governance. The digital community project in the Dongming Road subdistrict of Pudong, Shanghai, explores how emerging "metaverse" technologies, such as digital twins, augmented reality (AR) and non-fungible tokens (NFTs) are reshaping the visibility of proximity, commercial vitality and youth engagement in a super-aged society.

The Dongming Road subdistrict is characterized by a severely aging population, low youth engagement in community affairs and a neighbourhood economy dominated by food and drink businesses that foster a vibrant "street" atmosphere, see Figure 3-1. The proportion of residents aged 60 and older has surpassed the international threshold for a super-aged society, while the relationship between the youth demographic and community space reflects a pattern of "spatial separation between work and residence". Though many young people have a household registration document or reside within the neighbourhood, their economic activities largely occur outside the area during the day and they only return to the community in the evening. Despite this spatial mismatch, the neighbourhood's commercial density has not diminished.

The combination of high commercial density and the aging residential population has given rise to three issues explicitly identified by grassroots governance bodies: ① insufficient visibility of governance and merchant information; ② low customer traffic leading to weak business performance; and ③ limited knowledge of and participation in community affairs among young residents due to a temporal structure in which they work outside the subdistrict during the day and return after dark.

### Implementation Process

In response to residents' needs, the Dongming Road subdistrict and social organization Huimingxin established the public space hub Huimingxin Neighbourhood Development Service Centre. Utilizing a metaverse-based interface, the centre established a three-layered digital governance system consisting of a

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1   Author: Zhe Sun, Associate Professor, Department of Economic Sociology, Shanghai University of Finance and Economics; Director, MSW Programme.

Source: Huimingxin Neighbourhood Development Service Centre.

Figure 3–1　Logo wall in the Dongming Road subdistrict



Source: Huimingxin Neighbourhood Development Service Centre.

Figure 3–2　Metaverse interface of the community application

visual layer, a computational layer and a relational layer. Founded in 2023, the centre is a social organization. It provides a smart space for learning, communication, exhibitions and work for businesses and residents throughout the subdistrict. Using space as its vessel, the centre advances the efficiency of metaverse tools in participatory community governance and enhances their reach among youth through mobilization, operations and activation. The obstacle preventing young people participating in community activities lies in the fact that they work during the day and therefore cannot take part in daytime community events on working days. Through the metaverse space, however, young people can synchronize participation in community life around their work commitments and engage with their home community through both online and offline means. The Dongming Road subdistrict piloted a blockchain-based "digital badge" in 2022 to encourage citizen participation in the community, launching the mobile application Interactive Sharing at Lingyan in 2023. As a result, the Dongming Road's public spaces have achieved online–offline integration. The offline centre interacts with the online mobile application to create a multidimensional space for community engagement.

**1. The Visual Layer: Using Digital Twins and Artificial Reality to Facilitate Inclusive Community Engagement**

In response to the need for greater visibility of information, the mobile application uses digital twin technology to create a 3D, virtual replica of the centre. Governance-related content, such as official notices, subdistrict news and event schedules, is displayed in 3D in a virtual exhibition space. Users with mobile or
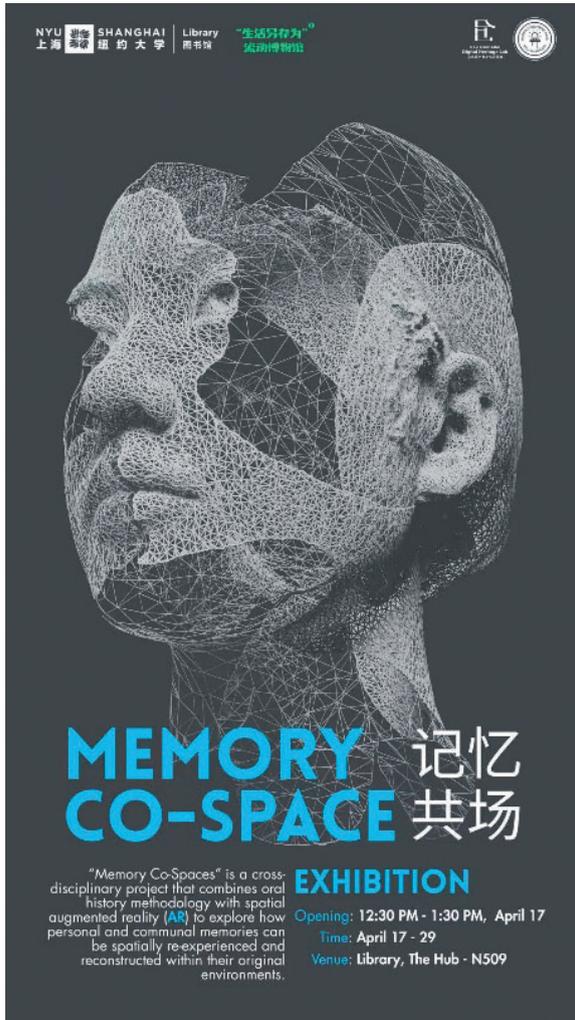
Source: Huimingxin Neighbourhood Development Service Centre.

Figure 3−3    Augmented reality oral history project

desktop devices can log into the application and, at any time, browse the latest community developments via an immersive, roaming perspective, see Figure 3-2.

The centre has also partnered with the New York University, Shanghai to develop an AR-based oral history system that transforms history of the community into an interactive digital narrative. Residents can scan specific physical markers such as historic buildings or street corners to trigger AR overlays of images and audio recordings. For example, scanning a long-standing restaurant reveals a video of the owner recounting the story of the business across three generations. This technology has transformed individual memories into shared community knowledge, and has proved to be particularly popular with younger residents who engage with the content through a gamified experience that reintroduces them to their community, see Figure 3-3.

Digital twin technology has also facilitated presentation of intangible cultural heritage artworks. AR technology has enabled resident-created art pieces (e.g., paper cuttings, tie-dye) to be exhibited virtually,

while the physical pieces are displayed offline. This "phygital" curatorial approach resolves a predicament for elderly artists who are unfamiliar with the internet, while offering young people an entry point for participation.

**2. The Computational Layer: Providing Automated Digital Incentives to Drive Local Commerce**

In response to the demand from local merchants for more customer traffic, the centre has developed a location-based urban "air drop" that distributes electronic discount coupons. Technically, a virtual geofence has been established around the centre. When a resident enters the geofenced area with GPS on their mobile phone, and then opens the community mini-programme, the backend system automatically triggers the coupon distribution logic, the "airdrop" of digital benefit. Coupons are pre-configured by merchants in the backend including value, validity periods, minimum charge and inventory limits, see Figure 3-4. The system then matches and ranks coupons based on users' historical behaviour and merchant tags, prioritizing the most relevant ones. Coupons are stored in the user's "card wallet". When a coupon is redeemed, the merchant scans a QR code via the mobile merchant interface. The system then automatically deducts the redeemed coupon from the inventory and returns data to the backend. To reduce operating costs for merchants, the centre developed a digital dashboard that displays real-time indicators, such as coupon collection volume, redemption rate and peak customer traffic hours, enabling merchants to reconcile transactions with a single tap. A multi-channel reminder network pre-announces coupon airdrop schedules via community WeChat accounts, elevator screens and shopping centre television terminals.

**3. The Relational Layer: Constructing a Digital Identity System**

To address the challenge of limited youth participation in community governance, a digital badge system project based on NFT blockchain protocols was introduced in 2022. NFT digital badges were minted via Shanghai's Conflux Tree-Graph blockchain. Badges are acquired by submitting community proposals, organizing offline volunteer activities, collecting AR oral histories or assisting merchants with digital marketing training. They are displayed as dynamic cards on the user's community mini-programme homepage showing the badge's date of issue, reason, serial number and on-chain hash. Badge holders are given the digital identity of "community influencer" and are granted a dedicated display slot on the interactive logo wall. The logo wall, originally an LED screen in a public space, has now been mapped to a metaverse twin wall. Badge holders can upload text, images or short videos from their mobile devices at any time. After AI-based content moderation, event copy is automatically generated. Users can also participate in topic discussions by posting content with a single tap to social media such as Xiaohongshu.

Introduction of these digital badges has further promoted a sense of identity and engagement from young residents and over 100 NFT digital badges have been issued to date, see Figure 3-5. From the joint efforts of the Dongming Road subdistrict and Huimingxin on activating vitality and active youth

Source: Huimingxin Neighbourhood Development Service Centre.

Figure 3–4   Automated digital voucher airdrop based on community spatial boundaries
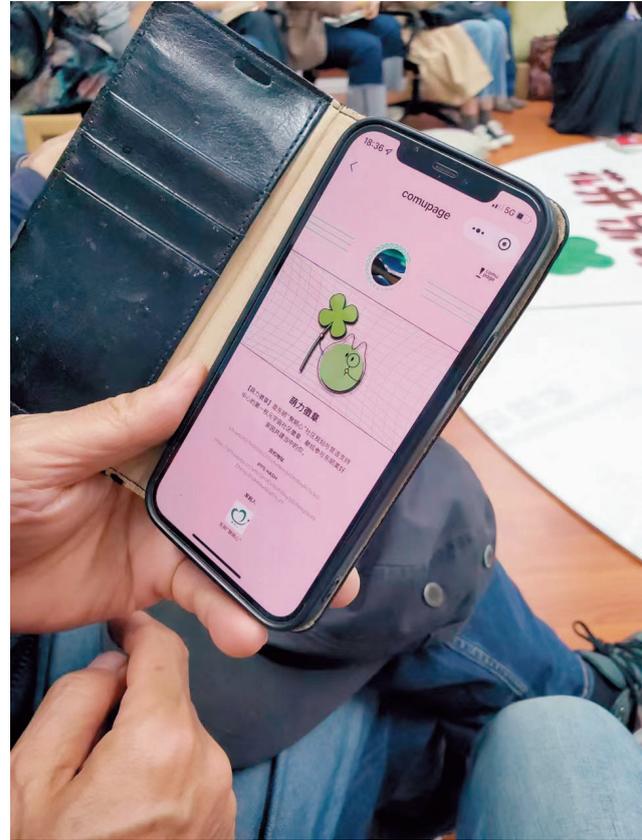


Source: Author.

Figure 3–5   The first NFT digital badge in the Dongming Road subdistrict

participation, 1,287 community proposals have been sublitted since 2023. Proposals cover topics such as the night-time economy, senior-friendly facilities, micro-renewal of community spaces and parent-child activities. Of these proposals, 128 were put on the subdistrict agenda and 32 have been implemented. The digital badge system project won the Gold Award at the 2024 Social Organization Innovation Competition. It has engaged over 3,000 direct participants through around 300 online and offline activities, reaching an estimated 100,000 people (from summer activity data).

## Reference Experiences

Dongming Road subdistrict demonstrates that the key to building a digital community lies not in technological sophistication but in how technology transforms into a mechanism for reproducing "community self-organization". Community digitalization does not revolve around social networking, instead, it unites platforms and high-tech companies around community residents as the core, forming what can be described as "intelligence in proximity". High-tech platforms should serve community life rather than the other way around. Communities should be

able to establish the temporal and spatial boundaries of technology platforms rather than allowing these platforms to expand blindly. This attitude toward high technology can be extended to other communities that are currently being impacted. Beyond the Dongming Road subdistrict, Huimingxin has integrated metaverse technology into its activities for promotion in projects across several subdistricts in the Pudong New Area-Changning, Fengxian, Huangpu and Putuo. This case offers experience in three dimensions:

**1. Enhance Connection Between Online and Offline Spaces to Broaden Participation**

Visual-layer technologies can do more than provide virtual displays. By combining digital twins with AR, the "time gap" of young residents, often absent during the day, turns into an online presence. Through the digital twin of the Neighbourhood Development Service Centre, young people can browse notices and event updates while commuting. AR oral history and cultural heritage features overlay historical narratives onto real streets and buildings, allowing users to access content by simply scanning locations. This seamless link between online browsing and offline check-ins bridges the gap between seeing and being there, widening opportunities for youth participation without adding time burdens.

**2. Harness Digital Automation to Streamline Engagement and Local Commerce**

Automation in the coupon system drives the computational layer. The mini-programme manages issuance, redemption and data feedback end-to-end, removing extra work for merchants. Real-time data such as redemption rates and peak traffic helps businesses adjust strategies quickly. Each scan completes a transaction instantly and provides immediate feedback, lowering administrative costs, improving profitability and creating a seamless cycle that links technology, commerce and local governance.

**3. Promote Transitions From Digital Identities to Digital Proposals**

Together, the NFT badges and interactive logo wall have created a relational-layer experience pathway. More than 100 NFT badges now represent digital identities as "community influencers." Badge holders can submit proposals without secondary review, their content appears in real time on the virtual wall and is projected on physical screens during the evenings. Over two years, this has generated 1,287 proposals, completing a three-tier progression from "digital identity" to "digital interaction" to "digital proposal," significantly increasing submission volume.

Overall, the case positions the Neighbourhood Development Service Centre as the hub for a digital twin of public space, enabling multiple stakeholders to participate in inclusive governance. Traffic is contained within the community's own intelligent interface instead of being diverted to external platforms. The resulting "intelligence in proximity" is defined by the community itself. Rather than serving the expansionist logic of platform capital, technology is subordinated to community needs. Users can translate the digital space back into perceivable physical space at any time, continuously reinforcing a sense of boundaries.

## Santiago, Chile
## Metropolitan Mobility Network: A Digital System to Facilitate Inclusive Urban Mobility

Santiago's rapid urbanization has generated pressing challenges, including severe traffic congestion, rising air pollution and inadequate public transport accessibility. These issues have diminished residents' quality of life while constraining the city's ability to meet its development goals. To address this, the Ministry of Transport and Telecommunications launched the Metropolitan Mobility Network Red Metropolitana de Movilidad project in 2017 (rebranded in 2019) with the objective of transforming Santiago's transport system into an integrated, data-driven network. By leveraging real-time data and smart technologies, the initiative aims to unify different modes of transport, create a seamless mobility experience and establish a sustainable, efficient public transport ecosystem. The project has achieved significant milestones across three strategic dimensions: pioneering electromobility and sustainable infrastructure; enhancing user experience through smart technologies; and advancing social equity and gender inclusion in the transport workforce. Together, these achievements position Santiago as a global reference point for sustainable and human-centred mobility systems.

**Pioneering E-Mobility and Sustainable Infrastructure Development**

Through large-scale electrification of public transport, Santiago has emerged as a global leader in urban e-mobility. By the end of 2024, the city operated 2,480 electric buses representing 37 per cent of the total bus fleet, placing it among the world's top adopters of electric public transport.[1] The project also incorporates advanced optimization technologies such as Optibus software which is used to manage operations across 1,000 electric buses. Drawing on real-time data, Optibus enables precise scheduling of operations, charging and route planning, while conducting rapid scenario simulations based on electric battery performance. This integration reflects a strategic shift: rather than simply procuring electric vehicles (EVs), Santiago has adopted an intelligent, data-driven approach to maximize environmental impact and operational efficiency.[2] Beyond vehicle deployment, investments in supporting infrastructure have been critical. The city has introduced 360 solar-powered bus stops and developed 445.8 km of dedicated bus lanes which have improved

1    Busworld Latin America (2024) Santiago de Chile will complete 2,600 electric buses by the end of 2024. Available at https://www.busworldlatinamerica.org/en/news/santiago-de-chile-will-complete-2600-electric-buses-end-2024 (Accessed: 03/07/2025).

2    Norman, H. (2025) Optibus to optimize 1,000 buses in new Santiago tender. Available at https://www.traffictechnology-today.com/news/public-transit/optibus-to-optimize-1000-buses-in-new-santiago-tender.html (Accessed: 03/07/2025).

accessibility and reduced travel times.[1] Creating this infrastructure demonstrates a holistic approach to sustainable mobility, encouraging modal shifts from private vehicles to public transport by making it more reliable, efficient and environmentally friendly.

**Enhancing User Experience and Transforming Travel Behaviour through Smart Technologies**

Within the broader framework of smart cities, the convergence of cloud computing, AI, machine learning and IoT is reshaping Santiago's mobility landscape. The Metropolitan Mobility Network exemplifies this transformation by embedding data-driven technologies, GPS and mobile platforms into everyday transport operations. A central feature is the unified travel app which integrates buses, the metro and MetroTren Nos into a single digital platform, see Figure 3-6. The app hosts multiple tools that streamline the passenger experience including:

- "When to Arrive?" to deliver real-time bus arrival data.
- "How to Get There?" to support personalized journey planning with filters for fastest routes, bus-only journeys or minimal transfers.

- "Route Details" to provide comprehensive guidance for specific journeys.
- "Nearby" which maps out available transport options close to the user's location.

This digital integration has been shown to drive behavioural change. A study of the Red Travel app revealed that 23.5 per cent of users have modified their travel habits, with 10.5 per cent changing their mode of transport and 13 per cent optimizing their routes or stops.[2] These results highlight how accessible, real-time information can encourage a shift towards public transport, strengthening the system's efficiency and sustainability.

**Fostering Social Equity and Gender Inclusivity**

The project also foregrounds equity and inclusion in urban mobility. One notable achievement has been the sharp increase in female bus drivers from just 100 in 2012 to over 1,000 by 2022.[3] This progress has been supported by scholarships for professional driving courses and by locating bus terminals closer to drivers' homes to improve job accessibility. Within just

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1　Red Movilidad (2025) MTT and the Municipality of Santiago announce the renovation of 620 Red Movilidad stops in the commune. Available at https://www.red.cl/en/red-communicates/mtt-y-municipalidad-de-santiago-anuncian-la-renovacion-de-620-paraderos-de-red-movilidad-en-la-comuna/ (Accessed: 03/07/2025).

2　Henriquez-Jara, B., Arriagada, J., Montenegro, K., Tirachini, A. and Munizaga, M. (2025) The Effects of a Real-Time Public Transport Information App on Travel Behaviour, Traffic Levels and the Environment. URL: https://www.utwente.nl/en/et/cem/news-events/2025/5/311451/the-effects-of-a-real-time-public-transport-information-app-on-travel-behaviour-traffic-levels-and-the-environment (Accessed: 3 July 2025).

3　UITP (2024) A Driver's Programme for Women Across the Red Metropolitana de Movilidad. Available at: https://www.uitp.org/case-studies/a-drivers-programme-for-women-across-the-red-metropolitana-de-movilidad/(Accessed: 3 July 2025).
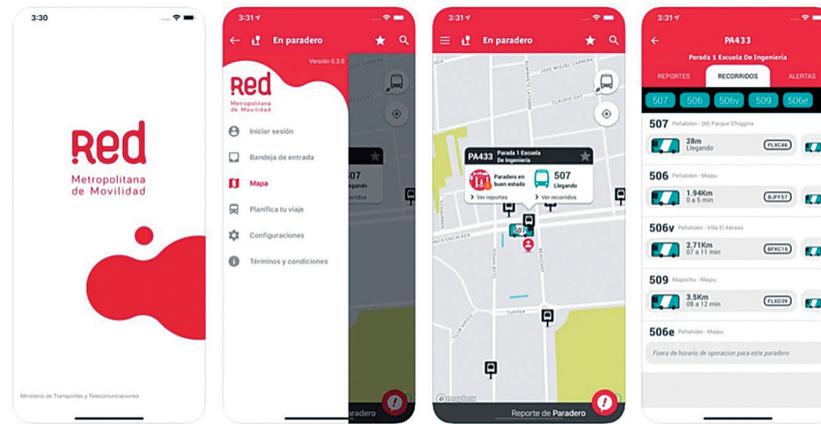
Source: Red Movilidad (2025) Red Movilidad App interface [Digital image]. Available at: https://www.red.cl/acerca−de−red/app−red/ (Accessed: 3 July 2025).

Figure 3−6　The user interface of the Metropolitan Mobility Network's unified travel application

four months, female participation in the transport workforce rose from 5.7 per cent to 7.5 per cent.[1] Beyond improving equity in a traditionally male-dominated sector, studies indicate that women's participation correlates with higher operational standards and improved community well-being. The initiative thus not only expands women's career opportunities but also strengthens the social and economic fabric of Santiago. In addition, the Dale QR! programme enhances affordability and social equity by introducing a monthly fare cap whereby after reaching CLP 41,000 (equivalent to 47 rush-hour trips), passengers can take unlimited journeys across the network using a QR-based payment system. This innovation particularly benefits frequent users and low-income groups, ensuring predictable and affordable access to public transport. By reducing economic barriers, the programme ensures that the benefits of Santiago's mobility transition are shared broadly across society.

Through the initiative, Santiago has redefined the role of public transport in a rapidly urbanizing city: from reducing emissions and improving infrastructure to reshaping user behaviour and embedding equity into mobility governance. Its integrated, human-centred approach provides a replicable model for sustainable, inclusive smart transport systems worldwide.

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1　UITP (2024) A Driver's Programme for Women Across the Red Metropolitana de Movilidad. Available at: https://www.uitp.org/case-studies/a-drivers-programme-for-women-across-the-red-metropolitana-de-movilidad/(Accessed: 3 July 2025).

## Kampala, Uganda
## The Weyonje App: An Innovative Mobile Application to Transform Urban Sanitation Services

Kampala has long grappled with severe sanitation challenges amidst rapid urbanization. These include hazardous and inconsistent pit latrine emptying services, weak coordination among providers, widespread public health risks from contaminated water sources and inadequate supporting infrastructure. Traditional paper-based systems, opaque and difficult to monitor, have further compounded inefficiencies and underscored the urgent need for a modernized, technology-driven response. The Weyonje app, developed by the Kampala Capital City Authority in collaboration with licensed sanitation providers, residents, civil society groups (including Community Activation Teams and Village Health Teams), government agencies such as the National Information Technology Authority-Uganda and international partners such as the Bill & Melinda Gates Foundation, was designed to meet this need. Its central objective is to strengthen sanitation services through digital tools, community partnerships and effective data utilization. By digitizing the pit emptying process, the app enables residents to directly request services while allowing providers to manage and track jobs in real time. Beyond a technical upgrade, this initiative represents a paradigmatic shift in governance from reactive, fragmented service delivery towards a proactive, integrated and transparent model. It positions Kampala's sanitation reform as a critical step in the city's transition towards a smart, tech-driven and inclusive service delivery system.

**Developing an Integrated Digital Platform with Gegraphic Information System Mapping**

The Weyonje App functions as a centralized digital platform to streamline sanitation services. Licensed service providers can record job details, track orders, manage payments and build business profiles, thereby professionalising the sector. Residents, in turn, benefit from a user-friendly interface to request services directly, ensuring timelier and more reliable sanitation access, see Figure 3-7. A key innovation is the integration of GIS mapping which provides real-time spatial data on pit latrines across the city. This enables sanitation teams to optimize service routes, prioritize underserved areas and guarantee citywide coverage. The platform also enhances occupational safety by facilitating worker training and monitoring compliance with standards. By coupling operational management with spatial intelligence, Kampala has shifted pit latrine emptying from a reactive, ad hoc practice to a regulated, data-driven efficient service.

**Facilitating Data-driven Governance and Policy Formulation**

The App also generates vital datasets for the Kampala Capital City Authority, capturing information on pit latrine conditions, emptying frequencies and service distribution. These datasets

inform multiple governance functions: the public health directorate uses them to manage a medical call centre for sanitation-related emergencies; government ministries leverage them for evidence-based reporting; and the Ministry of Health has introduced new sanitation indicators based on this data, strengthening national public health monitoring. In effect, the Weyonje app transforms operational data into a strategic asset, underpinning adaptive governance and evidence-based policymaking. Governments can now identify trends, target interventions, measure outcomes and refine policies in real time — marking a clear shift from reactive problem-solving to proactive urban management and continuous improvement.

**Promoting Inclusive Community Engagement and Digital Bridging**

The Weyonje App initiative is deliberately human-centred, ensuring that digital innovation advances equity and inclusion. To bridge the digital divide, community activation and village health teams act as intermediaries, extending sanitation access to low-income and smartphone-excluded populations. The App doubles as an educational platform, equipping residents with information on hygiene and sanitation best practices, and fostering shared responsibility for community cleanliness. The initiative also embeds gender inclusion by creating forums for women's participation across the sanitation value chain, supporting their involvement in decision-making, entrepreneurship and service provision within industry associations. In doing so, the Weyonje model expands access, empowers marginalized groups, and promotes both social inclusion and digital equity.
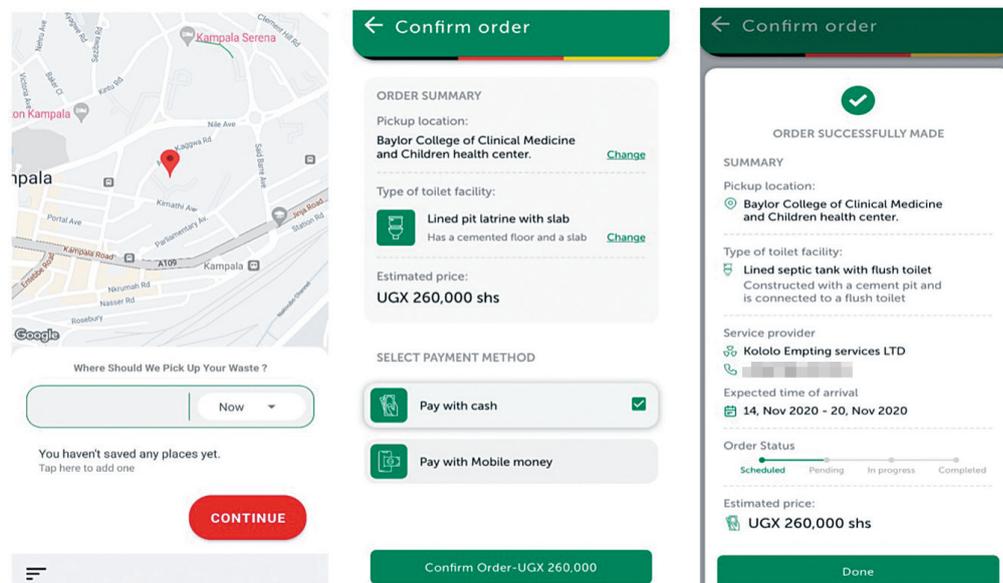


Source: Kampala Capital City Authority (KCCA) (n.d.) WEYONJE CLIENT GUIDE [PDF]. Available at: https://www.kcca.go.ug/media/docs/WEYONJE−CLIENT−GUIDE.pdf (Accessed: 3 July 2025).

Figure 3−7　The user face of the Weyonje App

## Belo Horizonte, Brazil
## The Belo Horizonte Digital Inclusion Programme

### Case Background

Despite improvements in digital transformation, more than 20 million Brazilians still lack access to technology which constitutes approximately 10 per cent of the population.[1] The COVID-19 pandemic further shifted citizen behaviour in which social distancing rules saw many public services transition online, exacerbating issues of digital exclusion and leaving the most vulnerable further behind. A technology, information and communication households survey found that although 42 per cent of the Brazilian population use the internet for educational purposes, this rate is considerably lower among the poorest urban citizens. Limitations in access to equipment and high-quality internet hinder the development of more advanced digital skills which limit opportunities within the technology sector. As the capital of the state of Minas Gerais, Belo Horizonte has more than two million inhabitants, accommodates major startups and is ranked as Brazil's third largest creative centre. Despite its growth, however, it has faced significant challenges in expanding the supply of qualified labour in the technology sector, with a need to meet the growing market demand for skilled IT professionals. In light of Belo Horizonte's emergence as a key in-

novation and technology hub, the city has therefore faced an imperative to integrate these needs whilst increasing digital, social and economic inclusion for the most marginalized urban citizens.

To extend digital connectivity and strengthen digital literacy, the City Hall established a dedicated policy for digital inclusion launching a comprehensive digital inclusion programme. The Coding Dreams programme was first launched in 2019, however, coordinated initiatives were first implemented in 2022 with the official launch of the digital inclusion programme.

The Coding Dreams in Vilas and Favelas 2023 programme is a special edition of the Coding Dreams programme targeting citizens living in the city's informal settlements and disadvantaged communities which are specially designated within the municipal masterplan as Special Zones of Social Interest. By offering training to these urban communities, the programme helps to reduce digital and social inequalities by facilitating productive inclusion of disadvantaged citizens into Belo Horizonte's innovation ecosystem.

### Implementation Process

To operationalize its commitment to bridging digital, social and economic divides, the City Hall facilitates the digital inclusion programme via three pillars: ① connectivity; ② equipment; and ③ training. These pillars serve as the foundations for targeted interventions designed to expand access to digital tools and skills among the city's most marginalized populations. The connectivity pillar ensures connection

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1 Cities for Digital Rights. (n.d.) Belo Horizonte, a commitment to digital inclusion through citizen-centred service design. Available at https://citiesfordigitalrights.org/belo-horizonte-commitment-digital-inclusion-through-citizen-centred-service-design (Accessed: 9/7/2025).

to individuals who are digitally excluded through the provision of free internet access with Wi-Fi signalling maintained by the City Hall.

The Coding Dreams in Vilas and Favelas 2023 programme was developed by Prodabel, the City's digital infrastructure and IT company, and funded by the United States. The partnership arose through international promotion from the International Relations Board, and the Belo Horizonte and International initiative of the Municipal Secretariat of Economic Development. A number of technology companies also participated in activities including Avenue Code, Localiza and Montreal.

**1. Establishing a Citywide Network of Digital Inclusion Points**

The provision of free internet access with the installation of WiFi hotspots across Belo Horizonte has reflected a key component of the city's digital transformation process. The initiative has delivered digital inclusion points with internet access to all 220 villages, informal settlements and housing estates across the city with more than 4,900 active points across the municipality and over 4.7 million registered users.[1] In addition, 146 active telecentres have been established which offer free computer access along with internet connectivity to allow citizens to carry out basic functions such as email and online payments, see Figure 3-8. They also provide opportunities to attend free technology courses within Belo Horizonte's Distance Education platform designed to

facilitate remote learning to enhance knowledge and digital citizenship among urban residents. To cement a network across the city, the digital inclusion points have been deployed in libraries, City Hall bodies, cultural and social assistance reference centres as well as civil society organizations.

The programme also works to connect disadvantaged communities with digital products. Prodabel's Computer Reconditioning Centre, a government established remanufacturing facility to reduce e-waste, is responsible for restoring equipment that is either replaced by the City Hall itself or donated. By January 2025, over 1,800 refurbished devices were donated to previously excluded individuals, 2,700 to legal entities providing social purposes and more than 50,000 to students within the municipal network.[2] Under the third pillar of training, the city guarantees several free online and face-to-face courses and workshops for technology, robotics and digital entrepreneurship, and environmental management for e-waste with more than 12,000 places being offered by the end of 2025.

**2. Leveraging Training to Build Digital Skills Development**

With training a central pillar of the digital inclusion programme, it has also deployed a number of educational courses to help bridge the digital divide. Prodabel offers over 20 free online courses with 3,000 openings per quarter covering content from basic technological introduction on computers to

1 Belo Horizonte City Hall. (2025). Digital Inclusion. Available at https://prefeitura.pbh.gov.br/prodabel/inclusaodigital (Accessed: 9/7/2025).

2 Belo Horizonte City Hall. (2025). Digital Inclusion. Available at https://prefeitura.pbh.gov.br/prodabel/inclusaodigital (Accessed: 9/7/2025).

Source: Cities for Digital Rights. (n.d.) Belo Horizonte, a commitment to digital inclusion through citizen−centred service design. Available at https://citiesfordigitalrights.org/belo−horizonte−commitment− digital−inclusion−through−citizen−centred−service−design (Accessed: 9/7/2025).

Figure 3−8　Free telecentres provide space for young people to access the internet and acquire digital skills

more advanced classes on webpage development and programming. There are also courses designed for seniors, women and youth who have historically been largely excluded from digital training. In the second half of 2019, the city introduced Coding Her Dreams, a course that taught programming skills to women to ensure a gender-inclusive approach to digital skills building and to lower their barrier to participation with regard to digital skills. Women now make up around 60 per cent of certified participants on train- ing courses, and partnerships have been cultivated with NGOs to offer support to women experiencing domestic violence through workshops, or specialized professionals who provide hearing-impaired residents

with access to supportive technology and sign lan- guage.

The Coding Dreams in Vilas and Favelas 2023 programme offered training for 160 people of which 111 students in socially vulnerable situations completed the programme with certification in web programming over a 12-month period between 2023–2024. Held at Prodabel's Information Technology Qualification Cen- tre, it targeted both youth and adults, and focused on programming languages and computational thinking fostering leadership and social innovation through tech- nology; promoting opportunities for job insertion and/ or digital entrepreneurship; and connecting peripheral talent to the city's innovation ecosystem. Beyond pre- paring participants for employment in large technology companies, the programme has placed equal emphasis on leadership, social innovation and digital entrepre- neurship. In addition, training modules combined tech- nical programming skills with soft-skill development to foster autonomy and civic participation. By linking technological learning with opportunities for social in- novation, the initiative has supported youth in building capabilities that can be applied both in the job market and in community settings, strengthening digital citi- zenship and creating pathways for productive inclusion in Belo Horizonte's broader innovation ecosystem.

The training was structured into two modules covering the development of technical skills in digital programming as well as soft skill acquisition such as leadership and autonomy. It also enabled students to directly engage with the IT job market through visits to partner companies to provide hands on learning opportunities, see Figure 3-9. Over the course of

Source: Prodabel (2023).

Figure 3–9　Students visit the software consultancy Avenue Code for coding training

12 months, two cycles of training were conducted offering a total of 160 seats. Training opportunities were widely publicised in the media, with student selection based on a basic computer literacy test and verification of personal data. Targeted sessions were conducted to support student entry into the job market including workshops on resume writing and interview mentoring, along with in-person experience sharing sessions with professionals from the technology sector, see Figure 3-10. Students were awarded



Source: Prodabel (2023).

Figure 3–10　Students undertake job market mentoring

certificates for digital inclusion courses at graduation ceremonies in which the first training cycle included the participation of staff from the United States Consul in Belo Horizonte.

**3. Solidifying Digital Transformation within Urban Operations**

The city has also committed to institutionalizing digital transformation, structing processes and providing tools for improved urban decision-making in the event of catastrophes and crises. The City Hall trains employees in the use of technology to increase efficiency and improve decision-making. As of February 2025, citizens have been able to interact remotely with the City Hall through requests to the 1,435 available services on the Belo Horizonte Digital Platform, including 128 quick request services via the Prodabel PBH APP mobile application. Via a pioneering Data Intelligence Policy, the city ensures that data is collected, stored and shared through an Open Data Portal which makes over 500 datasets available to ensure transparency and security, whilst also prioritizing the responsible use of AI. The Belo Horizonte Operations Centre translates this policy into practice, integrating data from over 20 institutions to improve the quality of public services, coordinate major events and respond preventively to crisis situations, see Figure 3-11. These efforts are not only filling a gap in technology but also creating a future in which every resident can excel in a rapidly changing world.



Source: Global Future Cities Programme. Belo Horizonte "Intelligent Mobility in Express Amazonas" project in review. Available at https://www.globalfuturecities.org/story/belo−horizonte−intelligent−mobility−expresso−amazonas−project−review (Accessed: 15/7/2025).

Figure 3−11　The Belo Horizonte Operations Centre

Reference Experiences

**1. Position Digital Spaces as Everyday Urban Social Infrastructure**

Beyond its programmatic structure, the digital inclusion programme has illustrated the transformative social potential of digital access in the daily lives of marginalized urban residents. In communities historically excluded from full participation in the city, particularly those in peripheral and informal urban areas, the presence of open and accessible digital tools has offered more than just spaces for non-formal education and social change but also critical support facilities for intellectual and cultural formation among young people and adults who are in situations of social vulnerability. They have thus enabled people to see themselves as active participants in urban social processes. For young people, they have marked spaces that enable digital expression and peer-to-peer collaboration. For job seekers, spaces that can facilitate access to formal labour markets and services. And for community members, safe spaces for gathering, learning and mutual support. They have helped to reduce the social invisibility that many residents experience, fostering recognition, civic presence and community identity.

**2. Recognize the Role of Local Ownership and Multi-sector Partnerships to Ensure Long-term Digital Inclusion**

The location of digital access points within existing community structures such as schools, cultural and social assistance reference centres has reflected an important mechanism in fostering long-term sustainability in digital inclusion efforts. Rather than operating as top-down technology installations, many telecentres are co-managed by community organizations and staffed with locally recruited "digital inclusion agents". This participatory approach has not only improved uptake but also allowed the programme to evolve alongside local needs, providing elements from basic computer literacy to support for job searches, digital government services and youth media production. As telecentres have become places of learning as well as spaces that facilitate connection, mutual support and civic participation, the programme offers a model that strengthens local social networks and deepens the sense of ownership and belonging within urban communities. The application of locally tailored and collaborative strategies therefore presents a scalable solution that can help facilitate digital inclusion as a long-term, community-driven process rather than temporal urban intervention.

**3. Support Youth Empowerment and Creative Expression through Digital Media**

The programme has demonstrated how dedicated digital spaces can serve as important platforms for youth empowerment, creativity and future-oriented skill-building. Many telecentres host youth-led media labs, video production workshops and collaborative digital storytelling initiatives which allow marginalized young people to explore their identities, document their communities and gain practical skills in design, communication and technology. In this regard, the programme provides space for active creation and leadership as opposed to passive users and beneficiaries. It has not only built digital competencies but also nurtured confidence among some of the city's most

marginalized citizens, unlocking pathways for further education and entry into formal labour markets. It highlights how digital inclusion efforts can play a powerful role in activating latent potential among those urban citizens who have previously lacked access whereby well-formulated urban digital strategies can position youth as agents of change and curate new pathways towards social and economic opportunities.

## Turin, Italy
## ToNite: Increasing Night-time Safety through Community-led Urban Renewal Solutions

### Case Background

Launched in 2019 under the European Union's Urban Innovative Actions programme, the ToNite project was initiated to enhance night-time safety along the Dora River in Turin's Aurora and Vanchiglia neighbourhoods. Due to urban decline, these areas have faced challenges after dark with increased disturbances and a general sense of insecurity among residents resulting in a reduction in economic activities and services, with social protection assigned to public security forces and the police. These largely inefficient traditional security measures prompted the introduction of a more integrated and community-driven solution to tackle issues of local community safety, with a need to transition to collaborative policies based on social empowerment, active community participation and sociotechnological innovation. The ToNite project was therefore developed to rethink night-time safety and livability not through policies but via co-design, regeneration and placemaking, and new community services.

Combining ethnographic research, urban regeneration and digital innovation, the project has harnessed multidisciplinary solutions to address key issues of urban security. Critically, it has employed a community co-creation approach in which residents and stakeholders have been closely involved in the design of public space interventions and digital infrastructure implementation. In addition, the project has supported local services to enhance social cohesion and night-time livability, thus not only improving safety perceptions but also contributing to broader goals of social innovation, making it a replicable model for other cities.

### Implementation Process

**1. Participatory Research and Community Co-design**

The project was initiated in September 2019 via a baseline research study to gauge safety perception among local residents. To assess the existing culture of night-time security, the project leveraged design ethnography and service design. Experientia, a user-experience and service design consultancy, supported social enquiry activities within both the Aurora and Vanchiglia neighbourhoods and defined 33 new opportunities for the city. Between January and October 2020, they engaged with over 500 local residents, conducting 36 in-depth interviews, 5 explorative urban walks and an online questionnaire to capture qualitative insights, see Figure 3-12.[1] The objective

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1　Experientia. (n.d.) ToNite: social innovation and urban regeneration in Turin, Italy. Available at https://www.experientia.com/portfolio_/to-nite-urban-regeneration-in-turin/ (Accessed: 1/7/2025).

Source: Experientia. (n.d.) ToNite: social innovation and urban regeneration in Turin, Italy. Available at https://www.experientia.com/portfolio_/to−nite−urban−regeneration−in−turin/ (Accessed: 1/7/2025).

Figure 3−12    Local community members partake in exploratory urban walks as part of a co−design process for placemaking solutions to enhance the security and use of public spaces

was to understand how people used space after dark, which urban environments deterred or invited social interaction, and what defined safety beyond formal security metrics. Opportunity mapping and persona modelling were utilized to guide co-design processes to generate impact-oriented services for the selected area and inform the design of targeted interventions. Co-design marked an integral component to the initiative whereby citizens were provided the opportunity to define solutions to strengthen social cohesion and enhance the perception of night-time security and liveability within local public spaces across the various project phases.

**2. Implementing Community Led Projects for Socially Oriented Placemaking**

Under a co-creation approach, a keystone of ToNite was its call for proposals launched in December 2020. Municipal authorities received over 80 pro-posals developed by NGOs, universities, schools and informal community groups, of which 19 were selected through co-funded grants totalling approximately EUR 1 million. Selected beneficiaries ranged from neighbourhood associations and youth groups to migrant cultural collectives, senior citizen networks and small local enterprises, ensuring a diversity of social actors. Focused on active citizenship actions, social and cultural initiatives, and the development of new local services, projects connected more than 30,000 people; 2,222 events were held, 15 new partnerships were created and 4 formal collaborations were signed with community groups.[1] Activities included inter-cultural festivals, night-time guided walks, open-air

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1    Howard. N. (2025). Turin's ToNite project is illuminating the night through community and care. Available at https://eurocities.eu/stories/turins-tonite-project-is-illuminating-the-night-through-community-and-care/ (Accessed: 3/7/2025).

theatre and music performances, youth mentorship programmes, night markets and skills-sharing workshops. Events were coordinated through a combination of municipal grants, "pacts of collaboration" with the city administration and self-organization by resident committees, providing a flexible structure for community leadership.

A number of innovative measures emerged with some of the most notable including YallAurora; a former tailor's workshop turned community youth hub led by Muslim students providing after-school classes, bridging cultural and generational divides. A previously unused avenue has been redesigned into the Ⅱ Salotto di Miranda (Miranda's Living Room) replacing a boules court with a greenhouse in the central alley of a tree-lined boulevard in the Aurora neighbourhood. As a modular open-air kiosk, it serves as a gathering place for hosting community and cultural activities, offering workshops, performances and light installations while consciously addressing night-time safety through cultural atmospherics, see Figure 3-13.



Source: Urban Innovative Actions. (2024). ToNite-Journal n.4-A final update on the project and its legacy in Turin. Available at https://www.uia-initiative.eu/en/pdf/3122 (Accessed: 3/7/2025).

Figure 3-13　The Il Salotto di Miranda serves as a social gathering point hosting cultural activities

Leveraging people-centred urban design principles, three core spatial interventions have served as physical anchors for the project: ① Viale Ottavio Mario Mai; ② Giardino Pellegrino; and ③ the Dora riverbank.

Viale Ottavio Mario Mai was previously a bleak corridor with poor public lighting situated behind the University of Turin's Luigi Einaudi campus. Through ToNite, it has been redesigned as a new "outdoor campus", transforming it into a pedestrian area of over 5,000 square metres in the Vanchiglia neighbourhood, see Figure 3-14.[1] Elements such as pedestrian and cycling paths with reconfigured paving, seating, lighting and overhead signage have created a welcoming, safe space for students and residents, which operates multifunctionally hosting evening markets, student performances and community events. The new public lighting system was designed in collaboration with Iren, and included the insertion of 13 new poles, one of which lights a mural designed for TOward 2030-18 works of art inspired by the SDGs and the United Nations 2030 Agenda.[2]

To protect nature within the stretch and ensure the application of conservation principles, the integration of soil allows for permeability to naturally manage stormwater, whilst increased greenery increases air quality. Alongside existing plane trees, four new plantings have been created as well as flower beds

1　Howard. N. (2025). Turin's ToNite project is illuminating the night through community and care. Available at https://eurocities.eu/stories/turins-tonite-project-is-illuminating-the-night-through-community-and-care/ (Accessed: 3/7/2025).

2　ToNite. Urban regeneration of Viale Ottavio Mario Mai. Available at https://tonite.eu/en/urban-regeneration-of-viale-ottavio-mario-mai/ (Accessed: 3/7/2025).
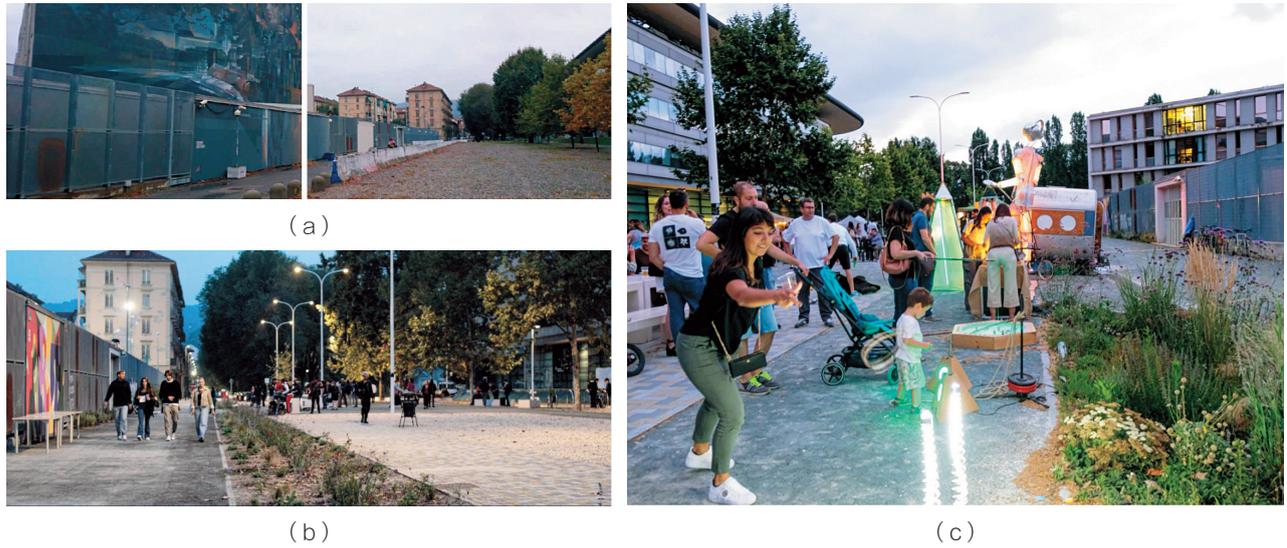
（a）

（b）                                                    （c）

Source: ToNite. Urban regeneration of Viale Ottavio Mario Mai. Available at https://tonite.eu/en/urban−regeneration−of−viale−ottavio−mario−mai/ (Accessed: 3/7/2025).

Figure 3−14    The transformation of Viale Ottavio Mario Mai: (a) the area before transformation; (b) and (c) a new identity following installation of street lights, furniture and green infrastructure

containing herbs and non-allergenic ornamental grasses, and a raingarden comprising of plants resistant to water stress to help absorb excess rainwater runoff, see Figure 3-15. The avenue is crossed by interconnected paths in which an ecological pavement stabilized in earth was designed as a cycle path on the adjoining Corso Farini avenue connecting it with Viale Mai along the Edisu University residence. Outdoor furniture has been adapted to contemporary urban dynamics, exploring principles of physical distancing while fostering inclusivity and social interaction. A communal table was also introduced featuring modular benches that are strategically spaced yet easily reconfigurable to enable closer seating when appropriate. This design ensures



Source: ToNite. Urban regeneration of Viale Ottavio Mario Mai. Available at https://tonite.eu/en/urban−regeneration−of−viale−ottavio−mario−mai/ (Accessed: 3/7/2025).

Figure 3−15    Rain garden installation as part of a nature−based solutions approach to climate change adaptation along Viale Ottavio Mario Mai

accessibility for individuals using wheelchairs and allows for the addition of extra seats as needed. Newly integrated urban amenities including benches, chaises longues, table tennis and bicycle racks were placed at strategic nodes, such as the intersection with Corso Farini and the northern connection to Lungo Dora Siena, enhancing both functionality and connectivity within the public realm, see Figure 3-16.

The previously abandoned Giardino Pellegrino-a 2,640 metre square garden within the heart of the Aurora district-was redeveloped between May and August 2023. Focused on inclusivity and accessibility, the redesign has transformed it into a multifunctional family-oriented playground and reuseable cultural venue. This site marks another core hotspot of regeneration through the ToNite initiative in which the revival of this public garden offers a primary green space within the Aurora neighbourhood. In cooperation with the community foundation Porta Palazzo, the project integrated new street furniture and a children's playground as well as cultural and social activities for families. These measures have increased access to public spaces for various types of users, supporting the shared management of services and public spaces via a pact of collaboration between the municipal government authority and a community foundation comprised of local residents, associations and informal groups. The garden is now a symbol of the local community and citizen co-creation, offering a diverse range of community activities across the thematic strands of dialogue, culture and sociality including social theatre, experiential art workshops, reading groups,

cultural mediation activities, gardening and games, see Figure 3-17.

The reactivation of the Dora riverfront stretching over 2 km has unlocked a new and engaged part of the public realm through placemaking, see Figure 3-18 Measures such as art installations, sensor-enhanced lighting and pedestrian linkages have been introduced with spaces available for performances, film nights and pop-up yoga sessions which have turned the riverbank into an evening attraction. Many of these programmes were co-curated by resident artists, student associations and migrant-led radio collectives using participatory scheduling to decide event times and formats thereby strengthening local ownership. These interventions have not only improved community safety but also functionally activated spaces, transforming them into platforms under community ownership.

Along the Lungo Dora Napoli which runs parallel to the riverbanks, the Lunadora initiative reflects a unique revitalization project running an outdoor nocturnal web radio laboratory co-managed by local youth members, artists and migrants, see Figure 3-19. The scheme also creates itineraries designed to rediscover hidden areas and streets within the Aurora neighbourhood and features creative recycling workshops, photography exhibitions and live music concerts. The Giardini sulla Dora (Gardens on the Dora) now features as a permanent point of reference-a renewed public garden and the community gateway of the popular culture network. Serving as the community "concierge", it maintains the green space adjacent to a local primary school during evening hours

Source: ToNite. Urban regeneration of Viale Ottavio Mario Mai. Available at https://tonite.eu/en/urban−regeneration−of−viale−ottavio−mario−mai/ (Accessed: 3/7/2025).

Figure 3−16　The adoption of socially oriented design principles within Viale Ottavio Mario Mai allows citizens to gather, play, rest and hold public events in the evenings



Source: ToNite. ToNite at the Cities Forum 2023: site visit to the Pellegrino Garden and the Arsenal of Peace | March 16th. Available at https://tonite.eu/en/tonite−at−the−cities−forum−2023−site−visit−to−the−pellegrino−garden−march−16th/ (Accessed: 3/7/2025).

Figure 3−17　Giardino Pellegrino provides a safe, interactive social space with live events for local residents

Source: Experientia. (n.d.) ToNite: social innovation and urban regeneration in Turin, Italy. Available at https://www.experientia.com/portfolio_/to-nite-urban-regeneration-in-turin/ (Accessed: 1/7/2025).

Figure 3-18　The Dora riverfront before regeneration

offering cultural activities including open-air theatre and dance classes, see Figures 3-19 and 3-20. This metamorphosis of riverbank areas has strengthened the shared neighbourhood identity, unlocking vibrant and safe public spaces for day and night.

Alongside entertainment and cultural efforts, activities targeting civic-mindedness and behavioural change have also been instigated. The Scandagli project engages children and teenagers to take better care of school courtyards and public spaces, while the Per. Notte scheme supports young people and club managers via creative activities to prevent and minimize risks to alcohol and substance abuse. The ApeCare scheme offers primary healthcare and guidance to local services for marginalized communities, while the Manage Your Night initiative raises awareness and building skills among managers working in the evening to prevent and manage night-time risks. These programmes often combine peer-to-peer education with municipal support, demonstrating how small-scale, resident-led initiatives can address social and health-related concerns in a night-time context.

**3. Real-time Data Collection to Support Security through Digitized Urban Management**

Each local project was embedded in an acceleration programme offering mentorship, training in digital tools and assistance in forming legal "pacts of collaboration" which operate as formal agreements to delineate stewardship responsibilities and enable the co-management of public space and civic infrastructure. As a regulatory tool, the agreement of three-year pacts between the local authority and community

Source: Urban Innovative Actions. (2022) ToNite local projects are now in full swing: new services and initiatives along the Dora River. Available at https://www.uia−initiative.eu/en/news/tonite−local−projects−are−now−full−swing−new−services−and−initiatives−along−dora−river (Accessed: 1/7/2025).

Figure 3−19    Live music events along the Lungo Dora Napoli through the Lunadora initiative



Source: Ortialti. (n.d.) I Giardini Sulla Dora. Available at https://ortialti.com/portfolio/i−giardini−sulla−dora/ (Accessed: 3/7/2025).

Figure 3−20    Residents watch a live open−air performance at the regenerated Giardini sulla Dora

associations supports the long-term sustainability of project activities to improve neighbourhood areas along the Dora River.

An urban data platform designed and implemented between 2020 and 2022 also provides recipients with real-time data across urban dimensions such as demography services, public space, mobility and urban safety-all integrated into city servers. The platform enables analysis into the impact of social and cultural services across targeted project areas and allows tracking regarding the evolution of activities undertaken by local associations and third sector organizations. It integrates sensor feeds to monitor elements such as light levels, pedestrian counts, noise, incident logs from municipal and police records, as well as perception inputs via apps and surveys submitted by residents or civic actors. The platform thus serves as a key tool to measure activity, gather user feedback and generate data-led proposals for further funding. This

has strengthened organizational capacity, ensuring projects are more than just ephemeral events but civic foundations to further stimulate social innovation.

All partners-from the city's urban planning office to community hubs-can access and contribute data. For example, Giardino Pellegrino's caretaker group logged evening attendance figures and satisfaction surveys, and urban planners analysed noise and lighting data to fine-tune regeneration interventions. The combined dataset supported decision-making across departments enriching the Night Management Plan launched in 2023. The open architecture of this platform has inspired similar systems in other cities under the Urban Innovation Actions Urban Lab of Europe and is adaptable to different civic governance contexts.

Co-creation approaches ensure a human-centred focus on data modelling in which evidence from research on the culture and perception of safety is

integrated to inform the design of technology infrastructure to support the city and help define a call for innovative local social impact projects. Data revealed emotionally resonant barriers including poorly lit passageways which symbolized abandonment, while the absence of programming also triggered avoidance. Conversely, spontaneous cultural expressions such as impromptu music or communal dinners revealed latent civic energy in which findings then shaped the subsequent co-design workshops. In both Vanchiglia and Aurora, residents worked with architects and local NGOs to imagine place-specific interventions ranging from lighting schemes to container installations for cultural pop-ups. This participatory design phase ensured that interventions were context-sensitive and authentic in regard to the physical transformation of urban space.

As the initiative concluded in mid-2023, its processes and infrastructure had gained institutional wings:

- Input from the Urban Data Platform was incorporated into the official Night Management Plan (approved July 2023).

- Four civic initiatives obtained additional funding from ImpatTO (2024), an open call supporting proximity services across the city.

- ToNite's methods have been mainstreamed across building decarbonization, mobility and education programmes, leveraging over EUR 30 million in combined European Union and national funding (Recovery Assistance for Cohesion and the Territories of Europe, Piano Nazionale di Ripresa e Resilienza).

- The city also joined the URBACT 2Nite transfer network, sharing its model in workshops with

Cluj-Napoca, Riga and Sant Boi de Llobregat.

## Reference Experiences

**1. Redefine Urban Safety as a Spatial Transition and Community Connection Transition as Opposed to Surveillance**

The ToNite project demonstrated that improving the perception of safety in urban areas is most effective when rooted in community empowerment and active involvement in the regeneration of public space. Safety is not achieved solely through physical upgrades or surveillance; it emerges from vibrant, inclusive public environments that reflect the needs and identities of its residents. By engaging local communities including marginalized and migrant groups through participatory co-design processes, storytelling tools and culturally inclusive activities, ToNite has fostered a renewed sense of place, strengthened social ties and supported the continuous use of public spaces throughout the day and evenings. This inclusive approach contributed to reimagining previously unsafe or neglected areas as shared community assets.

**2. Connect Spatial Regeneration with Social Development to Instigate Long-term Urban Transformation**

An integrated and multisectoral approach to urban regeneration proved crucial to achieving long-term impact. The initiative has demonstrated the importance of pairing physical improvements to public spaces with investments in social infrastructure to achieve meaningful, long-term improvements in urban safety and quality of life. Regenerating the

Dora riverside and other target areas is not only about benches, lighting or landscaping but about reactivating the spaces through new services, cultural programming and social initiatives that respond directly to community needs. By integrating urban design with socially-focused urban development, such as supporting local associations, youth programmes, migrant inclusion activities and even extended university opening hours, ToNite has cultivated a richer ecosystem of local care, solidarity and engagement. This integrated approach has transformed previously neglected spaces into hubs of everyday urban life, reducing marginality and promoting a more inclusive, liveable city after dark.

**3. Recognize Participatory Monitoring are Key to Enable Project Replication and Institutional Learning**

One of ToNite's most innovative contributions has been its development of a participatory monitoring and evaluation framework that not only tracks outcomes but supports funded stakeholders throughout implementation. This real-time, collaborative system has helped measure impact more effectively and provided institutional learning that has informed future urban interventions. It has also strengthened the city's capacity to design funding instruments focused on social impact. Via peer learning events and its leadership within the URBACT Innovation Transfer Network (2Nite), Turin has laid the groundwork for replicating this model in other European cities, embedding inclusive and participatory principles into urban safety and night-time policy.

# Policy Suggestions

**1. Centre Local Community Needs as a Core Pillar for Smart City Development Strategies**

The essence of smart city development lies in serving the well-being of the people; thus, community needs must be established as the central orientation of technological applications. This requires that at the stage of technological planning, solutions must directly address issues of genuine concern to residents. At the same time, feedback channels should be opened by combining online and offline mechanisms to ensure residents can conveniently express their needs. During implementation, dynamic evaluation mechanisms should be established using the actual effectiveness of problem resolution as the principal benchmark, with timely adjustments and optimization of technological solutions. In this way, technology can truly become an effective tool to meet residents' needs.

**2. Promote Technological Transparency to Enhance Citizen Participation in Urban Development**

Transparency is the cornerstone of trust-building. Technology providers must abandon "under-the-table" service models and proactively disclose to community residents and city managers the principles, implementation pathways and expected outcomes of the technologies in use. By organizing lectures and opening access to platforms, the public can better understand the operational mechanisms. This not only helps dispel public concerns about new technologies and enhances social trust, but also transforms the process of technology dissemination into

a platform for improving digital literacy. This drives the enhancement of digital skills among community residents, creates more employment opportunities and maximizes the social value of technology.

### 3. Mainstream Participatory, Multi-stakeholder Approaches to Urban Development

The effective implementation of smart city technologies cannot rely solely on technology enterprises. A supervisory mechanism must be established that involves joint participation by governments, enterprises and residents. Regular communication platforms and collaboration mechanisms should be institutionalized, enabling residents to take part directly in the entire process of technology implementation from planning and design through to operation and maintenance while fully expressing their views and suggestions. At the same time, urban governance actors should play a coordinating role in integrating resources from all sides, ensuring that technological solutions are deeply aligned with actual community conditions. This will enable sustainable operation and genuine integration into residents' daily lives, ensuring that the achievements of smart city development benefits every resident.

### 4. Position Artificial Intelligence as a Tool for Community Empowerment

Technology is not in opposition to people, rather, it empowers humanity to become enhanced agents of action. In the cases presented in this chapter, technology has generated more local employment, promoted gender equality and strengthened community relations. The connection between technology and society must be both recognized and amplified within community governance. Community governors must avoid the colonization of community life by the purely instrumental application of technologies, while also guarding against community residents developing technological resistance out of fear. Befriending AI may not be an objective inevitability, but as a guiding vision it can significantly increase the likelihood of AI being directed toward social good.

### 5. Advocate for Urban Development Mechanisms that Move from Questions to Proposals

Interaction with AI underscores the value of human questioning, while AI's responses and assistance can encourage residents to generate proposals. In the case of Shanghai, the digital transformation of community governance has significantly increased both the initiative and volume of proposals submitted by young residents, thereby providing legitimacy and sustained momentum for urban development. Community participation empowered by AI represents a critical dimension of AI's socialization. When AI enables residents to progress from asking questions to submitting proposals, it demonstrates that human agency is not displaced by AI but rather reinforced within this new form of partnership. This ensures that the vision of a smart city ultimately serves the goal of people-centred community life.

# Chapter Four
# Economy: Smart City Driven Industrial Upgrading and Economic Innovation

# Introduction[1]

As the global economy undergoes rapid digital transformation, cities are increasingly functioning as integrated hubs for data, computing power, algorithms and applications. Faced with industrial restructuring, rising factor costs and fiscal constraints, smart cities are emerging as engines of economic productivity and innovation. Their effectiveness depends on the coordinated interaction of digital infrastructure, enabling institutions and industrial ecosystems. This chapter highlights a pathway that connects people, industry and economic systems. In practice, this involves the reduction of institutional transaction costs through unified data and standards systems; the combination of industrial collaboration via specialized industrial parks and open application scenarios, and the generation of innovation and human capital through the delivery of inclusive urban public services and mechanisms that attract and retain skilled workers. Together, these measures can help cities pursue sustainable and high-quality economic growth.

Smart city development combines both public infrastructure and goods in support of economic transformation. On the one hand, city-level digital systems and data infrastructure, digital twin city and AI tools create reusable capabilities that underpin the coordination of governance and industry. On the other hand, specialized industrial zones and innovation networks help consolidate dispersed strengths into ecosystems that reinforce competition and expand opportunities for collaboration through reinforcing feedback loops including: ① transforming digital content into applications via advanced computing; and ② turning real-world scenarios into data that informs algorithms and drives innovation. Together, these loops create a continuous cycle of learning, application and improvement across industries and governance systems. This process allows government public services to shift from being perceived as costs to being recognized as strategic investments that lower business risk, attract and retain talent, and enable innovation at scale. In tandem, the establishment of data governance frameworks, compliance mechanisms for data circulation and transparent resource "factor" markets provide essential foundations for emerging sectors such as AI and advanced manufacturing.

This chapter presents four case studies from cities of different development stages and institutional contexts, illustrating complementary evidence of this pathway. In Changsha, China, the

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Malanshan Cultural and Creative Park has integrated the entire video production chain through unified data infrastructure, supporting wider manufacturing industries with simulation design, predictive maintenance and supply chain collaboration, demonstrating the synergies between industrial parks and industrial improvements. In Singapore, the national-level Virtual Singapore (VSG) initiative uses a 3D digital twin city to integrate spatial data, governance tools and industrial applications, forming a shared citywide growth platform. In San Francisco, the United States, through the Yes SF programme, is experimenting with climate technology and urban regeneration using flexible zoning, blended financing and open innovation challenges to drive local economic revitalization. And in Sèmè City, Benin, an integrated "education—entrepreneurship—applied research" model is helping to cultivate a youth-focused innovation hub to stimulate competition, support youth employment and foster long-term inclusive growth. These experiences demonstrate that smart cities are most effective when aligned with the real needs of industry and talent, and when they foster positive interactions between governance frameworks and practical applications.

Drawing on these observations, this chapter analyses four dimensions: how technology enters industry; how institutions can reduce barriers and costs; how real-world applications drive adoption and diffusion; and how inclusivity can translate into "soft" power. The chapter highlights governance priorities for urban infrastructure and data factor markets, organizational methods for specialized industrial parks and social networks, mechanisms of diffusion along manufacturing value chains, as well as the foundational role of urban public services and employment-friendly policies in shaping urban innovation ecosystems. It thus aims to provide a comparative, replicable and applicable reference framework along with actionable recommendations for cities in different stages of development.

# Reference  Cases

## Changsha, China Unlocking Smart Urban Upgrading Pathways through Industrial Parks

### Case Background

Changsha, a national historic and cultural city located in central China, is reshaping the trajectory of its urban development pathway through smart city construction. As the capital of Hunan Province, Changsha has developed a diverse industrial landscape in fields like engineering machinery, automobiles and auto parts, electronic information and new materials. In recent years, however, the continuous increase in the urban population has escalated the problematic matching of public resources, such as space, transportation, education and healthcare. At the same time, traditional manufacturing has revealed shortcomings in intelligent upgrading, supply chain coordination, and alignment of talent and technological resources. Emerging industries, particularly those dependent on algorithms, data and computing power, also require more systematic support.

At the city level, Changsha has been integrating information management responsibilities since 2019, establishing the Municipal Data Resource Bureau to coordinate and advance smart city and data governance efforts. To avoid redundant construction, Changsha has coordinated the city's core data infrastructure in which the Unified Cloud for Government Services is now efficiently supporting the operation of 520 systems across 78 municipal departments. The City Super Brain data middle platform, AI platform and application platform have also published a list of 627 items featuring shared capabilities including video intelligence algorithms, saving approximately CNY 120 million in construction funds. The City Network Security Operations Center safeguards over 2,600 applications in key industries in real-time, achieving 24/7 monitoring and minute-level response. The city has accumulated over 20 billion pieces of government data, responding to nearly 5,000 data-sharing requests. The government data open platform has shared over 83.43 million pieces of data with over 31.8 million accesses, see Figure 4-1. Provincial and municipal platforms have been connected, releasing a data catalog of 2,718 items, and achieving collaboration with 24 provincial-level entities with 216 data tables and 140 service interfaces; the total data volume reached 1.2 billion entries. The City Information Model platform covers 21 core categories including municipal roads, pipelines and buildings, and by 2023 it had already covered over 90 per cent of the city's built-up areas.



Figure 4-1　Changsha e-Government Cloud Innovation Center

Institutional factors directly influence business costs and talent retention. Changsha is the first city in China to establish smart, tailored bus routes. In July 2024, it was selected as a pilot city for the Vehicle-Road-Cloud Integration application, where the city-level intelligent connected cloud management platform allows for real-time linkage of intersections and bus trajectories. Changsha currently has 72 bus routes with 2,072 buses that have been upgraded to be intelligent and networked. These buses can receive accurate signal timing information improving punctuality during peak hours by up to 80 per cent. Based on the needs of residents, five customized smart bus routes have been launched with features like reservation-based rides and priority bus service, which is expected to reduce commute times by 30 per cent. By

leveraging the Traffic Operation and Command Center big data platform, comprehensive data analysis of bus routes and metro lines is conducted, and seamless connection routes have been established. The bus-rail transfer rate exceeds 90 per cent, significantly improving the flow efficiency of talent and resources between industrial parks and urban areas.

Against this backdrop, Malanshan Video and Creative Industry Park, or Malanshan Park as shown in Figure 4-2, has emerged, fully reflecting local characteristics. The park, located on the east bank of the Xiang River in Changsha's Kaifu District, is China's first video-centred digital cultural creative industry zone that hosts leading enterprises such as Mango TV, EE-Media and the renowned iQIYI, Xigua Video, Sina and Galaxy Cool Entertainment, earning it



Figure 4-2　The main entrance of Malanshan Park

the nickname "China's V Valley" (Video Valley). In 2023, the park had 463 large enterprises and achieved CNY 87.3 billion in annual revenue, driving employment for over 100,000 people.

The core idea of Malanshan Park is not to be "large and all-encompassing" but to focus on a track that holds a leading position in the audio and video industry, and then expand into the full industrial chain (creation—production—storage—broadcasting—trading). The first stage pivots on the video industry. Leveraging the local advantages of Hunan Broadcasting System Media Group and Mango TV, the park set its goal from the beginning: "This industrial park shall boast a full industrial chain with a complete upstream and downstream supply system." In just a few years, over 3,000 upstream and downstream enterprises were introduced. In terms of policy and brand synergy, Hunan Province and Changsha have continuously released supportive policies and specialized plans, consistently positioning culture as the pillar in the park's development, an effort that has strengthened public recognition of China's V Valley and its branding for investment attraction.

Subsequently, Malanshan Park has successfully transitioned from a content-creating park to an element platform, normalizing the construction of digital infrastructure such as video cloud, rendering, ultra-high-definition video production and digital studios. This has also catalysed new business formats like micro-short dramas, AI generated content, digital cultural heritage and virtual reality, demonstrating the platform evolution of "content creation—computing power—applications". Meanwhile, the park has advanced data element and copyright governance in parallel. Changsha has been designated as a pilot base for data annotation with Malanshan Park being one of the first carriers. The park has also launched platforms such as China V Chain, exploring a full-chain mechanism for "right confirmation-transaction-rights protection", creating a governance channel for the digitization and marketization of digital content elements.

Overall, Malanshan Park possesses both irreplaceable advantages as a startup with replicable systems and platforms. Government, enterprises and entrepreneurs collaborate in system provision, method accumulation and innovation diffusion. On the government side, it provides a trusted, compliant environment for transactions and platforms. On the enterprise side, projects are accumulated into methods and tools. On the entrepreneur side, rapid iterations are achieved through funding and incubation, ultimately converting content into data and algorithm supply, which spills over into manufacturing and service industries.

### Implementation Process

**1. Driving Expansion and Building Platform Capabilities**

The Malanshan Video Cultural and Creative Industrial Park covers an area of 15 square kilometres. Relying on local cultural characteristics and focusing on the full industrial chain of "content—data—computing power—distribution", Malanshan Park continues to build new infrastructure, including a video supercomputing platform, media cloud platform, ren-

dering platform and a 5G + 8K live-streaming base. These infrastructures facilitate integrated operations such as multi-language audio and video collection, processing, annotation, training and analysis, supporting the upgrade of content production to industrial, scaled and intelligent processes. This integrated capability has transformed the park from a content production base into a data and algorithm supply platform, providing a foundation for cross-industry model training and application migration.

Malanshan Park provides a good observational model of how the government, enterprises and entrepreneurs work collaboratively. The government's role involves top-level design, system provision and the establishment of public platforms. Changsha's municipal departments provide a stable institutional environment through specialized planning, standard exploration and the construction of element markets. For example, comprehensive copyright platforms (for the purpose of registration, rights confirmation, transaction and rights protection), the China V Chain digital asset platform, data annotation pilot projects, order organization, video cloud/studios, and other public technology platforms and testbeds as well as brand activities, competitions and exhibitions, continuously direct traffic, amplifying investment attraction and spillover effects. On the enterprise side (leading enterprises + platforms), companies like Mango TV continuously verify new technologies through local projects (such as AI review, blockchain proof and compressed micro-short video registration cycle), embedding these processes as reusable "scene—data—algorithm" paths. Technol-

ogy companies like Huawei implement production tools like computing power and cloud computing, enabling SMEs to integrate seamlessly. This combination of leading enterprise-led growth and platform spillover significantly increases the learning speed and resource efficiency of the cluster. Entrepreneurs and SMEs are also recognized, supported and able to achieve success under this mechanism. The park utilizes annual industrial guidance funds (CNY 500 million) and the Maju Plan (a fund to provide start-up capital for new businesses, CNY 100 million) as financial tools in addition to algorithm competitions, intellectual property (IP) open competitions and incubation bases, to create a channel of "competition selection—resource matching—funding and venue—product commercialization."

**2. Building a Closed-loop Data Ecosystem for Research Investment and Copyright Protection**

As the data annotation base for the video industry in Changsha, the park has developed a full-chain practice in producing data from multiple business types, governing public service platform and mining data from rich application scenarios. Currently, there are 10 million materials in the library including 6 million annotated data, 500,000 hours of video and 500,000 hours of audio. The capacity can reach 6 million entries per month with the value of data annotation reaching nearly CNY 200 million. Using the "copyright + data + blockchain" model, the park has constructed a full-process system for copyright confirmation, protection and transaction for audio and video content, along with a platform for the transaction and protection of digital assets across

the region. To improve the efficiency and quality of data production to model training, the park's data platform has developed and launched a video transcoding platform and a video splitting platform, preliminarily creating an ecological closed loop for data supply, data processing and large model applications.

In terms of leading enterprises and platforms, the park has attracted leading research-oriented enterprises, such as Huawei, iSoftStone Digital and ValiantSec, to establish research institutions like the Malanshan Audio and Video Laboratory. Huawei's regional headquarters in Hunan was completed in the first half of 2025, housing over 3,000 technical R&D talents, see Figure 4-3. The audio and video laboratory has more than 60 core team members, with over 80 per cent holding masters or doctoral degrees, and more than 75 per cent coming from leading enterprises in the industry. These leading enterprises and

platforms have transformed project experiences into methodologies and common capabilities, accelerating industrial diffusion.

When the platform's capabilities are stably output, new business formats will become the primary growth drivers, which in turn will spur the platform's iteration. As for business structure, of the 141 audio, video and cultural enterprises in the park, 108 are new business format enterprises accounting for 76.6 per cent. This has formed a matrix of new cultural industries, including animation and games, digital cultural heritage, micro-short dramas, large virtual reality spaces and AI industry models. The platform's capabilities and the expansion of new business formats promote each other, driving the scaling, standardization and intelligence of content production, distribution, operation and monetization.

The seamless integration of "computing pow-



Figure 4-3   The display screen of the Hunan Big Data Exchange

er—data—models—applications" enable the transformation of "content as data, data as elements" to be measurable, calculable and iterative, providing continuous support for large model training, algorithm optimization and cross-scenario applications in downstream industries. On this basis, the park's platform capabilities and element mechanisms can spill over to manufacturing and service industries in broader scenarios, achieving long-term and stable synergy and diffusion through institutional support at the city level.

**3. Designing for Mutual Innovation and Growth Between Malanshan Park and the Manufacturing Industry**

The data annotation and algorithmic capabilities of the park support simulation design, predictive maintenance and supply chain collaboration in the manufacturing sector. Conversely, the high-value scenarios and process data from the manufacturing industry are fed back into the park's model training and productization, creating a bi-directional gain and continuous spillover effect.

The "demonstration, replication and diffusion" pathway is an effective approach for moving from individual examples to collective elevation. In the field of construction machinery, SANY Group has taken the lead in advancing digital strategic transformation. Its No. 18 Factory has been certified as a "lighthouse factory" by the Global Manufacturing Alliance, achieving end-to-end intelligence from data collection, product design and automated manufacturing to intelligent logistics. This has accelerated the smart transformation

of upstream and downstream supporting enterprises. In the domain of characteristic industries, the fireworks industry in Liuyang has explored modern performance forms such as "fireworks+ drones" and "fireworks + multimedia art", integrating traditional crafts with digital technology. This has expanded product boundaries and market space, forming a new industrial chain supported by cultural creativity, technological applications and scene performances. With the "industry-leading enterprises leading the industrial chain" diffusion logic, Changsha has promoted the intelligent transformation of 1,660 enterprises over the past five years, creating more than 7,000 digital application scenarios, a feat that has established demonstration and diffusion pathways in sectors such as construction machinery, automobiles, new materials and food processing.

The rise of Malanshan Park is attributed to four key factors: ① unique advantages as a startup. The park benefits from Changsha's strong local content platforms and talent ecosystem. Hunan Broadcasting System Media Group and Mango TV provide powerful content supply, distribution channels and an IP ecosystem, giving birth to the establishment of a full-chain talent pipeline from production, post-production and publicity to brand development, which is a unique advantage that other cities have found difficult to replicate quickly. This has allowed the park to apply technological investments to specific programmes and projects, shortening the cycle from experimentation to product manufacturing; ② pursuit of ultra-performance with a full dedica-

tion to one sector. The park has chosen the audio-visual industry as its main focus, ensuring depth and completeness along the chain. From creativity to production, from cloud to end-user, and from IP to copyright and transactions, the park has created a pathway that combines specialization and scalability; ③ priority on institutional supply and reusable platform capabilities. Malanshan Park was one of the first to establish systems that treat copyright and data as governable and tradable elements. In terms of copyright, the park has launched China V Chain and established copyright service halls and courts that create a one-stop protection and transaction system integrating administration, judiciary and technology with an intention to reduce infringement costs and improve compliance efficiency.

Regarding data, Changsha has established a city-level data annotation pilot programme and issued orders, with the park collaborating with its peers to create an "acquisition—annotation—training—transaction—application" industrial closed loop, serving the park's AI generated content/short drama production, spilling over to industries like manufacturing and cultural tourism. On the technological front, the stable-and-smooth-running video cloud, shared production centres, digital studios and rendering/supercomputing platforms in the park allow enterprises to access underlying capabilities on-demand, reducing trial-and-error costs and time, a win-win cooperation thanks to brand-based investment attraction and involvement of leading enterprises. Huawei's regional headquarters in Hunan and its industrial innovation centre have been estab-

lished, jointly building media laboratories, audio-visual production lines and cloud platforms to drive the coupling of technology, content and scenarios locally. For the Malanshan Park, this is a key amplifier of its "platform capabilities".

## Reference Experiences

**1. Recognize the Development of Shared Data Infrastructure Foundations and Cross-departmental Collaboration as a Prerequisite to Expanding Digital Applications**

For cities with varying resource endowments, the primary task in smart city development is not to create additional projects, but to first build robust data infrastructure. Fragmented development can lead to redundancy and data silos, quickly consuming fiscal resources and reducing overall efficiency. The experience of Changsha illustrates a more effective approach; using a unified data infrastructure as the backbone, integrating the City Information Model, data middleware, AI middleware, application middleware and cybersecurity operations systems within a single governance framework. This enables shared capabilities such as unified algorithms, interface standards, identity management and authorization systems to be reused across applications, thus significantly lowering the marginal cost of deploying new scenarios.

**2. Capitalize on Local Characteristics To Promote Systemic Change with Specialized Parks and Urban Public Services as Dual Drivers**

Cities should shift from adding generic policy measures toward creating initiatives that are both shareable and replicable. Changsha demonstrates that

by using models which integrate specialized parks with urban services, cities can achieve this via two complementary pathways. One pathway focuses on the internal infrastructure and platform capabilities within the park including video cloud services, rendering platforms, data labelling and certification, compliance trading and quality management systems. In contrast, the alternative pathway focuses on city-level institutional services such as One-Stop Government Services accommodating streamlined components such as youth employment support and adaptive elements that enable access by senior citizens, alongside integrated "vehicle–road–cloud" solutions for commuting. When these pathways interact in a stable cycle, the park not only produces enterprises and economic output but also continuously drives the overflow of algorithms, data, content and talent, which then feeds back into broader industrial scenarios, including manufacturing, services and cultural tourism.

**3. Understand the Value of Capturing "Soft Power" Benefits from People-centred Approaches to Urban Industrial Upgrading**

For a smart city to develop sustainable competitive advantages, inclusivity, accessibility and equity remain key principles in both institutions and products. By translating people-centred approaches, cities can create soft power that attracts talent and fosters innovation. It is important that digital services are designed for everyone. Digital services, in particular, must be designed for all groups whereby age-friendly, accessible and multilingual government and public service platforms are essential to ensure full work-force participation and stabilize societal expectations. Youth employment also requires systematic support. Talent development, job placement and entrepreneurship incubation should be integrated into a complete, continuous chain. By using industrial parks as practical scenarios, universities and vocational institutions as talent providers and city platforms for employment services and rights protection, cities can create a virtuous cycle linking education, employment and growth.

## Singapore Driving Economic Transformation through Digital Twin City Insights

### Case Background

Singapore, as a city-state with a limited land area (approximately 728 square kilometres), a dense population (approximately 5.91 million) and relatively scarce assets is required to overcome development bottlenecks through its efficient use of resources. To drive its transition toward a knowledge-intensive economy, the government launched the Smart Nation strategy in 2014, leveraging digital technologies to modernize – in a comprehensive manner – national governance, economic transformation and social services. The core objectives include enhancing public service efficiency, strengthening urban resilience and improving economic competitiveness. Among its key initiatives, VSG — a cornerstone of Smart Nation 2.0 — is the world's first nationwide 3D digital twin city model as shown in Figure 4-4. Serving as a "digital simulation foundation", it underpins policy re-

search at the urban scale and supports the cultivation of new industrial ecosystems.

VSG is a collaborative platform equipped with rich data environment and visualization technologies that enables citizens, businesses, government agencies and research institutions to develop tools and services to address Singapore's emerging and complex challenges. Built on Dassault Systèmes' 3DEXPERIENCity platform, VSG connects diverse stakeholders within a secure and controlled environment. The model utilizes data analytics, and simulation and modelling capabilities to test concepts and services, inform planning and decision-making, advance research and foster community collaboration. By integrating graphical and statistical data collected from different public sectors including geographic, spatial and topological data, as well as demographic, mobility and climate information (both historical and real-time), VSG users can generate rich visual models and simulate real-world scenarios across Singapore at scale. In this way, users can digitally explore the impact of urbanization on the nation and develop tailored solutions to optimize logistics, governance and operations in areas such as environmental and disaster risk management, infrastructure, homeland security and community services. Due to the scarcity of land and space, and the dual risks of rising sea levels and flooding, Singapore urgently needs data and simulation to support forward-looking decision-making. VSG also serves economic structural upgrading and industrial innovation, providing a simulation platform for scenarios such as construction, transportation and energy optimization, promoting the application of scientific research results.

The rapid growth of the digital economy in Singapore has provided a strong foundation and skilled workforce for the development and application of VSG. As of 2023, the digital economy accounted for



Figure 4–4　Dynamic 3D city model of "Virtual Singapore"

17.7 per cent of the GDP; more than 95 per cent of SEMs adopted digital technologies; 5G broadband coverage reached 99 per cent; and the pool of digital talent exceeded 200,000 people.[1] At the same time, the government has promoted technological innovation through initiatives such as the Generative AI Sandbox and open data strategies, integrating VSG with frontier technologies including AI, cloud computing and quantum computing. These efforts have further expanded its economic potential and industrial synergy. Through the establishment of VSG, Singapore has enhanced industrial planning capabilities, reduced trial-and-error costs and created new business models, thereby advancing economic diversification and innovation-driven development.

## Implementation Process

**1. Multi-sector Collaboration: Building a National Project Management Structure**

In late 2011, the Singapore Land Authority (SLA) launched the National 3D Mapping Project, serving as the preparatory and foundational stage for the VSG platform. During the first phase, the project team conducted aerial surveys using light detection and ranging scanners, and high-resolution cameras mounted on aircraft, completing island-wide 3D data collection of buildings, terrain and vegetation. Subsequently in December 2014, the first prototype version of the 3D platform was officially released, laying the groundwork for future data integration, simulation analysis and functional expansion.

1 Cai et al., Singapore Digital Economy Development Report. (2024). Social Sciences Academic Press, Beijing: October 2024.

As a flagship initiative under the Smart Nation strategy, VSG is spearheaded by the National Research Foundation (NRF) in collaboration with key agencies including the Infocomm Media Development Authority, the Government Technology Agency (GovTech), and the Building and Construction Authority. The government has explicitly positioned this project as part of the national infrastructure with functions extending beyond urban planning to encompass multidimensional scenarios such as future energy management, emergency response and traffic regulation.

At the early stage of project implementation, the government established the Smart Nation and Digital Government Group to ensure inter-agency collaboration, data standardization and coordinated governance mechanisms, see Figure 4-5. In parallel, partnerships were forged with academic institutions such as the National University of Singapore and Nanyang Technological University to establish a joint research consortia. These collaborations focus on the development of key technologies including
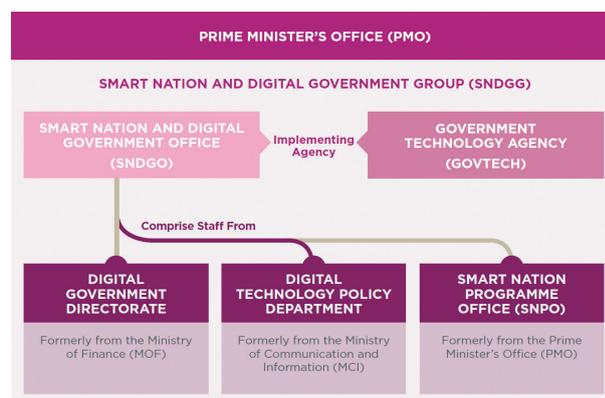


Figure 4–5　Organizational structure of the Smart Nation and Digital Government Group

spatial modelling algorithms, scenario simulation engines and privacy-preserving data anonymization mechanisms, ensuring that the platform is technologically feasible and scalable while safeguarding the public interest.

**2. Establishing the Technical Foundation: Three-dimensional Modelling and Dynamic Data Integration**

At its core, VSG is a dynamic 3D GIS and Building Information Modelling (BIM) integrated digital twin city platform. The platform first constructs a 1:1 urban spatial model based on nationwide high-precision aerial survey data, light detection and ranging scanning technology, and geospatial information. The model is detailed down to every building, underground passage and tree, ensuring spatial accuracy at the level of architectural design. Subsequently, the platform integrates a wide array of real-time data sources — including traffic flows, energy consumption, air quality, hydrological data and population density — by connecting IoT devices and public databases, thereby creating a dynamic and interactive mirror of the city.

The data governance framework of VSG follows a three-step process: centralized access → standardized processing → application programming interface (API) distribution. City Data Hub, established via GovTech, aggregates multisource urban data including IoT sensors, surveillance cameras, public platform datasets and third-party service data. Once ingested into the platform, the data is processed and archived in accordance with a unified metadata standard and made accessible to developers via Representational State Transfer (REST) ful APIs.

To ensure data quality and effective sharing, SLA and GovTech jointly issued the City Data Sharing Agreement and the 3D Model Management Specification, covering requirements on data sources, update cycles, privacy classification and access authorization. Institutions like the National Environment Agency and the Land Transport Authority connect their data in compliance with these agreements, and sign Service Level Agreements to define access frequency and service requirements. Through the City Data Hub, real-time monitoring of data subscriptions is enabled, supported by a visualized monitoring dashboard to guarantee data flow stability and reliability. See Figure 4-6.

**3. Expanding Application Scenarios: From Government Planning to Industrial Empowerment**

From 2018 onwards, the platform entered its expansion phase. In cooperation with GovTech and NRF, its applications were extended to municipal



Figure 4–6　View–shed analysis of the Jurong Area using the 3D city model

infrastructure, public services and urban transport, enabling real-time visualization of these domains. The governance model progressively evolved into a "platform + ecosystem" approach, in which SLA is responsible for platform infrastructure and unified GIS standards, GovTech leads the integration of sensor networks and cloud interfaces, while industry bodies, research institutions and enterprises are tasked with developing simulation models and implementing applications. At this stage, the engineering team established a two-tier technical governance framework under which the underlying urban platform is government-led with unified management of equipment interfaces, while industry users build specific applications on top of the platform, forming a "government + market" collaborative mechanism.

After 2020, the VSG platform entered the stage of large-scale application, supporting practical scenarios such as smart transportation, environmental monitoring and disaster emergency response. In the field of smart transportation, the platform enables real-time access to road traffic flows, traffic light operations and public transport data which are coordinated with AI algorithms to optimize routing and effectively reduce recurrent traffic congestion. The VSG platform authorizes the use of its scenario models in national design competitions and university curricula allowing students and startup teams to carry out creative development on the basis of real geographic carriers, thereby cultivating a fertile ground for social innovation in the city as shown in Figure 4-7. Some innovative tools and public pilot projects focusing on optimizing water resources,

microclimate control and community governance— such as the shared electricity forecasting platform EnergyWise—have already entered early-stage urban function trials.

In supporting startups, VSG has also become one of the core platforms for industrial incubation. By connecting enterprise resources with market channels, it has fostered the emergence of a range of BIM + GIS-based smart building and facility management applications. For instance, GreenView leverages the platform to dynamically simulate future building energy use and ventilation conditions, enabling clients to obtain performance evaluation data at an early stage, and CitySynth has developed a 3D urban exploration tool widely applied in real estate marketing and planning demonstrations.

**4. Governance Innovation: Balancing Data Sovereignty and Public Participation**

As a national-level digital city platform, VSG faces complex challenges in data privacy, security and algorithmic ethics. On the basis of the Smart Nation and Digital Government Group, GovTech and SLA jointly established a Data Governance Office, responsible for platform usage approvals, access auditing and oversight of algorithm transparency. The platform, by functions and levels, enforces safeguards such as sensitive data anonymization, permission-based isolation, access log recording, load segregation mechanisms and virtual firewalls to protect different categories of interfaces.

The government has enacted legal frameworks such as the Smart Nation (Think-Tank and Innovation) Act which explicitly stipulates that "platform
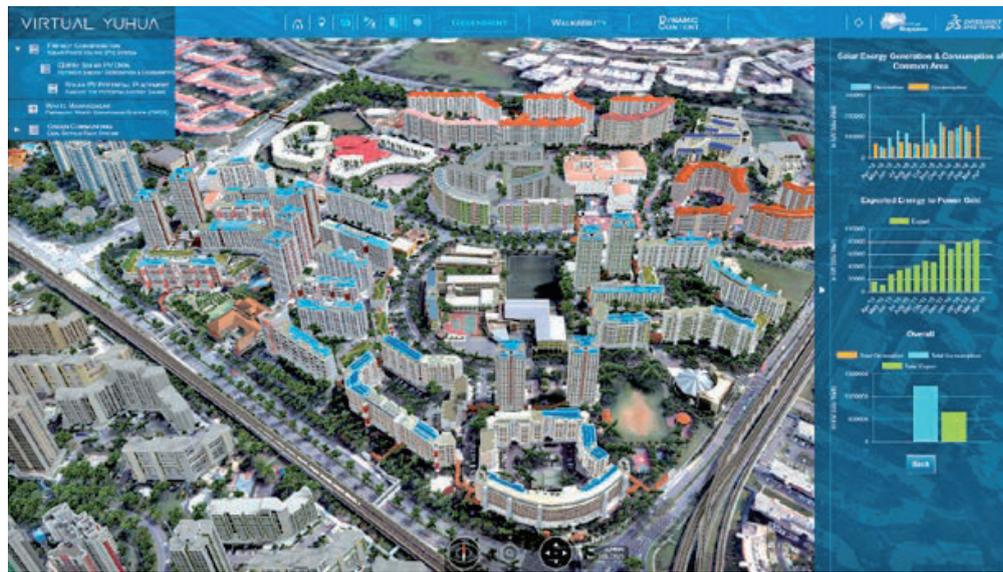
Figure 4–7    Analysis of solar power potential using the VSG system

data shall not be used for identity recognition or personal privacy analysis", and requires all simulation projects to undergo ethical review. Industry partners must sign legal agreements prior to platform use specifying requirements for data deletion, third-party disclosure and application accountability. In addition, the platform has implemented an algorithm transparency and disclosure mechanism: all AI models engaged in public governance processes shall be registered with the Urban Computing Office, accompanied by source code and counterfactual testing reports.

These governance mechanisms not only reduce the risk of privacy breaches but also enhance public trust in the use of the platform, thereby facilitating its integration into urban governance, public planning and industrial development. The practice of VSG demonstrates an integrated pathway from technical construction, data governance and application deployment to security and compliance. The entire process follows a "co-building of the platform, co-governance of data and co-creation of applications" model, embodying a structure in which government leadership, market-driven innovation and public oversight converge.

## Reference Experiences

As a national-level digital twin city project, VSG is rooted in the nationwide Smart Nation strategy and the pressures of hyper-dense urban governance, harnessing cutting-edge technologies to build a forward-looking economic governance platform. It is not only a new pathway for upgrading urban infrastructure but also a new model for economic growth, industrial organization and social sharing, providing a credible, actionable and replicable reference case for other global cities of similar scale.

**1. Prioritize National-level Design and Planning Using Unified Platform Standards to Guide Resource Integration**

The foremost lesson from the VSG case lies in its highly systematized top-level design approach. From the time NRF formally proposed the concept of VSG to the platform's full-scale launch, the government consistently adhered to a "national-level platform + cross-departmental collaboration" governance mechanism, thereby avoiding resource waste caused by fragmented investment and redundant construction. This top-down model of digital governance has not only eliminated institutional barriers to the integration of urban information resources but also significantly improved the systemization and efficiency of smart city development.

For other comparable cities, particularly those grappling with common digital city challenges such as "information silos" and "platform islands", the experience of Singapore demonstrates the need to establish unified data foundations and standardized interfaces, with the government or a cross-departmental coordinating body acting as the governance lead. This is the only way to achieve true cross-system and cross-sectoral integration. Top-level design is not merely a technical matter but a manifestation of institutional arrangements and governance coordination. It is recommended to govern digital twin cities as city-level economic infrastructure, incorporate industrial upgrading and emerging industry cultivation into the same roadmap and performance system, unify standards, interfaces and databases, and establish a list of reusable capabilities.

**2. Curate Open Ecosystems to Stimulate the Digital Economy and Emerging Industries**

VSG is not only a smart city governance tool but also an open digital innovation platform for industry, academia and the public. The government has clearly positioned the platform as foundational digital infrastructure for advancing the digital economy and urban technology industries. Through mechanisms such as open APIs, shared simulation models and testing sandboxes, it provides enterprises and universities with practical scenarios and computational support, greatly stimulating innovation capacity on the industrial front. This pathway of "foundational platform + innovation ecosystem" has not only increased the density of the city's digital industries but has also transformed what was once a government-centred smart city initiative into an open system spanning academia, industry and civil society, thereby driving the growth of emerging sectors.

For other rapidly developing cities worldwide, it is equally critical to establish platform-based digital public goods and embed them into the restructuring of urban industrial chains. By leveraging public computational capacity, data resources and experimental environments, cities can incentivize entrepreneurship and R&D, fostering a sustainable ecosystem for emerging industries. It is recommended to position digital twin cities as an open innovation ecosystem platform, open desensitized testing scenarios to enterprises and universities, adopt a sandbox supervision and pay-for-results procurement mechanism, introduce tools such as joint funds, data vouchers and computing power vouchers, and lower the entry

threshold for SEMs.

**3. Emphasize Data Governance and Ethical Safeguards to Strengthen the Foundations of Trust in Urban Digitalization**

The growth of digital twin cities in regard to the scale of data involved, the scope of coverage and the range of applications poses new challenges to ensure efficiency and optimization in urban governance. In the development of VSG, Singapore prioritizes data security, privacy and algorithmic ethics, ensuring efficiency in practice and transparency. Accordingly, the model highlights that digital twin cities require robust governance frameworks alongside technological advancement. It is also imperative that smart city initiatives balance practicality with trustworthiness. Technological advancement alone cannot ensure sound governance and systemic safeguards and ethical norms are equally essential. In this regard, digital governance frameworks that include clear rules for data use, platform accountability and public oversight to build trust can support cities embarking on smart city initiatives. The use of hierarchical and categorized authorization, the "minimum necessary" principle, auditable and rollback-capable models, and transparency reporting all serve as impactful actions to reduce compliance costs and enhance public confidence.

## San Francisco, United States
## Yes San Francisco–place–based Inno–vation for Urban Economic Revitalization

### Case Background

In the wake of the COVID-19 pandemic, San Francisco's urban economy faced unprecedented disruption. Once a thriving hub of commerce and innovation, the city's downtown area suffered from a sustained loss of footfall as remote work became the norm. Commercial vacancy rates in the financial district also surged, exceeding 35 per cent in some zones, in which small business closures stalled local economic activity, compounding the already existing housing and inequality challenges that had shaped the city's urban fabric.[1] Exacerbating these economic difficulties were the pressing environmental imperatives outlined in San Francisco's 2040 Climate Action Plan. The city faced a growing pressure to decarbonize its building stock and electrify transit infrastructure to facilitate the transition toward a green economy. However, fragmented governance structures and a lack of integrative physical and institutional spaces hampered cohesive action, with San Francisco's innovation ecosystem lacking a coordinated mechanism for deploying urban climate technology solutions.

To address these challenges, flexible zoning reforms were introduced in 2023, enabling for new land-use typologies in San Francisco's downtown core, allowing for the integration of office spaces on the ground floor. This has led to the application of co-working, civic engagement and innovation programming within previously mono-functional office spaces; instigating a regulatory shift that has since paved the way for new forms of urban intervention to simultaneously activate underutilized space, drive

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1　Dreher, Arielle. (2024). Despite 35% Office Vacancy, San Francisco's Office Rents Still Above National Average. Available at https://www.bisnow.com/san-francisco/news/office/vacancy-rates-havent-peaked-yet-in-downtown-sf-office-market-122796 (Accessed: 20/7/2025).

economic recovery and advance climate objectives. Led by the San Francisco Chamber of Commerce and supported by a coalition of city agencies, private investors, philanthropic partners and climate-tech accelerators, these challenges led to the emergence of Yes San Francisco (Yes SF); a hybrid initiative designed to reimagine the city's downtown. The project set out to create a physical and institutional hub for sustainability innovation, see Figure 4-8, while acting as a platform for deploying real-world solutions to the city's most urgent environmental and economic challenges.

## Implementation Process

Conceived as a response to the dual crises of post—COVID 19 pandemic economic stagnation and climate urgency, the Yes SF initiative was launched in June 2023 following a partnership between the San Francisco Chamber of Commerce, Deloitte, Citi, Salesforce and the World Economic Forum (WEF). In direct response to SDG 11 to "make cities and human settlements inclusive, safe, resilient and sustainable", it was shaped by a tailored strategy to bridge urban economic recovery with climate innovation, inviting global entrepreneurs and innovators to facilitate sustainable urban solutions within the city. In light of prior development strategies, the initiative was formulated in an effort to move beyond sectoral policy responses and instead anchor it in a model that prioritizes civic engagement, technological deployment and institutional collaboration. It has sought to activate dormant assets, reanimate underutilized urban infrastructure and mobilize a coalition of actors

to co-produce sustainable and inclusive solutions for the city's downtown area. The design of the initiative has capitalized on the city's unique innovation ecosystem, drawing upon flexible zoning regulations, unoccupied real estate and an established culture of entrepreneurship. Through this, Yes SF articulated a strategy that aimed to not only pilot green technologies but to embed them within a broader social and spatial transition in which sustainable economic development, a green transition and social equity were pursued in tandem.

**1. Creating a Network Platform to Support Green Innovators**

The development of the Top Innovator Programme has represented a core element within the Yes SF initiative that works to conglomerate high-quality innovators within the city. Run in cooperation with UpLink, a WEF open innovation platform recognizes and supports standout startups developing groundbreaking sustainability solutions, providing them with tailored mentoring, financing opportunities and visibility to scale-up their impact. The Yes SF initiative is funded by a blended finance model that combines public innovation grants with philanthropic donations and corporate sponsorships. A Sustainable Innovators Network was also established to connect changemakers across industries, fostering cooperation, knowledge-sharing and resource access to accelerate collective progress towards a more sustainable urban future. These programmes empower innovators to transform ideas into impactful and scalable solutions. Capitalizing upon changes in legislation from 2023, Yes SF established an operational ground-floor office in

Source: Peerspace.com. Peerspace. (n.d.) Yes SF. Available at https://www.peerspace.com/pages/listings/677dc3ffbb8b3d5fcf5b909e#images (Accessed: 20/7/2025)

Figure 4−8    Yes SF offers flexible space for co−working and events for entrepreneurs and innovators

September 2024 housing both public convening space and coworking studios, as well as a permanent exhibition dedicated to climate innovation. Yes SF's startup resources offer dedicated workshops and resources to entrepreneurs and small business owners to support their growth and development. In addition, community events are organized to empower visionaries in the city including innovators and communities with creative programming in areas such as climate action and green workforce development, connecting with their elected officials.

**2. Launching Place-based Urban Sustainability Challenges**

At the core of Yes SF is the Innovation Chal-

lenge, its flagship deployment mechanism. Held annually during San Francisco Climate Week, the challenge serves as an open call for early and growth-stage ventures offering scalable technologies in clean energy, mobility, building decarbonization and the circular economy. It has sought to cultivate an eco-system of circular, nature-based and other innovative solutions to bring new life and increased value to building, infrastructure and outdoor areas in downtown San Francisco.

In 2023, UpLink launched its inaugural place-based challenge with a call for sustainable buildings and blue-green infrastructure technology innovators to enable on-the-ground deployment of scalable solu-

tions in the city's downtown area. It attracted more than 150 applicants from companies and early-stage ventures, from which 14 top innovators were selected by a committee of reviewers for their potential to regenerate and increase the value of buildings, infrastructure and outdoors areas.[1] Each submission was evaluated by a committee of expert reviewers from the city, nominated by challenge collaborators for their knowledge of current issues and their technical expertise in sustainability. Innovators benefited from access to a suite of resources to help deploy their solutions with introductions to key stakeholders, potential funders, experts and advisory services. A pooled deployment fund of USD 1 million financed by Deloitte was distributed among winning innovators, designed for post-pilot development and scaling.

A second call for applications was launched in September 2024 with winners announced in April 2025. Twelve top innovators were selected from the second cohort of over 200 applications with solutions leveraging technologies such as AI and advanced software. They were provided with access to two support tracks including: ① a joint programme led by WEF and the San Francisco Chamber of Commerce Foundation that provides a suite of resources to help innovators, such as introductions to local stakeholders and advisory services; and ② UpLink's global innovation network which provides visibility, connections and tailored resources to help innovators grow and scale-up their solutions.

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1　Yes SF. About Yes SF. Available at https://www.yessf.org/about (Accessed: 20/7/2025).

**3. Piloting Innovative Solutions for Urban Sustainability**

Winning innovators brought a diverse range of sustainability solutions to the table, with significant potential to expand green jobs, drive equitable economic growth and deliver urban sustainability outcomes for the city. From the inaugural challenge, ideas included methods of sustainable construction, green energy, water conservation and waste management, as well as vertical farming and urban forest management.

Among the winners was the cleantech company, 374Water recognized for its use of AirSCWO, a compact, on-site waste treatment system which converts organic waste into clean water, energy and minerals. By using Supercritical Water Oxidation technology, their solution eliminates the need for hauling or incineration, substantially reducing greenhouse gas emissions. Another standout, Urban Machine, was selected for its AI-powered robotics designed to support the reclamation of waste wood from construction and demolition, generating revenue by selling it for new construction projects. To accelerate efforts in sustainable mobility, It's Electric was also selected for its services in delivering off-the-grid EV charging to 240,000 San Francisco drivers, as shown in Figure 4-9. By enabling commercial building owners to offer charging infrastructure, they are not only pioneering e-mobility but also creating new income opportunities while aiming for 100 per cent emissions-free transportation by 2024-the first batch of chargers were put into use in April 2025.

To facilitate the integration of nature-based solutions, the green architecture firm, Zauben, was

Source: San Francisco Municipal Transport Agency. San Francisco Municipal Transport Agency (2025). It's Electric! City Installs First Curbside EV Chargers. Available at: https://www.sfmta.com/blog/its-electric-city-installs-first-curbside-ev-chargers (Accessed: 28/7/2025).

Figure 4–9 EV charging stations installed in Duboce Triangle, San Francisco via the services of the cleantech startup It's Electric

chosen due to its use of biophilic approaches to building design, providing green roofs and living walls for commercial buildings and reducing energy bills for property owners. The cleantech startup winner, Sun-Ice Energy, supports solar powered temperature control using non-toxic and non-flammable thermal storage solutions with the ability to heat buildings using just two or three hours of solar power. Babylon provide indoor turnkey farming solutions that enable the production of fresh produce year-round via modular vertical farms –managed by its BabylonIQ software platform. And BluumBio uses bio-based remediation technologies that use nature to clean urban soil, air and water. This targets pollutants such as petroleum, heavy metals and microplastics enabling the transformation of contaminated sites into housing or green spaces, blending academic style innovation with commercial development to deliver faster and more cost-effective eco-friendly clean-up solutions.

Under the second challenge, solutions spanned EV infrastructure and clean mobility, clean energy and carbon capture, affordable and sustainable housing, waste reduction and sustainable packing, along with cold chain innovation. To address the city's housing affordability crisis, Kit Switch was selected as an innovator, offering pre-assembled interior retrofit kits that are quick to install, cost-effective and environmentally sustainable. These reduce project costs by 10~30 per cent while also cutting long-term operational expenses, extending building lifespans and reducing environment impact to redefine housing builds.[1] As an emerging financial technology company revolutionizing clean energy investment, Evergrow introduced a platform to make tax-credit financing to smaller, community-scale projects available by using advanced technology to conduct project and seller diligence at scale to promote clean energy within communities. Voltpost, a San Francisco electrical equipment supplier, was also recognized for its development of smart, modular EV charging systems that retrofit existing lampposts. This approach reduces infrastructure costs, accelerates deployment and minimizes the urban footprint of clean energy assets. In a similar vein, ChargeWheel was selected for its solutions in accelerating energy reliability and efficiency via advanced battery and software solutions designed for EV charging stations and data

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1 UpLink-World Economic Forum. (n.d.). Kit Switch: Densifying, Re-Inventing, and Renovating San Francisco Buildings. UpLink-World Economic Forum. Available at https://uplink.weforum.org/uplink/s/uplink-contribution/a012o00002hdzZHAAY/Kit%20Switch:%20Densifying,%20Re-Inventing,%20and%20Renovating%20San%20Francisco%20Buildings (Accessed: 20/7/2025).
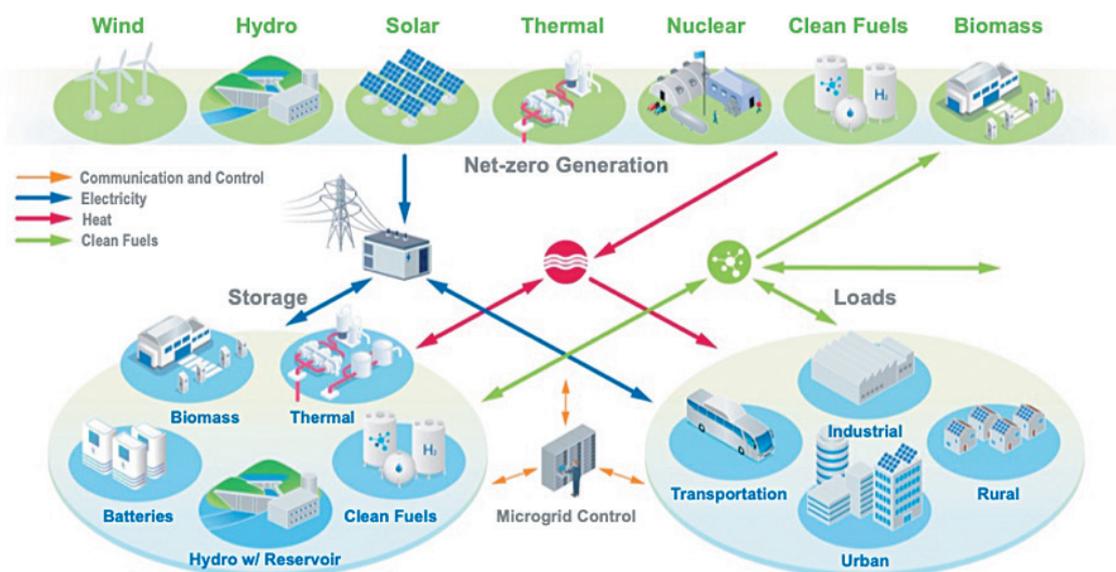
Source: Xendee. (2023). Report Reveals Potential of Small Reactors in Microgrids for Resilient Energy Solutions. Available at: https://xend−ee.com/insights/report−reveals−potential−of−small−reactors−in−microgrids−for−resilient−energy−solutions (Accessed 22/7/2025).

Figure 4−10　Conceptual diagram of the potential for microgrids and distributed energy systems via XENDEE

centres. Airbuild stood out as a climate technology company with its modular, algae-powered systems capable of capturing carbon dioxide, purifying water and generating renewable energy, an integrated solution supporting circular and regenerative urban infrastructure. Another notable innovator included XENDEE, offering integrated mechanisms for Microgrid and distributed energy system design and operation, optimized using AI-based software. See Figure 4-10.

Each deployment functions as a proof-of-concept, not only for technical feasibility but also for civic and regulatory adaptability. To date, Yes SF has hosted more than 70 business and investor events, spotlighting climate tech startups and their role in urban regeneration.[1] It has also created more than 20 local jobs while driving sustainable community development.[2] Yes SF positions itself not merely as an urban regeneration programme but as a civic catalyst that bridges innovation, governance and placemaking. By embedding new technologies and practices within the fabric of the city and building inclusive networks of co-production, it demonstrates how urban areas can lead in mobilizing just, green transitions that are locally grounded and globally scalable. San Francisco leads the United States in climate technology investment, attracting USD 8.8 billion since 2020, however, this opportunity extends beyond the Bay Area to other such areas that are leveraging sustainability-driven

1　Chambers for Innovation and Clean Energy. (n.d.) CASE STUDY: San Francisco Chamber Leverages Sustainability to Drive Economic Growth. Available at https://www.chambersforinnovation.com/cias/2025/3/17/case-study-yes-sf (Accessed: 22/7/2021).

2　San Francisco Chamber of Commerce. (2025) Yes SF Announces 2nd Innovation Challenge Top Innovators. Available at https://sfchamber.com/yes-sf-2nd-innovation-challenge-top-innovators/ (Accessed: 18/7/2025).

economic growth.[1]

## Reference Experiences

**1. Stimulate Urban Economic Innovation Through Network Building Between Startups, Corporates and Communities**

Yes SF demonstrates the importance of activating local networks to connect startups with established companies in order to help accelerate market entry for emerging enterprises. Strategic partnerships with major corporations and platforms bring valuable funding, credibility and expertise, while the establishment of physical hubs can further enhance collaboration and visibility for emerging sectors. Embedding sustainability into economic development strategies can help cities attract new industries, foster entrepreneurship and secure long-term investment. The initiative reflects a model for urban transformation as well as the role of chambers in integrating sustainability and innovation into urban economic development strategies.

**2. Enable the Piloting of Local Solutions To Promote Urban Innovation Among Startups and Entrepreneurs**

By embracing the city as a live testbed for innovation, Yes SF demonstrates how local government can accelerate urban transformation through real-world experimentation. Rather than relying solely on long-term policy shifts or market forces, it has en-

abled startups to deploy and test their solutions directly in the urban environment. Supported by civic partnerships and early public-private collaboration, this approach has allowed startups to pilot climate-tech solutions, accelerating economic activity that allows the city to adapt more responsively to emerging needs and technologies. These real-world trials have not only helped startups refine and scale-up their solutions but have also provided policymakers with tangible evidence to inform future regulations, zoning and investment strategies. This model repositions local government not just as a regulator, but as a co-creator of innovation, capable of catalysing inclusive and sustainable urban economies through agile and iterative action.

**3. Recognize the Potential of Repurposing Underutilized Urban Assets to Facilitate Economic Renewal**

The repurposing of underused commercial spaces into inclusive hubs for innovation and enterprise presents cities with pathways to drive economic renewal. In the case of San Francisco, the Yes SF initiative transformed a dormant downtown storefront into a multi-use innovation centre, blending coworking spaces with areas for startup incubation, public events and community interaction. This space not only lowered entry barriers for emerging climate-tech ventures but also attracted increased footfall and local spending. By aligning spatial reuse with economic development goals, the initiative demonstrates how cities can unlock the latent value of real estate to support entrepreneurship, foster green industry growth and stimulate inclusive economic activity. Regulatory flexibility such as

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1   Chambers for Innovation and Clean Energy. (n.d.) CASE STUDY: San Francisco Chamber Leverages Sustainability to Drive Economic Growth. Available at https://www.chambersforinnovation.com/cias/2025/3/17/case-study-yes-sf (Accessed: 22/7/2021).

adaptive zoning has been key to making this possible, offering a replicable model for other cities seeking to revitalize their economies from the ground up.

## Sèmè City, Benin A Knowledge and Innovation Hub

### Case Background

Benin, located in West Africa, has an economy in which over 70 per cent of development is derived from agriculture, underpinned by a narrow industrial base. Persistent structural challenges, including high youth unemployment and lagging educational outcomes, have constrained economic diversification and modernization, limiting national competitiveness. To break the cycle of path dependence and position itself within a knowledge-based global economy, the government launched the Programme d'Actions du Gouvernement in 2016. The plan identified four strategic priorities: human capital development; enhanced career prospects for youth; innovation-driven growth; and sustainable urban construction.[1]

Against this backdrop, the Sèmè City project — officially launched in 2017 under the direct leadership of the Presidency and implemented by the Sèmè City Development Agency (ADSC) — was conceived as a flagship initiative to establish a regional hub for education, research and entrepreneurship. Branded as La Cité Internationale de l'Innovation et du Savoir, Sèmè City seeks to respond to Africa's skills and employ-

ment needs through a tripartite approach: ① education and training; ② entrepreneurship support; and ③ the promotion of applied research. Its long-term ambition is to generate over 100,000 jobs, foster inclusive and sustainable economic growth, and advance the SDGs. The initiative has already attracted a growing community of over 650 students, 1,000 entrepreneurs and 115 researchers, supported by a suite of modern, purpose-built infrastructures and programmes designed to position Sèmè City as a pan-African community of changemakers.[2]

### Implementation Process

**1. Constructing Knowledge Economy Functional Areas: A Multi-level Spatial Layout**

Sèmè City's spatial development strategy adopts a phased, modular approach to maximize both functional diversity and catalytic impact with four operational sites forming the initial backbone of its innovation ecosystem. Sèmè One functions as a higher education and incubation hub, integrating collaborative workspaces, digital fabrication laboratories and open 3D printing facilities to support proof-of-concept projects and nurture early-stage innovations. Sèmè Two (Sèmè City Open Park) constructed from recycled shipping containers, delivers "digital literacy + creative thinking" programmes for youth aged eight and above, ranging from X-ray imaging principle workshops to digital design tool training, embedding technical competencies alongside creative problem-solving skills. Sèmè Three

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1　Sèmè City, Call for projects 2022. Available at https://www.seme-city.bj/wp-content/uploads/2022/09/call-for-projects-2022-seme-city.pdf.

2　Sèmè City. Who Are We? Available at https://semecity.bj/a-propos/qui-sommes-nous/.

( a )



( b )



( c )



( d )

Sources: Sèmè City; Lina Gbaguidi (Image source: Lina Gbaguidi. Available at https://linagbaguidi.com/meilleures−selections/scop−un−park−din−novation−au−coeur−de−cotonou/ ), U−Report Bénin (Image source: U−Report Bénin @ U−Report Bénin Facebook page. Available at https://www.facebook.com/UReportBenin/posts/hello−visite−ce−matin−au−centre−%F0%9D%97%A7%F0%9D%97%B6%F0%9D%97%BB%F0%9D%97%B6%F0%9D%97%BA%F0%9D%97%AE−dagblangandan−un−centre−communautaire−%C3%A9co/254390409935103/), Epitech Benin(Image source: Epitech Benin. Available at: https://epitech.bj/le−campus−benin/).

Figure 4−11   The four Sèmè City zones: Sèmè One−innovation and entrepreneurship centre; Sèmè Two−digital maker space for youth; Sèmè Three−youth training hub; and Sèmè Four−Epitech learning campus

(Agblangandan Community Centre), located in Sèmè-Podji Commune and implemented with the United Nations Children's Fund and the United Nations Population Fund, offers training in environmental stewardship, recycling, audio-visual media and social innovation for in and out-of-school youth from rural and peri-urban contexts, thereby reinforcing equitable access to innovation pathways. Sèmè Four (Pi Building) operated by Epitech, an IT-specialized higher education institution, provides im-

mersive, hands-on learning environments in digital technologies, lowering barriers to entry for science and technology education, see Figure 4-11. Looking ahead, the Sèmè Campus in Ouidah, currently under development, will apply eco-city principles through pedestrian-friendly layouts, solar energy systems, rainwater harvesting and community gardens, while co-locating universities, research centres, innovative enterprises and experimental sustainable urban zones. Leveraging Ouidah's rich cultural heritage,

（a）　　　　　　　　　　　　　　　（b）

Sources: Hardel le Bihan Architects(Hardel le Bihan Architects. (n.d.) Campus de Ouidah Benin. Available at https://www.hardel−lebihan.com/en/projects/campus−de−ouidah−benin (Accessed: 05/07/2025), Niez Studios(Niez Studios. (n.d.) University Campus Sèmè City. Available at: https://www.philippeniez.com/projet/campus−universitaire−seme−city/ (Accessed: 5/7/2025).

Figure 4−12　Sèmè City designs: campus ecological landscape diagram and the campus planning diagram

the campus is envisioned as a resilient, liveable and internationally recognized city of excellence driving innovation-led growth.

The Sèmè Campus in Ouidah, currently under construction, embeds eco-city principles into its design, integrating pedestrian-friendly networks, solar power generation, rainwater harvesting systems and community gardens as core features as shown in Figure 4-12. Once operational, it will serve as a convergence point for universities, research centres, innovative enterprises and experimental zones dedicated to sustainable urban development. Anchored in Ouidah's rich historical legacy and integrated cultural identity, the campus is strategically positioned to transform the city into a liveable, innovative and resilient international centre of excellence, leveraging its sustainable urban framework to catalyse innovation-driven growth.

## 2. Establishing a Bottom-up Entrepreneurial Ecosystem via a Learn to Launch Mechanism

According to the World Bank, technological innovation in sub-Saharan Africa has largely been driven by a top-down model in which governments create enabling business environments and invest in R&D. Yet, adaptive innovations and practical inventions often emerge from a bottom-up model led by entrepreneurs or private-sector actors operating within entrepreneurial ecosystems, see Figure 4-13.[1] Like many of its regional peers, Benin must embrace this bottom-up approach to fully unlock the potential of technological entrepreneurship. In this context, the

1　World Bank. (2017). Leapfrogging: The Key to Africa's Development? From Constraints to Investment Opportunities. Available at https://documents1.worldbank.org/curated/en/121581505973379739/pdf/Leapfrogging-the-key-to-Africas-development-from-constraints-to-investment-opportunities.pdf (Accessed: 5/7/2025).
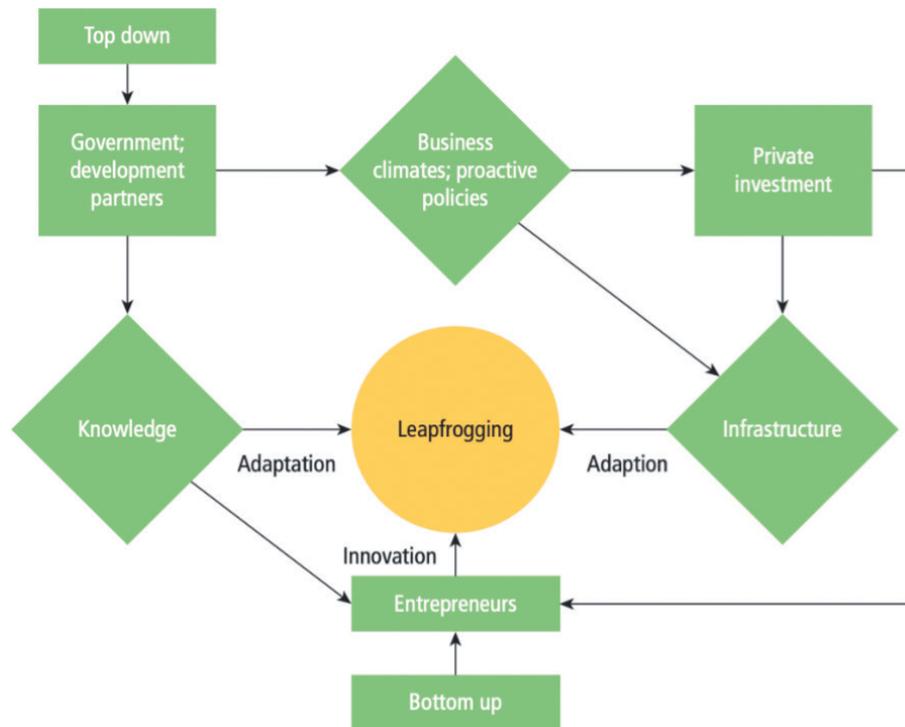
Source: World Bank. World Bank. (2017). Leapfrogging: The Key to Africa's Development? From Constraints to Investment Op-portunities. Available at https://documents1.worldbank.org/curated/en/121581505973379739/pdf/Leapfrogging-the-key-to-Af-ricas-development-from-constraints-to-investment-opportunities.pdf (Accessed: 5/7/2025).

Figure 4-13    Schematic of the top-down and bottom-up framework for sub-Saharan Africa's innovation ecosystem

development of Sèmè City as a smart city coupled with its accelerating digitalization has established a solid foundation for fostering a robust, bottom-up entrepreneurial ecosystem.

The development of Sèmè City's entrepreneurial ecosystem is anchored in education-driven entrepreneurial learning. This approach begins with real-world challenges and integrates project management and social practice into educational programmes, positioning educational spaces as the foundational platforms for cultivating the broader entrepreneurial ecosystem. For example, the Epitech learning campus has conducted training sessions and hackathons in Sèmè City focused on digital solutions to enhance tax collection in Benin. Guided by expert mentorship, participating teams designed innovative tools to make the *Directorate General of Taxes* services more accessible, intuitive and user-friendly. This initiative has already incubated three standout projects in simplified invoicing, tax forecasting and tax accessibility, which are set to be gradually implemented with financial backing from the West African Development Bank, enabling citizens to benefit from improved tax services provided by the General Tax Administration.[1]

Beyond educational support, Sèmè City has partnered with numerous international organizations,

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1    Epitech. (n.d.) Fiscathon: à la découverte des 3 solutions digitales qui vont booster la fiscalité Béninoise. Available at https://epitech.bj/fiscathon-3-solutions-digitales-qui-vont-booster-la-fiscalite-beninoise/ (Accessed: 5/7/2025).

foundations and governments to provide seed funding for the incubation and implementation of innovative prototypes aimed at addressing practical challenges. For instance, ADSC collaborated with the World Bank and the National Agency for the Promotion of Heritage and Tourism to launch a new round of innovation solicitations for Benin's tourism sector through Challenge Fund 2.[1] Through this integrated mechanism, Sèmè City has established a closed-loop entrepreneurial ecosystem linking education, innovation and industry, effectively promoting a sustainable, bottom-up model of technological entrepreneurship.

**3. Empowering Vulnerable Groups to Promote Inclusive Urban Economic Mechanisms**

In both the design and implementation of Sèmè City, vulnerable groups are given deliberate attention. Sèmè City's educational spaces, located within community centres, are open to individuals from both within and outside the local community regardless of age, gender or educational background, enabling broad participation in learning and innovative activities and striving to ensure equitable access to knowledge.

Additionally, Sèmè City has established a gender inclusion framework with official targets aiming for women to constitute 40 per cent of newly created jobs and participants in self-employment initiatives by 2030.[2] This indicator underscores the project's institutional commitment to gender balance. Concurrently, Sèmè City supports innovative initiatives that

address gender disparities, encouraging programmes that empower women entrepreneurs, integrate gender considerations into business models and influence organizational and operational decision-making. For example, in Sèmè City's partnership with the Tony Elumelu Foundation, the foundation provided training and seed funding to entrepreneurs, a partnership that explicitly emphasized encouraging female entrepreneurship and participation, including support for female mentors and female-led projects, see Figure 4-14.[3] Project practices based on inclusiveness promote the development of an inclusive economy by empowering vulnerable groups.



Source: Sèmè City(Sèmè City @ semecity Instagram page. Available at https://www.instagram.com/p/CqX7tGlKJgB/?img_index=3 (Accessed: 5/7/2025).

Figure 4–14 A women makers workshop in Sèmè City

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1 VC4A. Available at https://vc4a.com/seme-city/challenge-fund-ii/ (Accessed: 5/7/2025).

2 Ibid.

3 The Tony Elumelu Foundation. Tony Elumelu Foundation Supports Sèmè City – Benin's International Knowledge and Innovation Hub – In Empowering 50 Beninese Entrepreneurs. Available at https://www.tonyelumelufoundation.org/news/tony-elumelu-foundation-supports-seme-city-benins-international-knowledge-and-innovation-hub-in-empowering-50-beninese-entrepreneurs (Accessed: 5/7/2025).

## Reference Experiences

**1. People-centred Smart City Construction Facilitates Education-focused and Entrepreneurial Urban Ecosystems**

The innovation of Sèmè City lies in its integration of urban functions within the educational ecosystem and everyday life scenarios, rather than pursuing "technological showmanship" as an end goal. By cross-integrating community spaces, youth programmes and local entrepreneurship, Sèmè City positions smart city planning as a governance mechanism that advances "technology democratization". Within this urban environment, Sèmè City has established a closed-loop framework connecting education, innovation and industry, which not only enhances the city's human capital but also provides a skilled digital workforce for the local market. By aligning smart city development with the needs of education and innovation ecosystems, residents' capabilities are empowered and the cultivation of high-value human capital drives sustainable economic progress for the city.

**2. Place People at the Centre of Urban Construction to Stimulate Resilient Urban Economies**

People have consistently remained at the centre of Sèmè City's development vision. From its focus on education to its ultimate goal of generating job opportunities and fostering inclusiveness, Sèmè City prioritizes residents' needs and capacity building as core criteria in smart city development. As ADSC General Manager Ms. Claude Borna stated, "We are looking to give opportunities to be accessible to maybe people who may have been 'left out' of traditionally what we call innovation." Through initiatives such as women's empowerment programmes, skills retraining for less-educated individuals and youth entrepreneurship incentives, Sèmè City embeds the "right to participate" within its urban governance framework, broadening the equity and sustainability of resource allocation while ultimately promoting an inclusive economy and strengthening urban resilience.

# Policy Recommendations

**1. Promote Digital Public Infrastructure as a Key Tool for Urban Economic Development**

The development of digital urban public infrastructure is increasingly critical to provide cities with a foundation to drive industrial upgrading and facilitate sustainable economic growth. The creation of digital infrastructure that is interoperable, portable and auditable can help to cultivate a shared platform for businesses and industrial clusters. Organizing data, algorithms and processes through open standards and common interfaces can stimulate more effective collaboration across municipal departments, industries and enterprises of different sizes, while reducing duplication and the associated costs of their integration. Such infrastructure can also enhance enterprise operations including design simulation, production scheduling, supply chain coordination and quality tracking, and provide governments with tools for monitoring trends, assessing risks and evaluating policy outcomes. For cities globally, it is evident that governance practices are more important than technical checklists such as the specific technological and system characteristics of digital public infrastructure. Principles

including standards-first approaches, inclusivity, layered system design and comprehensive security can enhance sustainability. Clearly defined institutional responsibilities for managing standards, maintaining assets, ensuring security and operating services can enhance the impact of urban digital infrastructure. When it is treated as a reusable, on-demand public resource, investments in digital transformation are more likely to contribute to economic productivity and innovation, and thus more resilient urban business environments.

**2. Build Distinctive Urban Industrial Ecosystems through Specialized Parks and Factor Supply**

Diversifying industrial pathways can strengthen urban economic resilience. The development of specialized parks in line with local strengths can help cities build resilience against unexpected economic shocks and sustain long-term economic growth. The integration of digital development platforms can transform urban industrial parks from simple physical business clusters and provide enterprises with services such as computing and simulation, testing and certification, data and model management as well as compliance and intellectual property support. At the municipal level, comprehensive support and full-cycle factor supply to enterprises including inclusive government services, accessible transportation, talent attraction and high-quality housing can reinforce linkages and establish positive feedback loops between industrial parks and municipalities. The establishment of platform-based industrial ecosystems can serve to reduce transaction costs, foster collaboration and improve business and talent retention whilst the introduction of flexible and reusable capabilities can facilitate intra-industry collaboration. It is important to recognize that cities can leverage their own unique capabilities and advantages while promoting open standards and mechanisms for knowledge and resource sharing to prevent isolated industrial clusters. This approach can enable the growth and expansion of industrial activities and employment opportunities across broader urban areas.

**3. Recognize Inclusion as an Essential Principle and Strategic Driver for Industrial Development**

Human capital reflects a critical component to driving sustainable urban economic growth, where constraints to industrial upgrading often lie not in technology, but in people. Workforce skill mismatches, the migration of young talent and barriers to participation for vulnerable groups can limit innovation and reduce the market potential of cities. Embedding inclusive approaches to urban economic development and securing new talent are key to ensure the long-term prosperity of urban economies. By ensuring accessible urban public services, affordable housing and reliable commuting, cities can enable more diverse participation in labour markets. In the digital age, the adoption of age-friendly and accessible digital service design can facilitate labour market inclusion, while lifelong learning programmes aligned with an evolving industrial landscape also serve as key tools to help workers adapt to changing skills and roles. By institutionalizing these measures rather than implementing isolated projects, cities can strengthen talent retention, innovation capacity and social stability. In addition, well-designed urban public services can also enhance a city's "soft power", reflected in corporate investment decisions and supporting long-term industrial development.

Chapter Five
**Environment: Leveraging Smart Technologies to Accelerate Low−carbon and Resilient Urban Development**

# Introduction[1]

　　As global urbanization accelerates and climate change intensifies, environmental governance faces increasingly complex challenges. High-density urban populations place greater strain on infrastructure systems, while climate-related hazards expose the limits of traditional governance models which often struggle to manage overlapping disasters, heightening systemic risks to urban operations. Weak information sharing, fragmented data and a continued reliance on manual inspections hinders real-time monitoring and early warning, while the high cost of smart infrastructure simultaneously deepens regional inequalities whereby older communities and resource-constrained areas, particularly in developing countries, risk being left behind as access to digital technologies remains uneven.

　　The rapid development of smart city technologies presents new opportunities to address these pressures. Environmental monitoring is shifting toward integrated, real-time systems that combine satellite remote sensing, IoT networks and ground-based sensors to track elements such as air quality, water resources and ecosystems more comprehensively. Cities are also moving from reactive disaster management to proactive resilience planning through tools such as CIM and digital twin technologies, which can simulate disaster scenarios and optimize the performance of critical infrastructure. In tandem, urban governance approaches are becoming more collaborative, with open data platforms and mechanisms for public participation emerging as important pillars of environmental decision-making. Despite these advances, persistent data silos, unequal technological access and limited cross-regional coordination continue to constrain progress, underscoring the need for innovation not only in technology but also in institutional design.

　　This chapter presents five case studies that illustrate how smart urban environmental governance can be adapted across cites in different development stages, geographic settings and socioeconomic conditions. In Guangzhou, China, the city has constructed a comprehensive CIM platform that integrates 3D spatial data, multi-source monitoring and disaster simulation analysis. This platform supports China's first set of Technical Guidelines for the Construction

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1　This chapter was compiled by Dr. Chen Haiyun from Tongji University. The Guangzhou case study was provided by the Guangzhou Municipal Housing and Urban-Rural Development Bureau, authored by Wang Yonghai, Wang Yang, Lou Dongjun, Wu Yuanxin, Yu Baojun, and Chen Wujia. The Chongqing case study was authored by Wu Meihong and Lai Shiyu. The Barcelona case study was authored by Wu Hao and Tu Qi. The Helsinki box was authored by Chong Shen. The Josyka box was provided by UN-Habitat.

and Operation of Smart City Infrastructure Based on CIM, establishing a standardized framework for planning, building and managing smart urban infrastructure, industrial parks and community facilities. These efforts have strengthened the resilience of critical municipal services and improved community-level disaster preparedness. In Barcelona, Spain, the evolution of smart governance has followed a phased path. It began with enterprise-led technological experimentation, progressed to government-driven data management and platform integration, and now emphasizes citizen co-governance. This trajectory shows how open data and public participation can raise the quality and legitimacy of urban environmental decision-making. In Chongqing, China, to address the complex challenges of water management in the Yangtze River Basin, the city developed the "Bayu Zhishui" application system which integrates large volumes of environmental data across departments and has pioneered a cross-provincial collaborative disposal mechanism. This combination of technological and institutional innovation provides replicable solutions for the governance of large river basins. Helsinki's Energy and Climate Atlas offers a publicly accessible visualization platform that provides building-level energy consumption data and personalized renovation options. By enabling residents and businesses to plan energy-saving investments, the project has reduced carbon emissions in pilot areas while generating employment, demonstrating the dual environmental and economic value of open data. And the Chosica District of Lima demonstrates the potential for community-oriented technological solutions to support real-time, community-participatory flood monitoring and rapid emergency response. This initiative underscores the inclusive potential of appropriate technology to strengthen grassroots resilience in resource-constrained regions.

Together, these experiences show that the success of smart environmental governance depends on a combination of technological innovation, institutional reform and active social participation. Only when advanced technologies are paired with inclusive and locally responsive governance can cities achieve the sustainable goal of harmonious coexistence between people and nature.

# Reference　Cases

## Guangzhou, China
## City Information Modelling–driven Urban Infrastructure Transformation for a Resilient City[1]

### Case Background

Guangzhou, located along the coast in southern China, is a central city in one of the most dynamic regions in terms of both population inflows and economic vitality. By 2024, the city's population exceeded 22 million with more than 7 million residents living in 272 informal settlements. A complex population structure and high-density central urban areas, compounded by the long-term risks posed by rising sea levels, storm surges, typhoons, floods and other meteorological disasters, present higher requirements for the city's capacity to achieve sustainable development when confronted with natural disasters, socio-economic shocks, climate change and other complex scenarios.

In August 2020, the Ministry of Housing and Urban-Rural Development, along with other authorities, jointly issued the Guiding Opinions on Accelerating the Promotion of the Construction of New-type Urban Infrastructure (J.G.F. [2020] No. 73), which explicitly designated the construction of CIM platforms, and the construction and upgrading of intelligent munic-

ipal infrastructure as key tasks under the new-type urban infrastructure.[2] In October of the same year, Guangzhou was selected as one of the pilot cities in the Letter of the Ministry of Housing and Urban-Rural Development on Launching Pilot Projects for New Urban Infrastructure Construction (J.G.F. [2020] No. 152). The 14th Five-Year Plan for National Urban Infrastructure Construction further emphasized the need to accelerate new urban infrastructure construction and promote the smart transformation of cities.

Guangzhou, with its typical city characteristics, such as a high density, concentrated population and multiple overlapping disasters, has highly promoted the integration of new urban infrastructure construction for building a resilient city. Through a systemic solution featuring top-level design leadership, legislative and institutional safeguards, key industry cultivation and knowledge sharing, Guangzhou has worked to build a modern urban system that is impact-resistant, highly recoverable and adaptive. As both the "digital foundation" and "system engine" of urban resilience, new urban infrastructure construction continues to strengthen the capacity for disaster

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1　Author: Yonghai Wang, Yang Wang, Dongjun Lou, Yuanxin Wu, Baojun Yu, Wujia Chen, Guangzhou Municipal Housing and Urban-Rural Development Bureau.

2　Construction of new-type urban infrastructure refers to a series of actions that leverage next-generation information technologies to upgrade and build urban infrastructure in a digital, networked and intelligent manner in order to improve urban governance, operational efficiency and quality of life, while strengthening urban safety and resilience. Its key tasks include: implementing intelligent municipal infrastructure construction and upgrading; promoting the coordinated development of smart city infrastructure and intelligent connected vehicles; developing smart communities; enhancing intelligent housing management; building digital homes; facilitating coordinated development of intelligent construction and industrialized building; improving CIM platforms; and creating comprehensive urban operation and management service platforms.

early warning and emergency response, providing core support for enhancing resilience. At the same time, the CIM-based new smart city framework is empowering the high-quality development of resilient cities through digital technologies.

## Implementation Process

In June 2019, Guangzhou took the lead nationwide in piloting CIM platform construction. In October 2020, the city officially launched its pilot programme of new urban infrastructure construction. In 2021, Guangzhou established the innovative Joint Conference System for Piloting New Urban Infrastructure Construction to coordinate the programme. Throughout implementation, Guangzhou has advanced new urban infrastructure construction through a multi-dimensional framework, strengthening the CIM platform as a foundational support system, upgrading urban infrastructure through intelligent transformation to enhance resilience, and promoting smart upgrades in communities and industrial parks to bolster grassroots disaster prevention capabilities.

**1. Strengthen City Information Modelling Platform Construction to Enhance Supporting Capacity**

Guangzhou initiated construction of its CIM platform in June 2019, with the foundational build largely completed by December 2020. In June 2021, the platform (phase I) . As of December 2024, the platform has aggregated a wide array of multisource data and constructed a three-dimensional (3D) topography map of the city's entire 7,400 square kilometres. It includes a 3D current state model covering

1,300 square kilometres of key urban areas, white models of 2.97 million buildings, thematic layers related to building vulnerability findings and surveys of self-built houses. It also incorporates over 3,400 individual BIM units. Together, these make a complete 3D digital base map of the entire city. The CIM platform enables citywide sharing of data such as disaster-bearing body surveys, underground municipal infrastructure surveys, anonymized underground pipeline data and surveys of self-built houses. It also facilitates data sharing across departments including planning, transportation and the ecological environment, offering around 230 data services. To date, it has shared 3D current state model data covering about 2,700 square kilometres, saving an estimated CNY 162 million in redundant government surveying costs.[1] By integrating meteorological forecast data such as one-hour sliding rainfall, wind direction, wind speed and temperature, the platform supports extreme rainfall and waterlogging simulation analyses, enabling early warning and efficient response to disaster risks and issues, see Figure 5-1.

**2. Construct Smart Infrastructure to Enhance the City's Resilience**

Guangzhou has developed and issued the Technical Guidelines for the Construction and Operation of Smart City Infrastructure Based on City Information Modelling (trial). These guidelines provide unified direction for smart city infrastructure construction projects by specifying requirements for classification and coding, model hierarchies and

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1    Available at: https://zfcxjst.gd.gov.cn/xwzx/gdzw/content/post_4767310.html.

Source: Authors.

Figure 5–1    Guangzhou CIM platform

intelligent construction. They facilitate life cycle management of municipal infrastructure, promote the creation of replicable demonstration projects and experiences, and provide clear direction and guidance for intelligent infrastructure transformation. Using the guidelines through smart construction and renovation, Guangzhou continues to improve the resilience of critical municipal infrastructure, including water supply, drainage, electricity and energy conservation, gas and underground pipelines, to ensure the secure operation of the city's core functions.

A smart water supply information system has been developed to facilitate the intelligent transformation of water facilities and enable continuous monitoring of water quality, quantity and pressure throughout the entire water supply process from source to tap. The cloud-based platform for smart water supply services covers an ultra-large and complex water supply pipeline network of approximately 10,000 km and 1.7 million smart terminals. It serves a water supply area of 1,092 square kilometres, providing high-quality water services to 11.23 million people across the city.

The city has developed a smart drainage information system and established 6,860 IoT monitoring stations for water utilities which improve the ability to identify potential disaster risks and greatly enhance the resilience and adaptability of urban water safety. An integrated smart drainage platform, GuanYang-Tong, has also been developed which enables real-time monitoring of the sewer network and supports bidirectional traceability of drainage flow and source control. It ensures a swift response to drainage emergencies.

Guangzhou has undertaken smart development of its electric power tunnels. By standardizing the collection of data on tunnel and manhole locations and dimensions, the city has achieved interconnectivity and data sharing across its electricity, water and gas systems. Data synchronization has been

completed for over 4,700 km of utility tunnels, and more than 280,000 electricity manholes have been integrated into over 21,000 government comprehensive grids. The innovative use of technologies such as radio frequency identification tags and smart manholes enables dynamic updates of pipeline information, thereby improving power supply safety and quality.

A smart monitoring platform for the distribution of liquefied petroleum gas has been established allowing for the full-process monitoring of more than 5.4 million gas cylinders citywide. The platform enables mega scale data to be uploaded in seconds, reducing operational costs while improving user convenience and the safety and resilience of the gas pipeline network. As of December 2024, Guangzhou had over 2.67 million smart gas meter users, accounting for more than 77 per cent of the city's total users. This puts Guangzhou at the forefront nationally.

Guangzhou has also established an underground pipeline construction management system which provides a unified digital map of the city's underground pipelines. Guangzhou conducted a citywide census of its underground municipal infrastructure and was among the first cities in China to complete such an effort. As of December 2024, the city had completed the status survey of over 90,000 km of pipelines, 5.9 million square metres of underground transportation facilities and 23.66 million square metres of integrated civil air defense structures. These efforts have significantly advanced the smart management of underground pipelines, see Figure 5-2.



Source: Water Affairs Bureau of Guangzhou Municipality.

Figure 5–2　IoT monitoring points for Guangzhou's drainage system

### 3. Promote Smart Upgrades of Communities and Industrial Parks for Greater Disaster Preparedness

In December 2020, Guangzhou designated smart communities and smart industrial parks as a key task under its construction of new-type urban infrastructure pilot initiative, aiming to continuously strengthen disaster preparedness at the grassroots level. Guangzhou has actively developed and issued technical standards, including the Technical Guidelines for the Construction, Operation and Evaluation of Smart Communities Based on City Information Modelling, and the Technical Guidelines for the Construction, Operation and Evaluation of Smart Industrial Parks Based on City Information Modelling. Pilot smart
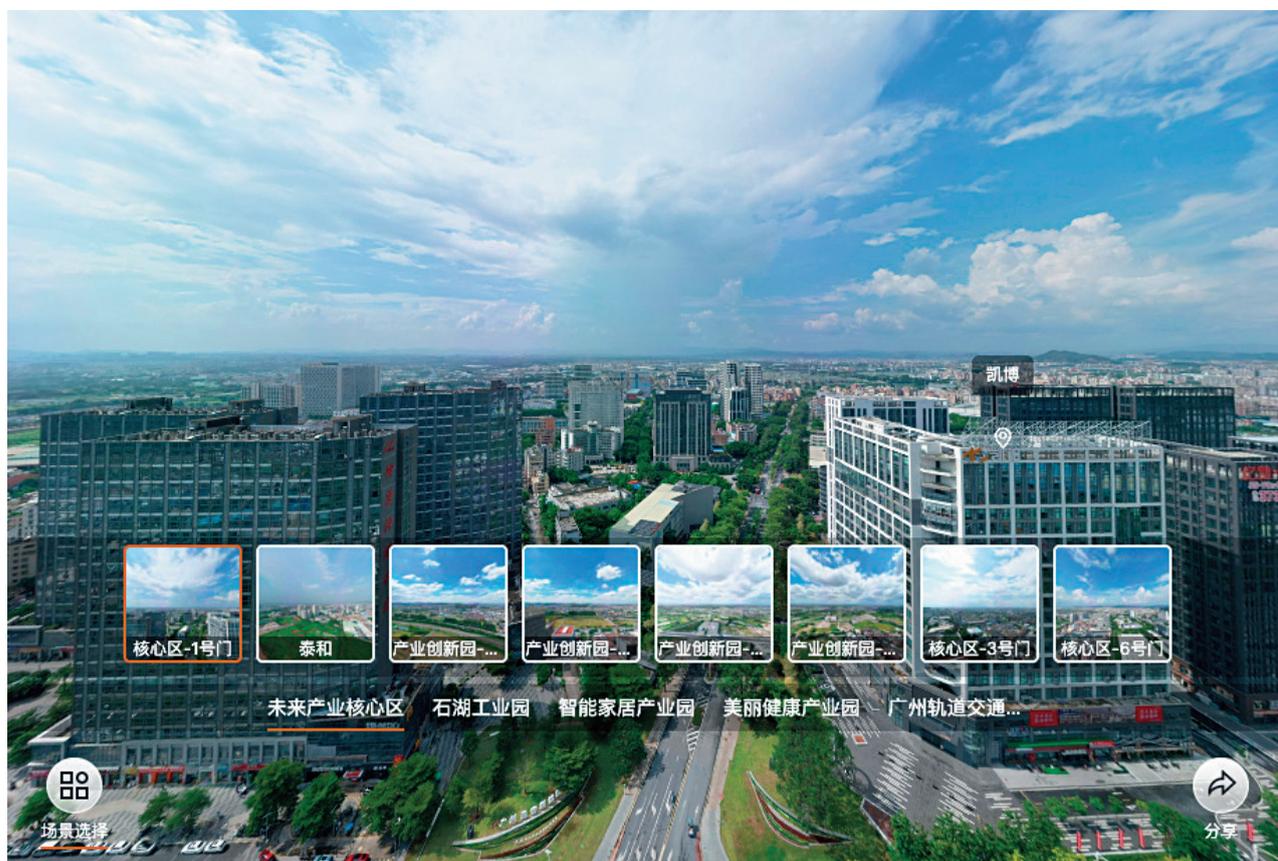
Source: Management Committee of the Private Science and Technology Park of Guangzhou High−Tech Industrial Development Zone.

Figure 5−3   Guangzhou Private Science and Technology Park

communities, such as the former Nanhai County in Yuexiu District and Sanyanjing, and smart industrial parks, such as the China Unicom Internet Application Innovation Base and the Guangzhou Private Science and Technology Park, have been successfully established, see Figure 5-3.

Guangzhou has provided active guidance to all districts to implement large-scale, integrated smart community development with 27 pilot projects progressing in a structured manner across 11 districts. The city is also expanding pilot applications for digital homes based on smart community models. For example, the inclusive medical and elderly care project in Panyu District has reached 8,526 households in the

Xianfeng and Jinhaian communities. In collaboration with hospitals, endpoint services such as in-home monitoring and health alerts have been extended to households. A remote monitoring and early warning mechanism reduces medical risks and establishes a medical and elderly care model that integrates hospitals, communities and households. In addition, Guangzhou is actively promoting the development of comprehensive communities by establishing a life cycle management mechanism that includes baseline assessments, diagnostics and evaluations, technical guidance, gap remediation and intelligent supervision. The city uses geospatial visualization to present a unified map of all integrated residential communi-

ties. This multi-dimensional, holistic approach has improved the communities' capabilities in smart security, monitoring and early warning, and emergency response, resulting in safer and smarter living environments.

## Reference Experiences

**1. Establish a Top-level Design Methodology That Aligns Strategy, Builds Standards and Integrates Technology to Create a Replicable Framework for Urban Infrastructure Development**

Strengthening the top-level design of urban infrastructure requires moving beyond single-policy approaches and creating a systematic framework of strategy, standards and technology integration. Guangzhou incorporated CIM and new urban infrastructure construction into its 14th Five-Year Plan, formulating the country's first smart city construction plan based on a CIM platform. This plan introduced the innovative concept of city life cycle management, addressing policy bottlenecks in cross-departmental collaboration. Guangzhou also established a "1+2+N"[1] policy framework for multi-level gover-

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1    The "1" refers to the Implementation Plan for Accelerating the Construction of New-type Urban Infrastructure in Guangzhou. The "2" refers to the Pilot Work Plan for the Integrated Development of Smart City Infrastructure and Intelligent Connected Vehicles in Guangzhou and Comprehensive Reform Pilot Implementation Plan for Smart City Construction in Guangzhou. The "N" refers to a series of specialized policies, including the Implementation Plan for Establishing New Urban Infrastructure Construction Industry and Application Demonstration Bases in Guangzhou, the Work Plan for Expanding Applications Based on the CIM-based Platform, the Implementation Plan for Guangzhou as a Pilot City for Intelligent Construction, the Action Plan for Developing "Smart + Quality" Housing and Building Better Homes and Communities in Guangzhou, and the Special Implementation Plan for Advancing New Urban Infrastructure Construction Across Haizhu District.

nance and issued 17 standards, including the nation's first Technical Guidelines for CIM-based Platforms, forming a comprehensive, multi-category CIM standards system. On the technical side, the city developed a low-cost data governance model and an open-source software integration platform that supports basic data management, visualization and analysis. Open interfaces enable diverse applications and are compatible with both Chinese and international BIM/ GIS standards, creating a technology empowerment chain from platform construction to scenario application. This framework offers a full-process methodology of strategy planning, standards support and technology implementation for city-level CIM development and provides a replicable model with broad reference value.

**2. Innovate Institutional Safeguards and Guide Smart City Development through Government Leadership, Multi-stakeholder Collaboration and Legal Protection**

New urban infrastructure construction requires a management mechanism that transcends conventional project-based approaches. Guangzhou pioneered a joint conference system chaired by the mayor and involving over 70 departments, fully mobilizing departmental initiative, coordinating cross-departmental issues and generating a synergistic effect. Recognizing the long-term nature of smart city development, Guangzhou moved beyond short-term project dependency by issuing the Guangzhou Digital Economy Promotion Regulations, the country's first local law on a city's digital economy. The regulations explicitly allow BIM to be supervised

through statutory engineering technical drawings. This dual approach of institutional innovation and legal safeguards provides long-term protection for smart city development, and offers a replicable model for addressing common challenges in urban infrastructure, including unclear responsibilities and insufficient sustainability.

**3. Explore Development Paths that Promote Enterprise Aggregation, Industrial Park Connections and Innovation to Facilitate Collaboration within Urban Industry Ecosystems**

To develop a robust industry ecosystem for new urban infrastructure construction and reduce barriers between enterprises, Guangzhou established a smart construction industry alliance involving 96 companies across construction, production, operations and finance. The alliance encourages participation from multiple sectors, including technology and real estate, to enable efficient resource allocation and coordinated industrial development. Leveraging the "2+4" demonstration bases comprising two leading parks and four associated parks, Guangzhou has created a regional ecosystem characterized by collaborative innovation and complementary specialization. The city has also reformed the professional title evaluation system, introducing a new category for Architectural Digital Technology to strengthen talent supply. The Pearl Bay Smart City Demonstration Park pioneers an operational model integrating statutory institutions, state-owned enterprises and technology companies, creating cross-system technolog-

ical pathways using digital twins, simulation-driven approaches and urban governance. This ecosystem approach offers a replicable, market-oriented model for shifting the industry from isolated breakthroughs to coordinated co-construction.

**4. Drive Industry-wide Smart Urban Infrastructure Uptake by Translating Practice into Knowledge and Scaling up Exchange Networks**

To expand new urban infrastructure construction from local practice to industry-wide application, knowledge and experience sharing remain essential processes. Guangzhou has shared its experiences of CIM platform development by hosting over 210 delegations from cities including Beijing, Shanghai and Shenzhen. The city has also compiled publications such as *CIM Technology Research and Application* and the *2024 Guangzhou CIM White Paper* which summarize technical pathways and implementation priorities, and form a knowledge accumulation chain from practical cases to theoretical insights and standards output. By hosting forums and seminars, including CIM/BIM forums and intelligent building expos, Guangzhou has established a diverse platform for exchange among government, enterprises and universities. This fosters technological cooperation and promotes integration of BIM/CIM with new urban infrastructure projects. The transformation model of output, accumulation and sharing provides an effective solution to experience silos and multiple channels for disseminating industry-frontier knowledge.

## Helsinki, Finland
## Helsinki Energy and Climate Atlas Based on City Information Modelling

As a high-latitude Nordic city, heating buildings in Helsinki accounted for 42 per cent of the city's total carbon emissions in 2018. Residential areas constructed between the 1960s and 1980s contain 63 per cent of the city's high-energy-consuming buildings,[1] however, the coverage rate of renewable energy facilities remains below 20 per cent,[2] revealing a spatial mismatch. Following the signing of the Paris Agreement in 2015, Helsinki has been faced with dual challenges in which the European Union 2030 target of 55 per cent reduction in emissions needs to be achieved, while coping with the restraint on climate resilience caused by frequent extreme weather events in winter.[3] Against this backdrop, the Helsinki municipal government officially launched the Helsinki Energy and Climate Atlas between 2018 and 2019. Based on CIM, the initiative has generated a dynamic, decision-support tool that helps to optimize energy efficiency, see Figure 5-4.

The Helsinki Energy and Climate Atlas categorizes carbon emission sources by building, block and energy type. The CIM platform integrates the life cycle data of 500,000 buildings dating back to 1945,[4] enabling analysis of anonymized heating and electricity data, building age, structural materials and current usage. This supports fine-grained energy modelling and energy system optimization. The platform combines satellite remote sensing and ground sensor data to identify heat islands, simulate the cooling effects of increasing green spaces and cool roofs, and mark flood-prone zones, enabling dynamic assessment of climate risks and offering critical guidance for adaptive urban planning. The platform also calculates the solar photovoltaic potential of each building's rooftop. By integrating geological data and district heating networks, it facilitates geothermal well site planning. A public enquiry interface allows residents to input their addresses to query building energy ratings (grades A–F), cost-benefit analysis of retrofitting and subsidy application procedures. This open-access tool helps transition emissions reduction efforts from government-led to society-wide action.

To date, the Helsinki Energy and Climate Atlas has demonstrated significant overall benefits. Since the 2022 heating season, carbon emissions

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1　City Planning Department of Helsinki, Figure 4.2 (Correlation between Building Age and Energy Consumption), Building Stock Analysis 2020.

2　Energy Authority, figure and table, p. 7. District Heating in Helsinki (2019).

3　European Commission, Objective 3, European Green Deal Communication (COM (2019) 640 final).

4　Helsinki ICT Department, Appendix A: Data Scope Description, CIM Data Inventory 2023.
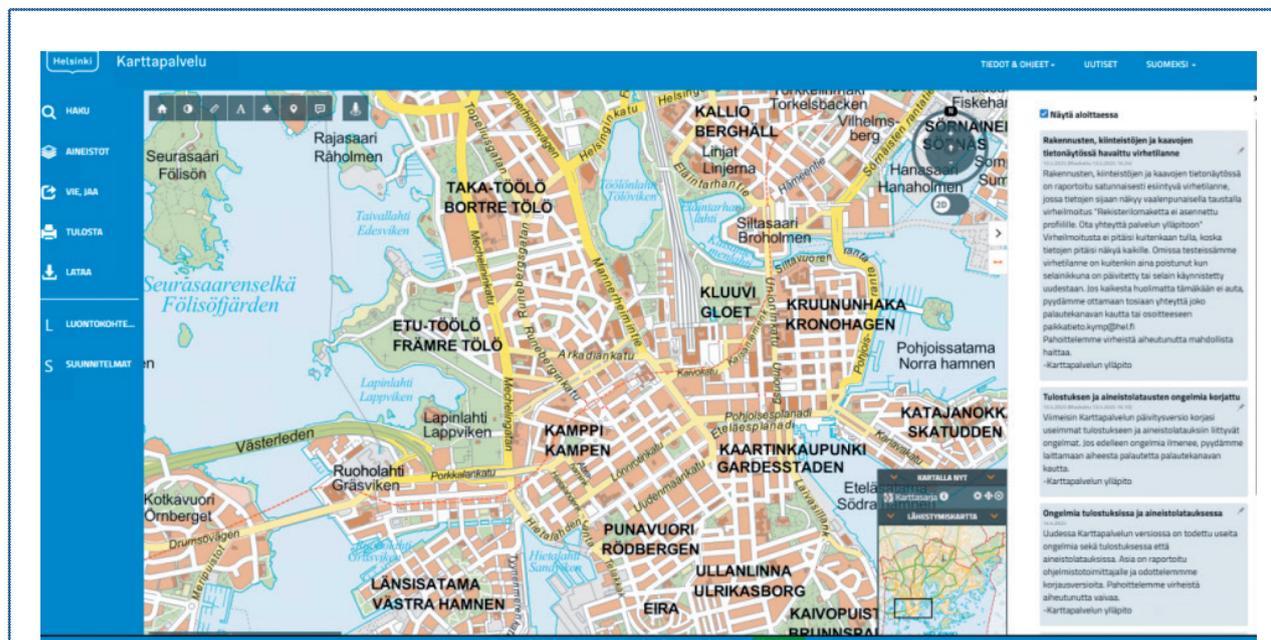
Source: Helsinki Map Service Platform.

Figure 5–4    Resident enquiry interface of the Helsinki Energy and Climate Atlas

in four pilot districts have dropped by 38 per cent year-on-year.[1] Emergency hospital visits during summer heatwaves have decreased by 22 per cent[2] and geothermal well siting accuracy has improved by 40 per cent[3] with per-well capacity doubling compared to conventional methods substantially enhancing Helsinki's climate resilience. On the socioeconomic front, the project has created 2,800 new jobs through building retrofits,[4] 65 per cent of which have benefited indigenous communities. It has also enabled low-income households to reduce annual energy expenses by EUR 1,200 on average,[5] reducing the city's energy poverty rate by 19 percentage points — a clear demonstration of strong social benefits. The project has established a replicable "data collection–model training–policy translation" closed-loop mechanism. It also contributed to revision of the European Union Energy Performance of Buildings Directive, leading to the inclusion of provisions on "citizen data rights", thereby providing an impactful institutional model.

From an experiential perspective, cross-departmental data sharing has been key to the success of this project. Rather than directly applying international tools, the project was localized to suit the Nordic climate characteristics

1    Helsinki Environmental Bureau, Figure 2.1 (Annual Emission Comparison), Pilot Area Climate Impact Assessment 2022.

2    Helsinki University Hospital (HUS), Table 4 (Medical Record Data Analysis), Heatwave Health Impact Study. (2023).

3    Geological Survey of Finland (GTK), Conclusion Section, Helsinki Geothermal Potential Study (2021).

4    Statistics Finland, p. 8, Labour Market Impact of Energy Efficiency Investments (Q1 2023).

5    Bureau of Social Affairs, Case Study K, Energy Poverty Alleviation Program Evaluation (2022).

which provided an essential foundation for improving the practical effectiveness of the project. The Helsinki Municipal Government also ensured that the project data directly supported key government planning and policies. For instance, based on the data analysis from the project, Helsinki has implemented policies to ban fuel oil boilers, making the project a truly effective tool for emissions reduction. In the future, to address data de-identification issues, the project should embed technology ethics and establish a "threefold validation" mechanism for data anonymization, which includes "administrative review + algorithm encryption + citizen oversight". Gradual reforms should also be promoted with phased opening of data access permissions and continuous improvement of the project's data security system.

## Barcelona, Spain
## Green Smart City Transformation Driven by Innovation and Citizen Participation

### Case Background

Barcelona, located in the northeastern Iberian Peninsula, is the capital of Catalonia, an autonomous community in Spain. A renowned port city, Barcelona serves as Spain's leading hub for trade, industry and finance, and is recognized as global tourist destination. In addition to its landscapes and cultural heritage, the city has undergone substantial urban development.

The city's modern industrial advancement spurred the creation of the world-famous Cerdà Plan, which established a model for high-density residential land use. The city's iconic urban image is characterized by a grid of uniformly arranged, chamfered "superblocks". Amid the technological revolution of the 21st century, however, Barcelona is facing new challenges in terms of urban development. Historic districts are faced with excessive population density and imbalanced access to community services. Hierarchical governance models suffer from inefficiency and pronounced data silos, and SMEs exhibit low levels of digitalization which undermines economic resilience. Amid the compounded risks of spatial congestion, fragmented governance and technological alienation, Barcelona is under urgent pressure to explore sustainable pathways for high-density urban development, making smart city construction imperative.

During its smart city transformation, Barcelona reimagined the interplay between technology, people and the environment and has sought to explore citizen tech-enabled urban governance models.[1] Since 2011, Barcelona has played an active role in promoting and hosting the Smart City Expo World Congress, creating the world's largest thematic exhibition and

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1  Barcelona digital city plan – Putting technology at the service of people. Available at https://www.slideshare.net/slideshow/barcelona-digital-city-plan/173086098# (Accessed: 21/7/2025).

communication platform dedicated to smart city development. At the 2023 event, Barcelona showcased its multifaceted efforts in urban transformation and digital innovation under the vision of shaping the future of cities and welcoming the new urban era. Barcelona's years of dedicated exploration and progress have made it the first historical city centre in Europe to obtain smart city certification. This achievement positions Barcelona as a pioneer and advocate for smart cities.

## Implementation Process

Barcelona's smart city journey can be delineated into three phases: ① technological experimentation; ② data-driven management; and ③ citizen co-governance, which reflect important features of smart city development. Over the years, the city has achieved large-scale infrastructure development, accumulated data and innovated technology, integrating these elements into every aspect of the city. This has laid a robust foundation for smart city construction.

**1. Technological Exploration Phase (2000–2010): Enterprise-empowered Technological Experimentation**

In this first phase, Barcelona started using new technologies to better manage the city and drive urban transformation. The city council had not yet developed a clear concept, functionality or developmental framework so interventions were largely experimental or explorative. In 2000, Barcelona implemented green, low-carbon development policies that encouraged citywide adoption of solar energy by residents. The city council installed extensive EV charging stations and promoted the use of EVs. By 2009, as the "smarter planet" concept gained global traction, Barcelona proposed the idea of a smart city to enhance citizen welfare and quality of life, drive economic progress and ensure sustainable urban development.

Barcelona's smart city construction was largely driven, initially, by enterprise-led technological innovation. In 2004, International Business Machines Corporation established the Barcelona Supercomputing Centre (BSC), marking a major milestone in Europe's high-performance computing landscape. Unlike earlier supercomputers dependent on UNIX systems, BSC made a definite shift to a Linux-based platform. This emphasized the flexibility of open-source technologies and better-adapted computing power. As the primary partner, International Business Machines Corporation managed hardware procurement, solution design and deployment. The system is backed by substantial computational power and offers solutions for a wide range of urban scenarios. For instance, Barcelona reduced its emergency response time due to heavy rainfall from 48 hours to just 6 hours by developing city-scale computational fluid dynamics simulation software, and the city achieved real-time monitoring of energy consumption by deploying 2,000 pilot smart meters.

BSC is the technological cornerstone and engine of innovation for Barcelona's smart city construction. As the core of computational power, BSC has laid a critical foundation for the city's intelligent development through technological innovation, cross-disciplinary applications and global cooperation. It has

Source: Official website of Barcelona digital city strategy.

Figure 5–5　Resource map for urban digitalization

opened a new pathway for smart, efficient governance of big cities.

**2. Digital Transformation Phase (2011–2014): Government-led and Data-driven Development**

In 2011, the city council launched its ICT strategy covering areas such as mobility, e-governance and smart city construction. It aimed to technologically empower coordinated development of the city's economy, environment and society. The strategy formally established Barcelona's identity as a "data-driven, sensor-intelligent" city, and ushered in a new era of government-led smart city construction, see Figure 5-5.

In 2012, Barcelona completed a series of impactful smart city projects, earning it recognition as a benchmark smart city in Europe. In alignment with the Europe 2020 Strategy, Barcelona launched the Mobility, E-Government, Smart City and Systems of Information and Innovation Strategy that same year.

The goal was to coordinate sustainable economic, environmental and social development, while also enhancing citizen welfare and economic progress.[1]

In response to the vast amount of sensor data, the city council launched the Sentilo (sensor) platform. The platform integrates data streams from 19,000 sensors[2] and uses the MQTT protocol to ensure low-power data transmission. Sentilo gives users access to citywide sensor networks that collect data on various dimensions, including data on pedestrian and vehicle traffic flows, ambient noise levels, temperature, humidity and air quality, see Figure 5-6.

During this phase, the city aggressively promoted IoT technology for effective management of

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1　MESSI: l'estratègia TIC de l'Ajuntament de Barcelona. Available at https://bcnroc.ajuntament.barcelona.cat/jspui/bitstream/11703/90323/1/19394.pdf (Accessed: 22/6/2025).

2　In Proceedings of the 2016 Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net), Vilanova i la Geltru, Spain, 20–22 June 2016 (Accessed: 22/7/2025).
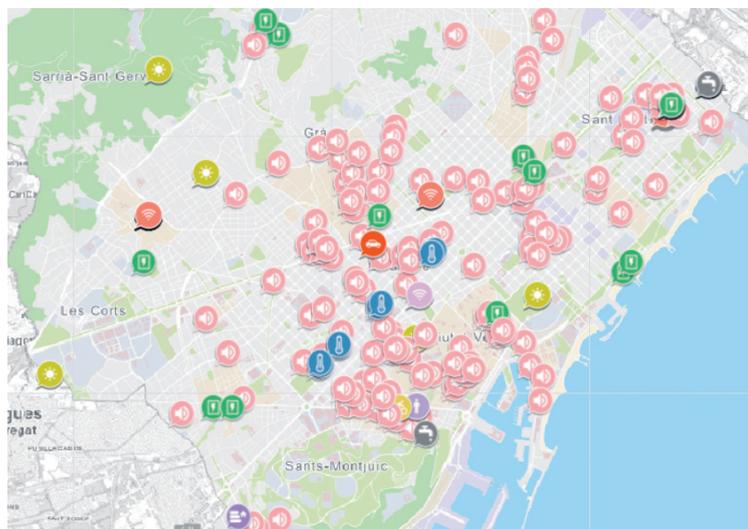
Source: Barcelona city council public services portal Connecta.

Figure 5–6　Sensor data in Sentilo

city systems, such as energy, municipal services and transportation. Installing smart meters and sensors in buildings to optimize energy consumption; using smart irrigation systems that monitor real-time data such as humidity and temperature to optimize irrigation schedules and conserve water; deploying interactive digital bus stops and sensor-guided parking facilities to alleviate traffic congestion and reduce emissions; and applying IoT technologies to acquire real-time data on traffic flow and environmental quality citywide have all helped to improve smart city infrastructure. Barcelona's operational efficiency has been significantly elevated as a result of refined management and smart decision-making.

**3. Citizen Co-governance Phase (2015–present): Citizen Empowerment through Technology and Multi-stakeholder Collaborative Governance**

From 2015, the city council began to develop a new model to empower citizens in urban governance using technology, building on the foundation of its earlier smart city initiatives. The Barcelona Digital City Plan (2015–2019), adopted by the city council, explicitly states that technology should serve people, not the other way around.[1] During this phase, Barcelona prioritized digital transformation, digital innovation and citizen participation. The city council launched high-quality projects across governance areas to improve efficiency and optimize the urban ecosystem.

In February 2016, the city council launched the digital platform Decidim, see Figure 5-7. Built on free and open-source software, this reusable, modifiable platform enables citizens to contribute knowledge, engage in discussions on issues of concern and suggest priority policies. In 2023, Decidim integrated AI-driven semantic analysis tools, continuously improving the accuracy in identifying trending topics.

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1　Barcelona Digital City Plan 2015–2019. (n.d.). Available at https://bcnroc.ajuntament.barcelona.cat/jspui/bitstream/11703/115018/1/pla_barcelona_digital_city_in.pdf. (Accessed: 23/6/2025).

Source: Decidim website.

Figure 5−7　Decidim, Barcelona's digital participation platform

These tools have facilitated the implementation of projects that reflect the interests of a broader range of citizens. The city council has made the architecture and code of Decidim publicly available and promoted its use. Since then, it has been adopted in over 450 instances across more than 30 countries and regions, including in governmental and social organizations in cities such as New York and Helsinki. Decidim has strengthened communication and trust between the government and citizens, improved the efficiency and quality of urban governance, and boosted the city's global recognition.

To reduce wastewater management problems and improve public health, the city council launched SCOREwater in 2019, selecting communities representing high, medium and low socioeconomic levels for experimentation. Sensor networks were deployed to monitor real-time wastewater flow and substance concentrations in the sewers. AI algorithms analysed the monitoring data to derive insights into residents' lifestyles and develop targeted solutions. Digital innovation was achieved in water supply services and the project collected 3.8 million sets of water quality data from sewer sensors.

Since October 2021, to improve the cleanliness and maintenance of urban streets, squares and parks, the city council launched Cuidem Barcelona (Let's Take Care of Barcelona) by involving citizens in a collaborative solution to city cleanliness, and maintenance and waste recycling, see Figure 5-8. Citizens were given access to a website where they could view waste management and recycling locations and schedules across the city, enabling them to track the community's waste disposal. They were also encouraged to provide feedback on areas in need of cleaning so that city managers could gather information and respond promptly. Citizens can then check the community's cleaning management plans and suggest improvements.

The implementation of Cuidem Barcelona represents a digital innovation in urban waste management and recycling by challenging the traditional idea that the responsibility for keeping public spaces clean lies solely with the government. By actively reporting sites of waste accumulation, citizens become engaged in the city's cleanliness and maintenance, see Figure 5-8. Data shows that Barcelona achieved a 40 per



Source: Official website of the Barcelona City Council.

Figure 5−8　City maintenance project Cuidem Barcelona

cent increase in waste collection efficiency and a 23 percent reduction in related complaints in 2023 alone through collaborative efforts in urban maintenance.

Barcelona has successfully achieved iterative upgrades in its smart city construction through efforts that have earned widespread recognition, such as actively promoting the development of urban IoT and digital transformation. According to the Smart City Index Report 2022, jointly published by the University of Cambridge, United Kingdom of Great Britain and Northern Ireland, and Yonsei University, the Republic of Korea, Barcelona ranked third globally. Juniper Research's 2023 evaluation of European smart cities also ranked Barcelona third, behind Berlin and London.

## Reference Experiences

In the global movement toward smart city development, Barcelona offers valuable lessons on how technology, governance and citizen engagement can be combined to create a sustainable and people-centred urban future. The city shows that a successful transformation depends not only on advanced infrastructure but also on organizational collaboration, continuous technological innovation and a clear commitment to human needs.

**1. Strengthen Collaborative Governance across Government, Civil Society and Industry**

Smart city development requires coordinated governance that engages government, the private sector and civil society. Barcelona demonstrates a government-led but broadly collaborative approach, advancing digital transformation through joint stra-

tegic planning, policy formulation, technological innovation and citizen participation. The city council provides overall direction by setting development priorities, establishing ethical and legal standards and allocating budgets, while civic organizations and technical partners help translate technology into inclusive, people-focused services. A flagship example is the Barcelona Digital Twin, a joint initiative of the Municipal Institute of Information Technology, the Barcelona Metropolitan Area and BSC. The Municipal Institute of Information Technology standardizes and manages city data; the Barcelona Metropolitan Area defines functional requirements, tests policy outcomes and addresses issues identified during simulations; and BSC contributes the high-performance computing capacity needed to model complex urban systems. This well-aligned, multi-stakeholder framework enables evidence-based decision-making, reduces governance risks and enhances accountability, offering a practical reference for cities worldwide seeking to build inclusive and resilient smart city strategies.

**2. Recognize Technological Upgrading as an Essential Process to Transform Urban Management and Services**

The introduction, refinement and application of technology are the core drivers of urban digital transformation. In Barcelona, technology underpins every stage of smart city development from the rollout of smart infrastructure to data-driven governance and collaborative innovation with citizens. Early deployments such as IoT networks, citywide sensor systems and green energy technologies established

the foundation for digital transformation. Over time, Barcelona's smart city model has progressed from an enterprise-led, data-driven approach to one that actively incorporates citizen participation, creating a more sophisticated and integrated smart system. Across public services, environmental management and the incubation of new digital economies, technological applications remain focused on human needs. The city advances sustainable development by remaining open, sharing knowledge and engaging citizens as active partners in innovation. On 8 July 2022, Barcelona Mayor Ada Colau, the Mayor of Bologna and BSC, along with other stakeholders, signed an MoU to advance evidence-based decision-making and policy formulation using urban digital twin technologies. The agreement sets a benchmark for digital urban governance. Looking forward, Barcelona plans to leverage digital twins to integrate large-scale urban data and advanced technologies, aiming to build a smarter, more efficient and responsive city.

**3. Harness Technology as a Tool to Catalyse People-centred Urban Governance**

A people-centred approach serves as a both a foundational principle and core objective of smart city development globally. Barcelona has moved beyond a purely technology-driven paradigm to smart city development by prioritizing human-centric governance and digital sovereignty. The city provides a robust suite of digital tools, open-source software and code resources, enabling citizens to engage directly in urban governance, contribute knowledge and shape urban policy priorities. This framework empowers

residents to fully exercise their rights including data protection, privacy and control over personal informational data, while simultaneously enhancing digital literacy and capabilities. To safeguard these rights, Barcelona has implemented a comprehensive set of measures, including ethical digital standards, participatory platforms, open data portals and collaboration with initiatives such as the European DECODE project. Across its smart city initiatives, the city exemplifies how technological innovation can be harmonized with humanistic values, ensuring that digital transformation serves the public good rather than technological imperatives alone. Years of sustained investment have established a solid foundation of infrastructure, data and technology, demonstrating the transformative potential of digital integration for social development, urban resilience and inclusive governance. At the same time, persistent challenges — high energy consumption from supercomputing infrastructure, sensor coverage gaps, privacy and data protection risks, and support for SMEs — underscore the need for ongoing innovation and regulatory oversight. Barcelona's experience illustrates a critical policy lesson: while technology and data are essential enablers, human-centred governance remains the cornerstone of sustainable smart city development. Avoiding the pitfalls of a "techno-utopia" requires coordinated action in which governments, citizens and technological systems operate in synergy, guided by inclusive participation, strategic planning and accountable regulation. Only through this integrated approach can cities achieve truly sustainable, equitable and resilient urban futures.

## Chongqing, China
## The Bayu Zhishui Application System: an Integrated Smart Sensing Network for Sustainable Water Management

### Case Background

Chongqing, located in the upper reaches of the Yangtze River in China's subtropical monsoon zone, is characterized by its predominantly mountainous and hilly terrain. The city is criss-crossed by more than 5,300 rivers of various sizes. While water resources are widely distributed, managing water quality has posed a significant challenge. In recent years, as urbanization has accelerated, industrial, domestic and agricultural wastewater has converged into rivers. This has led to the emergence of black and odorous water bodies in desakota areas and small to medium-sized watersheds, causing considerable disruption to residents' lives and public health. Traditional water environment management has relied on manual inspections and fixed-point monitoring which are time-consuming and slow in response. In the Longhe Lake Sea area, for example, a pollution issue such as excessive total phosphorus and permanganate index would take over seven days to detect. The lack of data sharing between departments, combined with severe information silos and long response times, made it difficult to meet the growing need for timely detection and response in environmental management.

To address these challenges, the Chongqing Municipal Party Committee and the Chongqing Municipal People's Government proposed the goals of smart water management and technological pollution

control, focusing on ecological conservation and digital governance by pushing for the integration of digital tools in water environment regulation. Chongqing launched a comprehensive initiative known as the Nine-Treatment (Jiu Zhi) Campaign, a strategy targeting nine key areas of environmental management: water, air, soil, solid waste, plastic pollution, mountain ecosystems, riverbanks, urban environments and rural regions. By balancing practical considerations with a commitment to self-imposed goals, the city introduced a "9+38" task system — comprising nine special actions and 38 key projects —which serves as an operational framework for implementing the Nine-Treatment Campaign.[1] Among these, the Bayu Zhishui application system is a key component, see Figure 5-9.

### Implementation Process

In April 2023, the Chongqing Municipal Bureau of Ecology and Environment led the planning for the Bayu Zhishui application system, which was piloted in key areas in December of the same year. The system builds upon existing digital governance initiatives, including pre-existing river basin monitoring data and smart city infrastructure, while also introducing new functionalities to enable cross-departmental data integration and intelligent analysis.

This system integrates over 900 pieces of data from 22 departments, sharing more than 150 mil-

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1   Carrying out Nine Special Actions and 38 Key Projects to Create the "Nine-Control" Ecological Conservation System in Chongqing. Available at https://www.cq.gov.cn/zwgk/zfxxgkml/zdlyxxgk/stbh/hjbh/202504/t20250429_14571708.html.
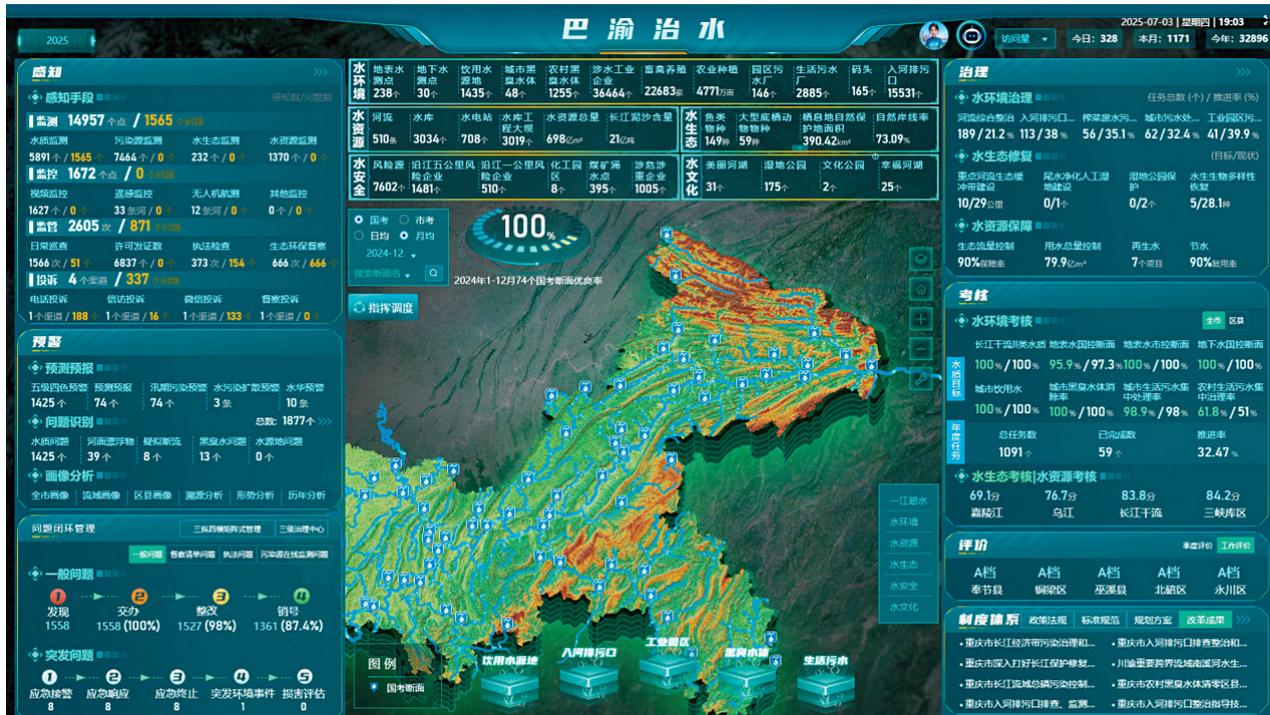
Source: Chongqing Municipal Bureau of Ecology and Environment.

Figure 5–9　Bayu Zhishui dashboard

lion data points, building a multi-level, multi-modal monitoring framework incorporating satellites, high-altitude drones, ground sensors and underwater equipment, tailoring digital monitoring maps for each river to realize a visible, accurate and controllable approach to smart water management. Once a water quality problem is detected, the system immediately triggers a warning message and, within minutes, an issue list is dispatched to enforcement personnel for swift response and investigation. This application addresses concerns such as fragmented water environment management data, delayed problem detection and a lack of coordination in responses. It achieves this by rebuilding a water management system featuring rapid perception, risk assessment, situational analysis and efficient disposal through digital means

facilitating comprehensive, intelligent water management.

**1. Expanding Smart Sensing and Accelerating Early Warning for Real-time Water Governance**

Since the pilot launch in December 2023, the Bayu Zhishui application system has covered over 16,000 sensing points, effectively integrating data from ground monitoring, drone and satellite observations, and public complaints to form a multi-level monitoring system. Ground sensors monitor indicators such as ammonia nitrogen, total phosphorus and permanganate index in real time, and identify abnormal changes in combination with AI. Drones conduct regular river patrols capturing high-definition images of illegal discharge activities; satellite remote sensing provides macro-level situational assessments; and

the public can instantly upload pollution problems through an app with the platform analysing these notifications to make comprehensive judgments.

The system made significant progress during its initial deployment with the number of sensing points expanding from approximately 1,500 in early 2023 to more than 16,000 by the end of the pilot phase, further strengthening data integration and rapid sensing capabilities, creating a "digitalized water management map" that supports the entire process from problem detection to resolution. At the same time, the integration of AI-enabled anomaly detection reduced the average time required to identify pollution events from over a week to less than 24 hours, significantly boosting pollution detection efficiency.

In addition, the system's early warning mechanism offers multi-level notifications and precise location capabilities. Not only does it notify streets, towns and enforcement agencies via SMS and app alerts, but it also provides issue categorization and traceability maps, effectively guiding rapid response efforts, see Figure 5-10. Chongqing has also continuously deepened and expanded the Bayu Zhishui application, accelerating the development of an integrated, full-chain water management system, aiming to empower comprehensive, intelligent water management with digital tools.

**2. Promoting Closed-loop Governance and Cross-regional Collaboration**

The Bayu Zhishui application system deeply integrates a closed-loop governance process, referring to a coordination mechanism that links three vertical



Source: Chongqing Municipal Bureau of Ecology and Environment.

Figure 5–10   Bayu Zhishui river basin ecological environment management elements map

levels (city, district/county, township) with four horizontal dimensions (districts/counties, departments, provinces/cities and townships).This enables surface water quality anomalies and other high-frequency events to be seamlessly connected across multiple levels and regions, with issues assigned digitally and resolved in a timely manner thereby significantly improving disposal efficiency.

In addition to rapid closed-loop disposal, another strength of this water management system is its cross-regional collaborative governance mechanism. The application facilitates the sharing of cross-border river water management data between Chongqing and Sichuan, establishing a joint prevention and control mechanism for rivers that span multiple regions. It also pioneered online collaboration between Chongqing's Liangping District and Sichuan's Dazhou, facilitating the resolution of interprovincial and intermunicipal challenges. For example, in March 2024, a pollution incident occurred in the Tongbo River, a transboundary river between Sichuan and Chongqing, see Figure 5-11. The Bayu Zhishui application system automatically detected that the daily averages of ammonia nitrogen and permanganate index at the state-controlled sections of the river's dam exceeded the standard limits. The system then precisely traced the pollution source using algorithms, identifying 2 sewage treatment plants, 4 industrial enterprises, 15 stormwater outfalls and 10 livestock farms as the possible source, and automatically sent warning messages to relevant personnel in the Liangping District Bureau of Ecology and Environment, and the section's chief. Subsequently, the system generated an issue list

and sent it to the Liangping District Bureau of Ecology and Environment who conducted an investigation. The issue list was also sent to the Dazhou County Bureau of Ecology and Environment in Sichuan. Liangping District and Dazhou County each addressed the problem within their respective areas, completing remediation and resolving the issue within two days.

Historically, the Tongbo River has struggled with severe pollution. Due to the absence of an effective cross-regional cooperation mechanism, water quality parameters in this river have frequently exceeded national standards, resulting in poor water quality that severely affects the lives and ecosystems of local residents. Through the data aggregation, integration and sharing capabilities of the Bayu Zhishui application system, cross-regional collaborative digital management of water environmental issues between the two areas has now been realized, see Figure 5-12.

**3. Empowering Public Participation and Strengthening Grassroots Level Governance**

The Bayu Zhishui application system underscores the importance of government-public co-governance. Since its launch, the system has actively engaged the public in water quality monitoring through reporting hotlines, WeChat complaints and other functions, providing a wealth of clues for water environment management. As a result, numerous water environment issues occurring in close proximity to residents have been addressed in a timely manner. To further incentivize public participation, Chongqing has implemented a reporting reward mechanism for citizens who provide valid leads. This has significantly boosted the enthusiasm of residents to engage in

Source: Water Ecological Environment Division, Sichuan Provincial Department of Ecology and Environment.

Figure 5–11　Tongbo River, a transboundary river between Sichuan and Chongqing



Source: Chongqing Municipal Bureau of Ecology and Environment.

Figure 5–12　Tongbo River

environmental protection.

Beyond complaint-based participation, the system also integrated local knowledge during its design phase. Residents were consulted in pilot areas on issues such as identifying typical pollution sources, setting priority monitoring locations and validating data accuracy. This process enabled the incorporation of community-level insights into the platform's data ecosystem, making public participation not only reactive but also proactive, contributing to co-creation and shared governance.

Primary-level workers receive and complete work orders in real-time via the app, taking photos, collecting evidence on-site and then feeding it back into the platform. The system automatically records the path, time and results of each task, generating concise reports that facilitate management tracking. In addition, the Bureau of Ecology and Environment releases regular primary-level disposal efficiency rankings, promoting rapid response and public accountability mechanisms. This creates a closed governance loop characterized by "online discovery–offline

implementation–visible results", thereby enhancing primary-level governance capacity.

The deployment of the Bayu Zhishui system has already delivered significant improvements in environmental governance. The Longhe river, a primary tributary of the right bank of the upper Yangtze River, originates from the Wuling Mountains. The river basin is densely populated and characterized by frequent human activities. Historically, it has faced challenges such as intermittent water flow, unstable water quality and deteriorating aquatic ecosystems. Today, the Bayu Zhishui application system can automatically label the river's pollution discharge points and associated enterprise information, allowing field investigations and remediation measures. Previously requiring more than 7 days this can now be completed within 48 hours. More broadly, the water quality of the Yangtze River's Chongqing section has been maintained at Grade Ⅱ, while 74 state-controlled sections have consistently achieved a 100 per cent rate of good water quality over the past two years. These outcomes illustrate the system's ability to accelerate

response times, enhance interdepartmental coordination and improve overall governance effectiveness across both urban and rural contexts.

## Reference Experiences

Chongqing's Bayu Zhishui application system has paved the way for intelligent water governance in a mega-city characterized by a complex terrain and a dense population. Its success is rooted not only in technical integration and platform development but also in its people-centred approach, systematic mechanism design and regional collaborative governance. The experience from Chongqing can be summarized in the following four key aspects which are transferable to other cities:

**1. Enable Data Integration and Apply Intelligent Analysis to Strengthen Governance**

The Bayu Zhishui application system integrates cross-departmental data to build a comprehensive water environment monitoring network. This data integration not only improves information transparency and accessibility but also provides scientific grounds for the efficient allocation of resources. By consolidating data, the system enables more accurate decision-making and faster response times, thus improving overall governance efficiency. This integration was made possible through explicit coordination mechanisms. A dedicated interdepartmental task force, led by the Municipal Bureau of Ecology and Environment, was established to harmonize data standards, manage more than 900 data interfaces across 22 municipal departments and ensure continuous system operation. Regular joint meetings and

digital dashboards enabled different bureaus — such as water resources, housing and urban-rural development, agriculture and emergency management — to share real-time information and jointly validate monitoring results. At the cross-regional level, formal cooperation agreements between Chongqing and Sichuan created a framework for sharing transboundary river data which was operationalized through online joint investigations and coordinated enforcement actions (e.g., the Tongbo River case). Furthermore, this integration fosters cross-departmental and cross-regional collaborative governance, breaking down data barriers between different sectors and regions. By institutionalizing these coordination mechanisms, the system ensures seamless information flow and promotes cooperative action across the entire river basin providing a replicable model for other cities facing fragmented governance challenges.

**2. Enhance System Efficiency for Smart Water Management through Real-time Monitoring and Early Warning**

The Bayu Zhishui application system employs an integrated "sky–space–ground" (a nationally recognized term in China for linking satellites, drones and ground-based sensors) intelligent perception network for comprehensive monitoring and intelligent early warning of the water environment. This intelligent governance ecosystem not only accelerates problem detection and response but also ensures efficient operation of the governance system through automated processes and algorithms. Advanced technologies, including satellite remote sensing, drone patrols, and intelligent monitoring and early warning with ground

sensors, significantly enhance monitoring coverage and accuracy, reducing human errors and delays. More precise issue identification and a faster response to emerging challenges is also enabled.

The model also offers scalable entry points for cities with reduced capacities. While Chongqing deployed a full spectrum of technologies, other municipalities can begin with lower-cost elements, such as citizen reporting apps, basic ground sensors at key river sections or shared access to regional satellite data, and progressively integrate higher-end tools like drones or AI-based anomaly detection as resources allow. This tiered approach ensures that the principles of early warning and rapid response are transferable to cities with more limited financial or technical capacity.

**3. Understand Public Participation and Social Co-governance as Key Processes to Engage Multiple Stakeholders**

The Bayu Zhishui application system has effectively mobilized public involvement in water environment management through features such as complaints via letters, visits, WeChat and other channels, empowering citizens to take an active role in governance. This public-demand-driven governance model has not only raised environmental awareness but also increased participation through incentives such as rewards offered for valid reports. To address equity concerns and bridge digital divides, the system was designed with multiple entry points. While smartphone users can submit evidence through apps and WeChat, offline channels such as telephone ho-

tlines, local service centres and village-level officials are also engaged to assist residents with limited digital access. Chongqing institutionalized citizen participation by embedding a reporting reward scheme into municipal regulations and publishing regular feedback on how citizen inputs were acted upon, ensuring participation is both incentivized and sustained. An important aspect of public participation is the monitoring and feedback provided by the public, which allows the system to quickly understand the effectiveness and problems of governance actions and identify any issues, enabling prompt adjustments to strategies. By institutionalizing participation and addressing inclusion, the system not only enhances transparency and builds public trust, but also provides a transferable lesson for other cities demonstrating how citizen engagement can be scaled in diverse socioeconomic contexts.

**4. Recognize the Potential of the Initiative to Support New Exploration in Smart Water Governance**

The Bayu Zhishui application system drives technological advancement and model innovation, facilitating a shift towards smarter, collaborative and sustainable urban governance. The innovative practices within the Bayu Zhishui application system not only provide valuable lessons for global urban water management but also offer a practical reference model for achieving the SDGs, providing support for other countries and regions in their efforts toward intelligent water governance.

## Chosica, Peru
## Digital Early Warning System Technology for Community−driven Disaster Risk Reduction

The district of Lurigancho-Chosica is situated in a valley approximately 20 km from the east of the capital, comprising part of the Historic Centre of Lima. It is surrounded by hills of loose soil and rocks with few natural buffers, and is highly susceptible to both flash floods and mudslides. Critically, in many instances, mudflows increase river flow volumes, serving to couple the two phenomena. As approximately 30 per cent of Peru's population are estimated to be highly susceptible to both, Practical Action in cooperation with Zurich Insurance Group Limited developed the Qawaq intermediate climate information system in late 2016 to provide technological support for a localized early warning system (EWS).

The system operates within the framework of IoT and comprises four key components: ① the generation of risk knowledge via cameras and sensors; ② risk monitoring and alerts distribution through the municipality; ③ communication and diffusion through the municipality and community leaders; and ④ active response through communities. Following research into the gaps for EWS implementation in the district, EWS development was designed to cover previously unmonitored areas addressing variables such as micro-watershed rainfall and soil saturation including visual record taking. Camera fitted monitoring stations were set up on the roofs of houses by community volunteers while others were placed in high hillside areas with photos taken every two to five minutes, see Figure 5-13.[1] Data is collected and transmitted using a wireless sensor network powered by affordable microcontrollers and microcomputers such as Arduino and Raspberry Pi. Images and sensor data are then disseminated to the government's local data monitoring centre, with devices connected via a cellular network and radiofrequency modules. This enables local authorities and residents to swiftly react to potential flooding where threshold levels are exceeded. For managing data and communication, Qawaq relies on several free and, in some cases, open-source web platforms that enable two-way communication, and also integrates conventional messaging services like WhatsApp and Telegram. Both the web interface and the mobile network via short message service are used to distribute alerts, warnings and notifications.

EWS, therefore, allows for the addition of

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1  United Nations Office for Disaster Risk Reduction. (2017). Early warning systems save live in Peru. PreventionWeb. Available at https://www.preventionweb.net/news/early-warning-systems-save-lives-peru (Accessed: 2/8/2025).

Source: Practical Action. (2020). Monitoring rainfall for early warning, Peru's Ingenious Solutions.

Figure 5–13　Solar–powered monitoring station in Lurigancho–Chosica measuring temperature, soil moisture, river activity and rainfall conditions with built in mobile technology to disseminate data to communities

critical minutes in the event of landslides and flooding whereby community leaders and first responders can be immediately notified via text by municipal officials to alert those at risk and proceed with evacuation processes, which can start within seven minutes along evacuation routes.[1] In addition to EWS, drainage systems were also

installed in flood zones with culverts integrated to enhance drainage capacities. Since 2017, 65 rain gauges have been operated by citizens in local districts including Lurigancho-Chosica, monitoring Rímac River activity and rainfall in which users are connected by WhatsApp to the Participatory Monitoring Network where rainfall data is recorded twice per day.

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1　Source: Practical Action. (2020). Monitoring rainfall for early warning, Peru's Ingenious Solutions.

# Policy  Suggestions

**1. Establish a Citywide Sensing Network to Build a Macro-level Digital Foundation for Environmental Governance**

Digital infrastructure, through high-precision

monitoring and intelligent analytical capabilities, is driving a paradigm shift in environmental governance from experience-based judgment to data-driven decision-making. At present, most smart city initiatives remain in the early stages of digital transformation and it is imperative to construct citywide sensing networks covering core environmental elements such as

air, water quality and geology at a macro scale. Governments should take the lead in building a city-level spatiotemporal information base and mandate through legislation or administrative directives that municipal, environmental and meteorological departments integrate real-time monitoring data. By consolidating multi-source, heterogeneous environmental information, governments can establish a central decision-support hub. Such practices have already proven effective. In Chongqing, data integration across 22 departments enabled the establishment of a three-dimensional monitoring system that greatly improved pollution tracing efficiency. And in Guangzhou, the CIM platform integrates three-dimensional geographic and meteorological data, reducing heavy rainfall and urban flooding early-warning response times by 40 per cent. This kind of citywide sensing mechanism not only strengthens pollution prevention and disaster response capacities but also provides systemic safeguards for urban ecological security through integrated data analysis.

**2. Advance Pollution and Carbon Reduction in Key Sectors through the Intelligent Upgrading of Micro-units**

Intelligent pollution and carbon reduction in the building and industrial sectors represent a critical pathway for sustainable urban development. Governments should promote digital management of the full building life cycle, coupling BIM models with energy consumption monitoring devices to enable precise energy control, and mandate that high-energy-consuming enterprises connect to resource metering systems via IoT, thereby constructing a digital traceability system for "production–consumption–recycling". For example, the pilot project Helsinki Energy and Climate Atlas integrates multi-dimensional data — including building type, energy consumption density and meteorological information — to accurately identify high-emission nodes and deliver personalized energy retrofit recommendations. This project reduced heating-related carbon emissions in pilot areas by 38 per cent, underscoring the emission reduction benefits of digital empowerment at the micro scale. Such technological approaches not only alleviate traditional environmental burdens but also provide precise regulatory tools for resource recycling and utilization.

**3. Coordinate Technological Innovation and Institutional Design to Construct a Pluralistic Governance Framework**

At the technological level, both efficiency and equity must be pursued. In the Chosica District of Peru, a low-cost flood early-warning network was established using Raspberry Pi devices, reducing disaster response costs by 75 per cent and demonstrating the empowering value of inclusive technologies for grassroots participation. Governments could establish dedicated funds to replicate such models in resource-constrained areas, ensuring that the benefits of smart technologies extend to all communities, preventing digital divides from exacerbating environmental governance imbalances. At the institutional level, it is essential to overcome administrative boundaries. Governments should establish mandatory mechanisms for cross-departmental data sharing and use high-level coordination to dismantle silos, thereby enabling real-time interoperability of environmental

data across different sectors. Guangzhou, for example, mandates by regulation that approved BIM models must be simultaneously integrated into the CIM platform, ensuring data interoperability through legal frameworks.

Strengthening public participation is key to sustainable governance. Barcelona's Decidim platform applies AI semantic analysis to accurately identify public environmental demands. Chongqing's water governance system provides a WeChat-based complaint channel and reward mechanisms to encourage citizen oversight. And the Helsinki Energy and Climate Atlas offers open interfaces for citizens to access environmental data. These practices demonstrate that governments must build lightweight participation tools that facilitate smooth public feedback channels while also feeding public input back into AI model training, thus forming a virtuous cycle of "participation–feedback–optimization".

# Chapter Six
# Culture: Embedding Cultural Values in Smart Cities

# Introduction[1]

Fostering intelligent cities is not a product of digital technology alone but a collective capability that can be cultivated by urban infrastructure and citizens. It relies on the ability of residents, institutions and communities to innovate and apply technologies responsibly, inclusively and sustainably to enhance the quality of urban life and facilitate shared urban prosperity. It requires smart governance, cultural values and social practices to guide the design and application of digital technologies as tools to advance sustainable urban development. In this sense, intelligence is inseparable from the human and cultural fabric of the city whereby it emerges when digital tools are aligned with social needs, cultural heritage and the principles of sustainability, ensuring that no one is left behind in the transition toward smarter urban futures.

Culture is a fundamental aspect of heritage and identity, providing cities with unique characteristics and distinct communities. Alongside education, culture forms the foundation for building "smart citizenship" . Advancing smart city development requires sustained investment in digital literacy and governance capacity at all levels, including urban practitioners and the public, as well as a strengthened understanding of digital transformation, inclusiveness, data governance and public participation. Ensuring digital literacy among all citizens will enable them to fully engage with new digital technologies, contributing to urban decision-making and therefore supporting the transformation of smart services into drivers of shared urban progress. In this light, smart cities can be understood as open and evolving platforms co-created and co-governed by citizens as opposed to rigid technological systems.

Cities are thus tasked to balance technological innovation with the safeguarding of cultural heritage, while also leveraging innovation to enrich urban culture, preserve heritage and strengthen social cohesion. Digital technologies can serve as tools to support the transmission of cultural knowledge, enhance access to cultural heritage and protect heritage assets. However, it is important that cities mitigate risks such as the rapid diffusion of technologies which can lead to the erosion of local identities and dilution of cultural memory if not guided by inclusive and sensitive governance.

People-centred smart cities are those in which culture enriches education, governance and

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1   This chapter was written by Tang Yingying, Ouyang Chen, Shi Wen, and Sheng Yang from the Shanghai Library (Institute of Scientific and Technical Information of Shanghai). The Ghent case was provided by UN-Habitat.

heritage preservation, serving as an internal and enduring force for transformation. This chapter highlights practices from four cities that illustrate these dimensions. In Chennai, India, smart campuses and widespread digital skill-building are expanding universal access to education and empowering citizens; while in Seville, Spain, the management of tourist flows demonstrates how smart governance can balance cultural heritage with sustainable tourism and economic vitality. In Suzhou, China, initiatives such as the Ancient City Cell Dissection Project and the CIM+ Digital Twin demonstrate how technology can both preserve historical memory and revitalize public spaces. And in Ghent, Belgium, the installation of mobile third spaces has highlighted their capacity to promote access to cultural heritage via open, decentralized heritage data architecture, while also strengthening public participation in cultural heritage and community bonds. Demonstrating contrasting strategies to tap cultural heritage, these cases highlight the importance of harnessing digital technologies and promoting digital innovation to better harness urban cultural heritage as a tool for advancing people-centred smart city development.

# Reference  Cases

## Chennai, India Building Inclusive Learning Ecosystems–smart Education from Classrooms to Communities

### Case Background

Chennai is the capital of Tamil Nadu in India. This irregularly shaped city, characterized by its coastal shoreline, stretches along the Coromandel Coast and extends inland. It covers an area of approximately 431 square kilometres and is home to a population of approximately 8.3 million people.[1] As a key commercial, cultural, economic and educational hub in southern India, Chennai is often referred to as the "Cultural Capital of South India". Greater Chennai Corporation, the city's statutory local government, has long driven urban governance and public service improvements through technological innovation. It is one of the first cities in India to explore the use of information and smart technologies to transform traditional infrastructure and service models. As early as 2013, Chennai pioneered the application of GIS-based waste bin cleaning and vehicle monitoring systems, enabling real-time management of urban sanitation via mobile platforms. In 2014, Chennai became the first city in India to officially implement a non-motorized transport policy, encouraging walking and green transportation, which has effectively improved the city's commuting environment and ecological sustainability. The city has also enhanced its comprehensive municipal facilities including a 5,275 km water supply network, a 3,643 km sewage network, and metro and bus networks, as well as introducing seawater desalination plants, multi-channel emergency water supply systems and smart patrol systems to enhance urban resilience through technological means.

Building on these long-standing technological applications and governance innovations, Chennai was selected as one of the first 20 pilot cities in the Smart Cities programme, a national flagship initiative launched by the Ministry of Housing and Urban Affairs in June 2015. This programme aims to create livable, clean and sustainable urban environments through smart solutions, improve the quality of life for citizens, and transform and rebuild existing areas using the "Area-based Development" model, making a city more organized and livable. At the same time by leveraging smart solutions, cities can make full use of technology, information and data to enhance infrastructure and public services, driving economic growth with a particular focus on inclusivity for marginalized groups, thus creating a more equitable urban environment. In this process, Chennai has placed particular emphasis on the smart transformation of the education sector. Greater Chennai Corporation recognizes that, "While the smart city mission has a large focus on developing public infrastructure, it is also about creating smart citizens who can operate fluidly within this new environment. These citizens can only be made smart if they are educated hand-in-

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1   C40 Cities Climate Leadership Group. Chennai, India[EB/OL]. [2025-4-20]. Available at https://www.c40.org/cities/chennai/.

hand with technology."[1] In the context of Chennai's smart city development, "smart citizens" mainly refers to residents who possess digital participation and community collaboration skills, while also adhering to rules and actively taking on public responsibilities, thereby facilitating the implementation of urban projects and the improvement of governance. Chennai is currently facing critical challenges in educational modernization. In traditional classrooms, rote learning does little to inspire a passion for knowledge, and opportunities for experimentation and hands-on practice are limited. Outside classrooms, a lack of special education resources makes it difficult for disabled children to access equal development opportunities. This coastal metropolis clearly understands that a truly smart city not only requires upgrading its road and utility networks but also needs to cultivate citizens capable of thriving in the digital age. This nurturing process must extend beyond classrooms and permeate the broader social environment as well.

## Implementation Process

Chennai's smart education transformation plan follows a phased and progressive approach, expanding technological innovation from classrooms to urban public spaces, thereby forming a complete smart learning ecosystem. The first phase focuses on the Smart Classroom Pilot Project, which integrates interactive digital whiteboards, adaptive learning systems and other tools to reshape traditional teaching environments. The second phase involves the development of Model & Smart Corporation Schools, creating comprehensive smart education hubs that cover campus management, teaching assessments and interdisciplinary collaboration. The third phase innovatively extends educational spaces beyond classrooms by embedding smart parks equipped with accessible digital interactive facilities into green public spaces, thereby creating a seamless connection between in-class deep learning and real-world application. This three-dimensional strategic design creates a lifelong learning environment that caters to all age groups and abilities, transforming the city itself into the largest open classroom.

**1. Establishing a Responsible Smart City Organization**

Greater Chennai Corporation, along with other shareholders, established Chennai Smart City Limited (CSCL), holding equal shares at a 50:50 ratio. CSCL operates as a legal entity Special Purpose Vehicle responsible for the planning, implementation and oversight of smart city projects. CSCL is led by a board of directors with the chairperson appointed by the Greater Chennai Corporation to ensure the project's close alignment with the city's development strategy, while allowing CSCL to focus on its specialized tasks. CSCL's specific functions include:

● Planning, approval and implementation: conducting technical evaluations, approving projects and allocating funds to ensure the timely completion of smart city projects.

● Financial assurance and management: securing stable and sustainable income sources, improving CSCL's credit ratings to raise funds in the market and

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1 Chennai Smart City Limited. About Smart Classrooms [EB/OL]. [2025-4-21]. Available at https://cscl.co.in/smart-classrooms.

ensuring government funds are used exclusively for public-benefit infrastructure development.

● Project execution mechanism: promoting project execution through joint ventures, subsidiaries, public-private partnerships and turnkey projects each with flexible income models tailored to the respective initiative.

● Resource mobilization and third-party supervision: mobilizing resources, monitoring review reports from third-party evaluation agencies and implementing corrective actions.

● Capacity building and collaboration: promoting capacity building and collaboration with universities and professional institutions to create an academic and technical support network for smart cities.

● Operations and revenue: legally charging user fees, taxes and surcharges, and establishing a framework for service charges.

Under the coordination of Greater Chennai Corporation, CSCL has implemented various measures to drive the smart city project forward with a strong focus on improving the quality of urban living and infrastructure through innovation and technology application. Among these, the smart transformation of education stands out as one of the most crucial initiatives.

**2. Pioneering Digital Learning through Smart Classroom Programmes**

As the first step in Chennai's smart education transformation plan, the city launched the Smart Classroom Pilot Programme, aiming to explore the deep integration of technology and education under the framework of the Smart City strategy. Led by

CSCL and the Greater Chennai Corporation with the collaboration of corporate social responsibility resources, the project tests the feasibility and effectiveness of smart education models on a small scale. For example, in partnership with technology companies like Samsung Electronics Co., Ltd., Chennai established 28 smart classrooms in public schools that had previously faced resource limitations, see Figure 6-1. Each classroom was equipped with interactive smart electronic whiteboards, 40 student tablets with keyboards, teacher computers, dedicated Wi-Fi and charging stations. The total investment for the pilot project was INR 17.5 million (approximately USD 205,000[1]). This setup has created an intelligent, interactive and mobile learning environment benefiting approximately 27,000 students, providing critical experience for future large-scale rollouts.[2]

Chennai's Smart Classroom initiative targets the municipal public school system. Participating schools were selected by the Greater Chennai Corporation and approved through municipal procedures. The schools are distributed across multiple geographic areas, such as Aminjikarai, Thiruvanmiyur and Triplicane to ensure priority coverage of disadvantaged, under-resourced schools citywide. For households without home internet access, basic training and support were provided to help avoid exacerbating digital divides.

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1　In this case, the exchange rate between INR and USD was based on data from the International Monetary Fund for May 2025.

2　Greater Chennai Corporation. Transforming Chennai [EB/OL]. [2025-4-21]. Available at https://smartcities.gov.in/sites/default/files/2025-01/Chennai%20CTB.pdf.
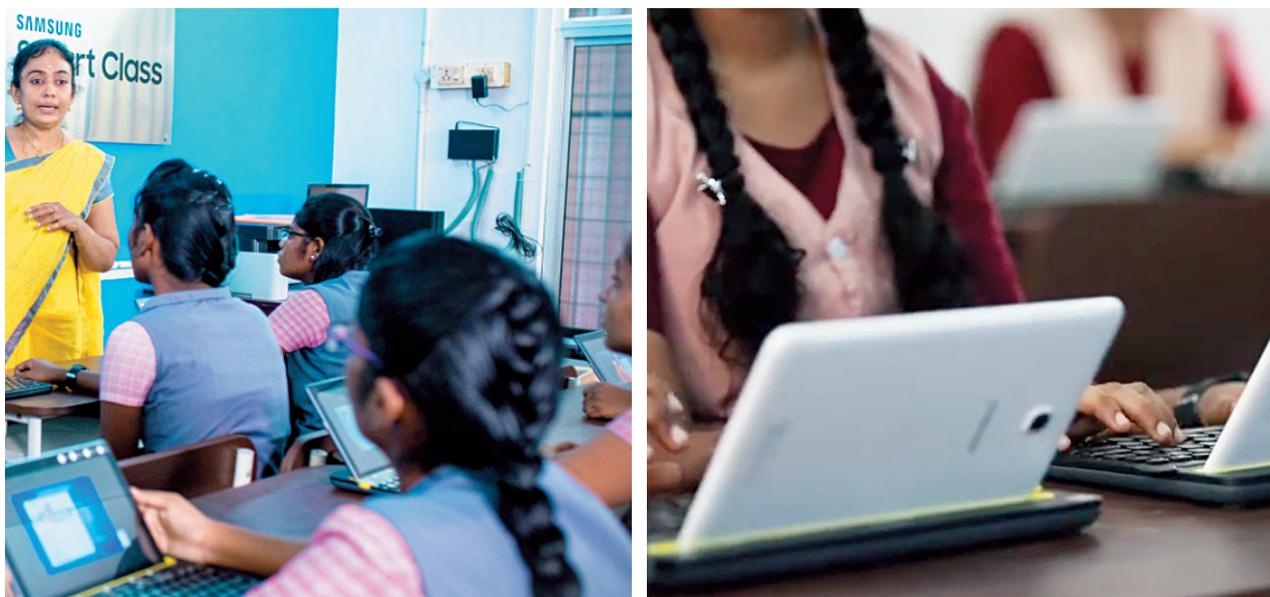
Source: Chennai Smart City Limited. (n.d.). Available at https://cscl.co.in/ (Accessed: 11/8/2025).

Figure 6–1　Chennai smart classrooms

As a pilot programme of the smart education transformation, this project focuses on three core objectives: ① to empower education via technology: the project uses digital tools to optimize teaching methods and enhance classroom interactivity; ② to enhance learning outcomes: multimedia and adaptive learning technologies are applied to improve course understanding and reduce dropout rates; and ③ to cultivate digital literacy: students are exposed to cutting-edge technology early, preparing them to be future-ready citizens in a smart society. The pilot project not only marks the beginning of Chennai's smart education transformation but also establishes a replicable model, laying the practical foundation for subsequent developments.

**3. Scaling Pilot Innovation to a Model for Smart Corporation Schools**

Building on the success of the Smart Classroom Pilot Programme, Chennai entered the second phase of its smart education transformation — Model & Smart Corporation Schools, see Figure 6-2. This phase was jointly led by Greater Chennai Corporation and CSCL with support from international institutions such as the French Development Agency. The total investment for this phase is INR 953 million (approximately USD 11.18 million). Chennai is the first of the 12 Indian cities participating in the Smart School Initiative to complete detailed planning and implementation. It aims to create a replicable model for future schools offering a nationwide demonstration of how digital upgrades can enhance basic education. Guided by the core concepts of "student-centred" and "digitalization-driven" development, the project focuses on five main areas to upgrade municipal schools:

(1) Improving the physical environment of

Source: Chennai Smart City Limited. (n.d.). Available at: https://cscl.co.in/ (Accessed: 11/08/2025).

Figure 6-2　Model & Smart Corporation Schools—left: the school building; right: smart facilities

schools including classrooms, toilets, cafeterias, activity spaces and campus aesthetics in 28 pilot schools, thereby enhancing the overall appearance.

(2) Enhancing teachers' digital skills and leadership by training 2,000 teachers and 600 principals and administrators, and establishing science, technology, engineering and mathematics (STEM) excellence centres to promote educational innovations that improve faculty leadership, information communication technology for education skills, language and STEM competencies, alongside next-generation teaching methodologies.

(3) Upgrading digital infrastructure by equipping over 500 classrooms with interactive electronic screens, full Wi-Fi coverage, and learning resource libraries and management systems. Additionally, STEM and language labs have been set up to support blended and inquiry-based learning.

(4) Strengthening physical education and extracurricular activities by providing specialized cricket and football training, and equipment for exceptional students, and upgrading sports venues and lighting thereby promoting the overall development of students.

(5) Exploring smart pedagogy including blended learning, deep learning and personalized adaptive learning.

In addition, the project focuses on collaborating with non-government organizations, corporate foundations and other social resources to improve governance and service levels. Chennai is exploring an integrated model that combines infrastructure digitization with the development of intelligent teacher capabilities to accelerate the transformation of educational environments. This approach offers a practical path toward achieving harmony between smart city initiatives, educational equity and innovative development.

**4. Towards Citywide Application through Sensory Park Development**

As the third phase of innovation in Chennai's smart education transformation, the city has expanded its educational spaces into urban environments by integrating sensory areas into green public spaces, creating a complete education ecosystem with both smart classrooms in schools and scenographic learning

spaces outside of schools. The Infinity Park project is a collaboration between Greater Chennai Corporation and CSCL, with funding from the City Investments to Innovate, Integrate and Sustain programme launched by the Ministry of Housing and Urban Affairs, and the French Development Agency. Its design and operation involves deep collaboration with Indian and international organizations focused on accessibility and children's rights, including Disability Rights Alliance, CityWorks and Kilikili. The total investment for this project is INR 13.7 million (approximately USD 160,000).[1]

Located in the Santhome area of Chennai, the Infinity Park covers approximately 1,500 square metres, pushing beyond traditional educational boundaries to redefine urban learning spaces through three innovative dimensions:

(1) Age-inclusive design: the park is divided into zones catering to children aged 0–8, 8+ and adult caregivers. All facilities meet accessibility standards including wheelchair-accessible swings, rotating platforms, basketball courts and climbing structures. The ground is covered with ethylene propylene diene monomer (synthetic rubber) non-slip mats and tactile guiding tiles. The entire park is equipped with accessible toilets, tactile handrails, wide ramps and clear directional signs, fully catering to the needs of people with mobility and sensory impairments, and ensuring that children of different ages and abilities can explore and interact in a safe environment.

(2) Multisensory education matrix: the park engages all five senses integrating stimuli for vision – brightly-coloured wall decorations, magnifying observation stations, Braille signs; hearing – music walls, water sound installations; touch – operable steering wheels, mirror walls, kaleidoscopes; smell – taste gardens, herb gardens, aromatic paths; and taste – edible plant gardens to foster an open, rehabilitative educational space.

(3) Smart infrastructure: the park uses IT-based signage systems, sustainable materials and data-driven spatial layouts, seamlessly integrating special education needs into the infrastructure standards of a smart city.

The Infinity Park blends multisensory experiences with rehabilitative education, crafting a layered outdoor learning environment through well-designed zones and diverse facilities, see Figure 6-3. The park brings dual value. For children with special needs, it serves as an outdoor classroom for sensory training, behaviour correction and social skill development. For children without special needs, it functions as a practical base for cultivating inclusive awareness and social empathy. Its innovative significance lies not only in filling the gap in inclusive play spaces in India but also in creating a new smart education model where the city itself becomes the classroom. It is a replicable solution for cities worldwide to promote educational equity and social integration through spatial design.

## Reference Experiences

Chennai emphasizes that the transformation of

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1   Greater Chennai Corporation. (2025). Transforming Chennai. Available at https://smartcities.gov.in/sites/default/files/2025-01/Chennai%20CTB.pdf. (Accessed: 9/8/2025).

Source: Chennai Smart City Limited. (n.d.). Available at https://cscl.co.in/ (Accessed: 11/8/2025).

Figure 6–3   Infinity Park

smart education takes place not only within classrooms but also through broad citizen participation; its true value lies in the process by which every citizen gradually adapts to and integrates with smart development in daily life. The smart classroom technology has benefited approximately 27,000 students by improving digital literacy and fostering independent learning. The sensory park offers inclusive infrastructure for children with disabilities, further enabling the fusion of special and general education systems.

**1. It is Necessary to Build Inclusive Learning Environments Beyond Classrooms**

The Chennai case shows that educational modernization should not be limited to hardware upgrades within classrooms. Instead, it should create learning environments that extend beyond the school campus. The three-step model of Smart Classrooms → Model & Smart Corporation Schools → Sensory Parks elevates digital technology from teaching tools to urban educational infrastructure, allowing learning to transcend the physical boundaries of classrooms. Developing cities can follow this gradual path. Starting with low-cost, high-efficiency "light-tech" pilot programmes (such as interactive whiteboards and tablets) to validate the model, and then extending these pilots to comprehensive campus transformations, ultimately integrating them with urban public spaces. This systematic approach avoids resource wastage while generating a synergistic effect between education and social development. At the same time, it is important to ensure that students from diverse social groups and family backgrounds can equally access these educational facilities, thereby effectively reducing the digital divide.

**2. Inclusive Design is the Core Value of Smart City Development**

Chennai's unique contribution lies in making the concept of "technology for good" tangible. Smart

classrooms prioritize under-resourced public schools, while the Infinity Park uses "low-tech and high-care" designs such as tactile tiles and wheelchair-accessible swings to achieve educational equity at a relatively low cost. This suggests to policymakers that smart technologies should not be about high-tech competitions, but about focusing on inclusivity using technology where it most effectively solves pressing social needs. For example, materials like synthetic rubber non-slip mats ensure safety while keeping maintenance costs low, offering more sustainability than more advanced technologies. Equally important, the project's design process should incorporate community feedback and user participation with attention to gender, cultural context and diverse accessibility needs so that inclusivity is ensured not only in outcomes but also throughout decision-making.

**3. Multi-party Collaboration Mechanisms are Key to Sustainable Transformation**

Chennai's experience shows that sustainable smart education transformation relies on a well-structured partnership among government, the private sector and civil society. The Greater Chennai Corporation established a Special Purpose Vehicle, CSCL, to provide institutional leadership, oversee project planning and ensure accountability through transparent governance and regular performance reporting. Corporate partners such as Samsung contributed resources and technology under CSCL programmes, helping to pilot and scale digital classrooms. Civil society groups, including organizations focused on disability rights and child development, played a crucial role in co-design, monitoring and ensuring that solutions meet community needs. To sustain this collaboration, Chennai formalized its partnership model through contractual public-private partnerships, corporate social responsibility agreements and a clear division of roles in planning, funding and maintenance. Governance and funding structures, such as CSCL's board oversight, diversified financing from municipal budgets, international aid and corporate contributions, and third-party evaluation, have ensured transparency and accountability. Cities with limited resources can replicate this asset-light collaboration experience. By establishing standardized cooperation frameworks (such as defining operational and maintenance responsibilities for donated equipment), cities can lower the barriers for social forces to participate and create a sustainable smart governance ecosystem. Chennai's experience shows that the essence of smart education is not in the technological "wow factor" but in whether affordable solutions can create a lifelong learning network that encompasses all citizens, both inside and outside classrooms. This philosophy of using limited technology with unlimited care is the wisdom that developing cities should adopt most.

## Seville, Spain A Model Practice for the Technological Revival of Historic Cities

### Case Background

Seville, the capital of the Spanish autonomous community of Andalusia and the fourth largest metropolis in Spain, is renowned for its rich historical heritage and unique cultural charm. The city is home to three UNESCO World Heritage Sites: Seville Ca-

thedral; the Alcázar of Seville that perfectly blends the cultural characteristics of Almohad Caliphate and Christian Andalusia; and the General Archive of the Indies which documents Spain's historical ties with the Americas. The charming Santa Cruz and Triana areas offer visitors a glimpse into the daily lives of the locals. As the birthplace of flamenco, Seville is also famous for unique cultural events such as the Holy Week celebrations and the April Fair, attracting 6.3 million visitors annually and generating EUR 1.26 billion in economic revenue.[1] Approximately 25 per cent of the city's population is directly or indirectly employed in the tourism industry.

The rapid expansion of tourism, however, has also exposed Seville to profound contradictions at the urban cultural level. On the one hand, cultural heritage serves as the core competitive edge for the city to attract tourists, requiring investment of resources for strict protection to prevent its historical authenticity from being eroded by excessive commercialization. On the other hand, the surging number of tourists has gradually disrupted the living order of old residential areas such as the Santa Cruz Jewish Quarter, posing challenges to the comfort of local residents. Meanwhile, the city still needs to rely on tourism to continuously drive economic growth and ensure employment stability. How to strike a dynamic balance between protecting cultural heritage, safeguarding residents' quality of life and promoting tourism-driven economic growth to achieve the coordinated unification of urban cultural value and sustainable

development has become a complex issue. This complexity makes traditional management methods difficult to use, thereby giving rise to the demand for the involvement of smart technologies.

Facing the challenges brought by the rapid growth of tourism, Seville has innovatively reshaped the tourism experience through digital transformation. The city has developed an AR tour system that brings historical landmarks to life and launched interactive mobile apps to guide visitors to hidden gems. These initiatives have not only transformed how people travel but also created a win-win situation for both residents and tourists. Through smart tourism practices, Seville has improved the activation of cultural heritage, created numerous job opportunities and accelerated the city's transition toward green, sustainable development.

In 2023, Seville was awarded the title of European Capital of Smart Tourism for its innovations and was recognized by the European Commission as a model city for smart tourism development.[2] Seville's success sets a global example of how smart technologies can support cultural heritage protection while promoting sustainable tourism.

### Implementation Process

**1. Establishing a Smart Tourism Office to Drive a Shared-city Tourism Model**

The Seville City Government established the Smart Tourism Office which plays a pivotal role in

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1   Sevilla City Office. (2023). Hello Virtuoso, I'm Sevilla. Available at https://sustainable.visitasevilla.es/. (Accessed: 10/7/2025).

2   Seville: Embracing the Future as a Smart Destination [EB/OL]. [2025-7-1]. Available at https://visiteurope.com/en/experience/seville-embracing-the-future-as-a-smart-destination/.

planning and designing smart tourism projects and solutions, applying innovative technologies, collecting and analysing tourism data, and fostering deep collaboration with industry partners. With the vision of creating a "shared city", the office is dedicated to developing and innovating sustainable tourism models, focusing on improving residents' quality of life, promoting harmonious coexistence between residents and tourists, and utilizing smart technologies to benefit both locals and visitors.

Seville's core philosophy, "Sharing is Smart", is built around four pillars: digitization; sustainability; accessibility; and cultural heritage and creativity, which collectively drive the city's smart tourism strategy. In the digital realm, Seville has driven the smart transformation of its tourism industry through initiatives like establishing a big data platform, setting up the International Centre for Tourism Innovation and Business Development, integrating tourism services with the citizen card/near field communication and developing the Digital Agenda 2030. These efforts have made Seville a leader in the standardization of smart cities in Spain and it has been certified as a Smart Tourism Destination since 2021. In terms of sustainability, Seville is a proud member of the United Nations World Tourism Organization Tourism Sustainability Observatory. The city has transformed 264 public buildings into nearly zero energy buildings and boosted the urban laboratory for sustainable tourism. Seville has also been included in the 100 Climate Neutral and Smart Cities of the European Union. For accessibility, Seville adopts a visitor-centric approach by pioneering flow management using AI, and infor-

mation and communication technologies, and promoting AR and virtual reality to make cultural heritage more accessible to all. Seville also maintains the first position in the country for the length of its bicycle lanes, rental points and accessibility of public transport; it was the first Spanish city to publish an Accessible Tourism Guide (2005). In terms of cultural heritage and creativity, Seville has enhanced the capacity of tourism as an activator of cultural heritage and the creative industry by establishing the Magallanes Innovation and Cultural Centre, a cultural innovation hub that promotes creative capacities such as transforming the historic building Reales Atarazanas into a new cultural container, promoting 5G in heritage sites with a high tourist influx and broadening attractions for tourists beyond the old town.[1]

As the central hub of the tourism ecosystem, the Smart Tourism Office not only provides market analysis, trend forecasting and industry reports but also facilitates collaboration between government, enterprises, universities and research institutes. The office has established a tourism carrying capacity monitoring system, improved visitor flow management, and ensured the sustainability and inclusiveness of the city's tourism development, ultimately creating a win-win situation for both residents and tourists.

**2. Applying Smart Monitoring to Transform Visitor Management**

As the artistic heart of Seville, Santa Cruz accommodates several historical treasures including the 12th-century Royal Castle, Seville Cathedral, the

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1   Sevilla City Office. Sharing is smart [EB/OL]. [2025-7-1]. Available at https://sevillacityoffice.es/en/sharing-is-smart/.
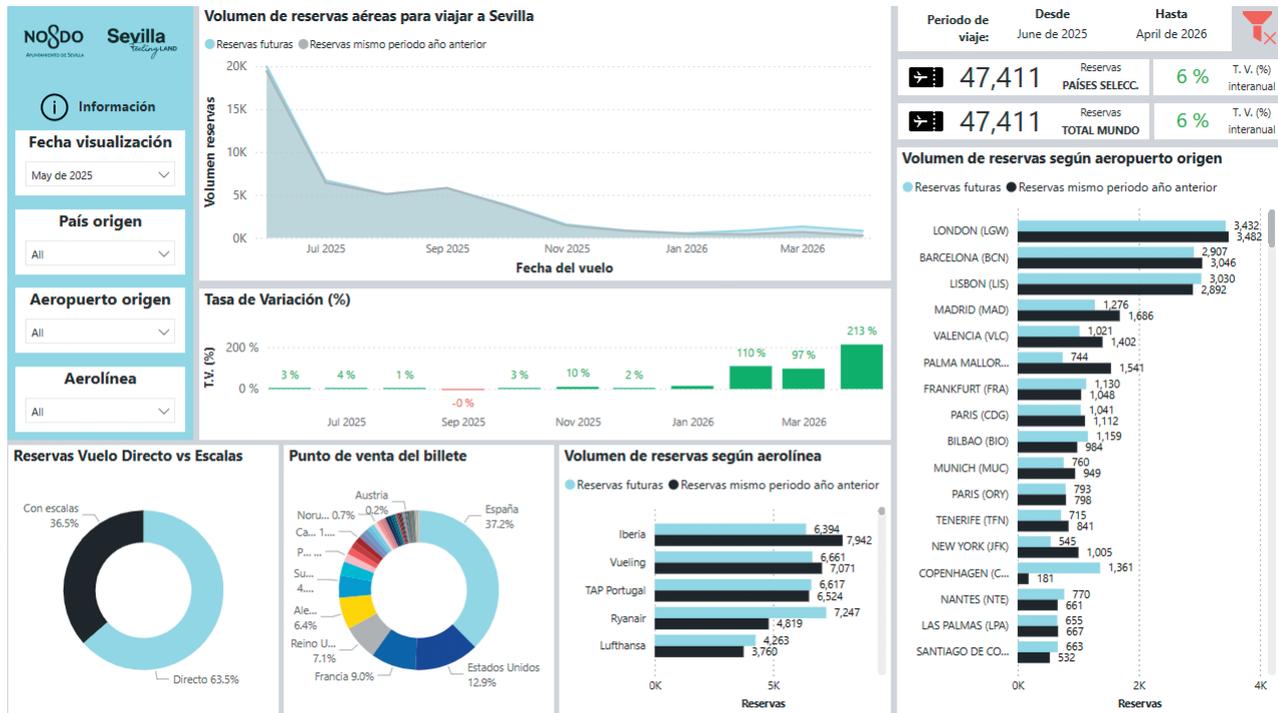
Source: Air bookings[EB/OL]. [2025-7-1]. Available at https://smart.sevillacityoffice.es/en/sit-bookings/.

Figure 6-4　Flight booking information for destinations to Seville from around the world

General Archive of the Indies, the Hospital de los Venerables and the Seville City Hall. However, the overwhelming concentration of tourist traffic has disrupted the tranquility of the area leading to a decline in residents' quality of life and other challenges.

To address these issues, the Seville Smart Tourism Office introduced a cloud-based big data platform known as the Smart Tourism Monitoring System.[1] This system targets high-traffic tourist areas and utilizes IoT to gather real-time data from a wide range of sources including public buildings, cultural attractions, hotels and transportation facilities which are monitored via sensors. This multi-source data is

then aggregated into a citywide data platform. The system features a visualization platform that displays three key categories of data as shown in Figures 6-4~6-6: ① visitor numbers and distribution, including providing real-time data on attractions, flight dynamics and tourism product reservations; ② visitor feedback, analysing overall sentiments and evaluations based on factors such as hotels, products, safety and weather; and ③ employment statistics of the local tourism industry, covering sectors such as accommodation services, dining services, tourism management and tourism product reservations.

Based on the data monitoring, Seville has adopted two major strategies to optimize tourism: ① designing diversified tourist routes to guide visitors away from crowded areas, encouraging tourism develop-

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1　Seville Tourism Intelligence System (SIT). [EB/OL]. [2025-7-1]. Available at https://smart.sevillacityoffice.es/en/sistema-de-inteligencia-turistica/.

Source: Visitor perception and behaviour [EB/OL]. [2025−7−1]. Available at https://smart.sevillacityoffice.es/en/sit/visitor−perception−and−behaviour/.

Figure 6−5　Tourists perceptions regarding hotels, products, safety, and climate
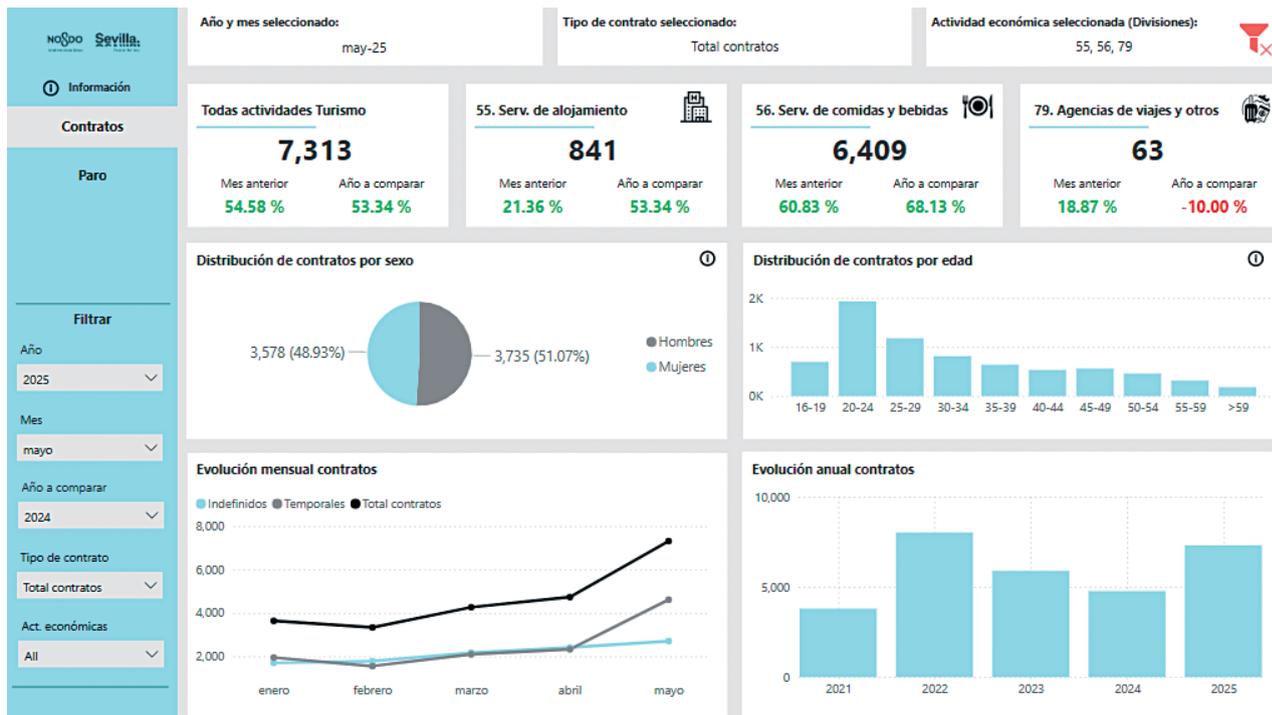


Source: Seville Smart Tourism Office. Available at https://smart.sevillacityoffice.es/en/.

Figure 6−6　Data on accommodation, dining and travel agency activities

ment in other parts of the city, such as the northern region, Macarena, Nervión and Triana. This strategy not only improves residents' quality of life but also allows tourists to enjoy world-renowned attractions in a more relaxed and pleasant environment or to explore the "lesser-known" Seville for a unique, personalized experience; and ② enhancing accessible tourism services. Seville has launched the Smart Accessible Tourism Activities programme using data to reasonably plan accessible routes between neighbourhoods and offer free services via an "accessibility app" for both residents and tourists. This initiative enhances the travel experience for all groups by providing convenient services enabled by technology.

**3. Incubating Sustainable Tourism Innovation**

Seville has established Smartspace,[1] an incubation platform designed to foster smart and sustainable urban tourism innovation and entrepreneurship. This platform provides physical spaces and regularly hosts entrepreneurial and training activities. Additionally, it leverages data generated by the Smart Tourism Monitoring System to offer data support and innovation guidance to tourism practitioners, businesses and startup teams, helping facilitate the development and implementation of sustainable tourism projects, see Figure 6-7.

In its daily operations, Smartspace organizes various training and exchange activities focused on sustainable urban tourism, such as lectures and roundtable discussions. These events continuously provide practitioners with opportunities to share practical

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1 Smartspace [EB/OL]. [2025-7-1]. Available at https://smart.sevil-lacityoffice.es/en/smartspace/.

experiences and explore cutting-edge ideas. For example, in December 2022, the Seville Smart Tourism Office hosted a specialized training session on Sustainable Tourism and Tourism Intelligence Systems at Smartspace. During the session, Dr. Xavier Font, a professor of sustainable tourism marketing at the University of Surrey in the United Kingdom, used a variety of practical case studies to explain, from the perspective of sustainable development marketing and communication, how to effectively design and promote sustainable tourism activities to help tourism enterprises and destination managers enhance their service quality and competitiveness.

The Smartspace platform also provides training on data and systematic data analysis for innovators, entrepreneurs and tourism enterprises by introducing and demonstrating Seville's Smart Tourism Monitoring System. The training includes an introduction to the system's functions, methods for data reading and filtering, as well as practical applications of data in business strategy development and decision-making, helping participants better utilize data to incubate new entrepreneurial projects, develop innovative tourism products and enhance their market competitiveness. To encourage innovators and entrepreneurs to incubate more sustainable tourism projects, the Smart Tourism Monitoring System has introduced the "Tourism Sustainability Index", which includes multiple sub-indicators designed to help startup teams assess the sustainability of their projects, such as the Tourism Revenue Distribution Index, Carbon Emissions Index, Tourism Supply Concentration Index, Tourism Sustainability Perception Index and Moti-
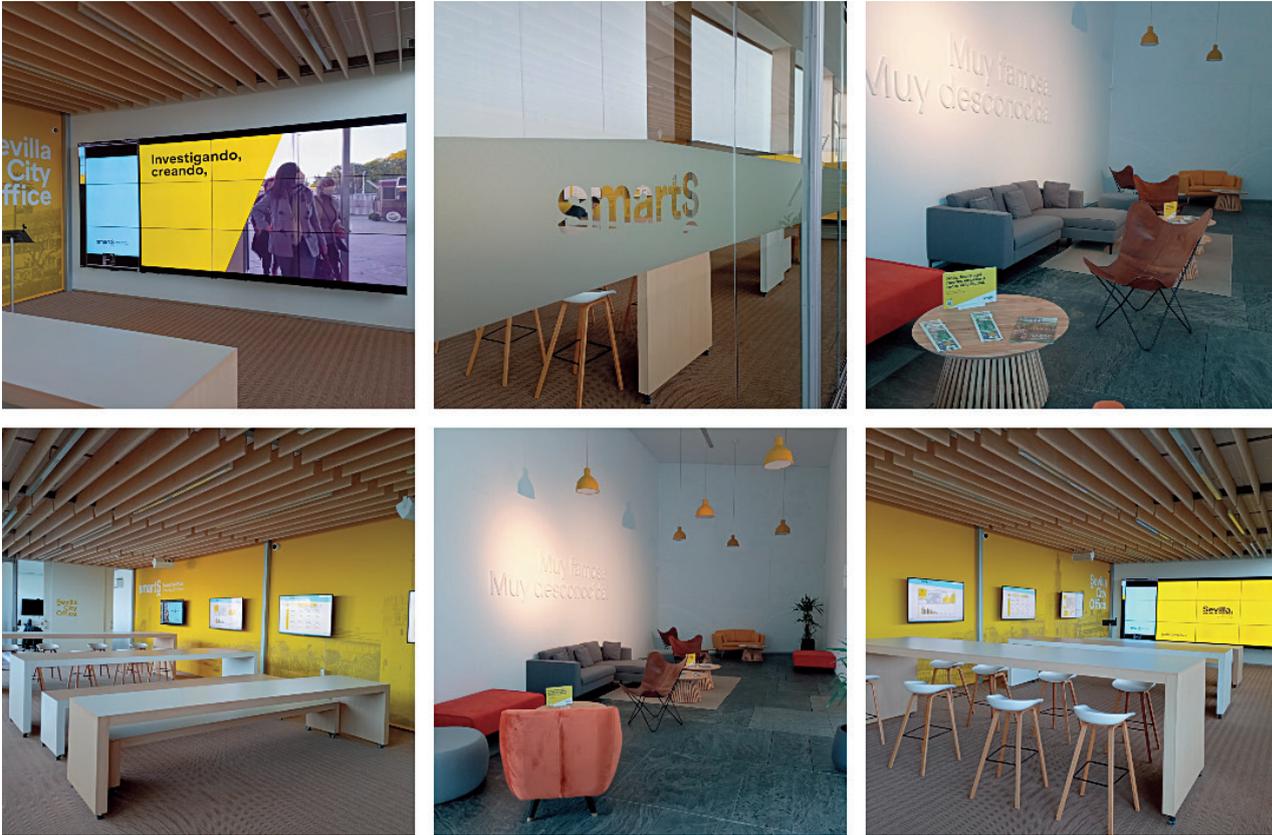
Source: Seville Smart Tourism Office. https://smart.sevillacityoffice.es/en/smartspace/.

Figure 6-7　Interior view of Smartspace

vation Diversification Index which measures a destination's ability to attract tourists through a variety of tourism motivations. A more diversified set of motivations helps reduce dependence on a single tourism resource, thereby lowering pressure on popular spots.

## Reference Experiences

The practice of Seville's smart tourism strategy shows that the smart transformation of a historical and cultural city should not merely rely on simple technological accumulation. Instead, on the basis of respecting cultural inheritance, it is necessary to comprehensively build a sustainable development system that combines cultural brand building, green

technology application and experiential design. Ultimately, this system serves three purposes: enhancing the resilience of urban culture; strengthening citizens' cultural identity; and fostering sustainable cultural industries. These three dimensions together form the core support for historical cities to preserve their cultural essence and achieve long-term development in the process of smartification.

**1. Integrated Digital Technology Supports the Development of Cultural Resilience**

The Smart Tourism Office has deeply integrated digital technologies into cultural preservation and tourism management, building a solid technological barrier for the city's cultural resilience. Popular cul-

tural heritage sites, as the core carriers of the city's culture, are also the destinations most vulnerable to the impact of excessive tourism. The big data platform can accurately predict peak passenger flows at different times by collecting real-time data such as tourists' locations, stay durations and reservation information. When the data shows that the number of tourists is approaching the capacity limit of a cultural heritage site, the AI system will immediately trigger an early warning, and push diversion suggestions through smart guide apps and scenic area electronic screens to guide tourists to cultural experience spots in another location. This model has effectively prevented cultural heritage from wear and aging due to overuse, and also avoided the disruption of the cultural experience atmosphere caused by concentrated tourist flows, enabling the urban cultural system to maintain stable operation even under the high pressure of the tourist season.

Furthermore, the integration of tourism services with the citizen card/near field communication payment system promoted by the Smart Tourism Office has also provided an application scenario for cultural innovation. The citizen card can not only be used for public transportation and daily consumption, but also serves as an experience portal for culturally innovative products. Residents can use the citizen card to participate in free cultural experience programmes developed by laboratories, while tourists can purchase relevant products at a discount. This combination of livelihood services and cultural innovation allows the achievements of cultural innovation to serve both tourists and benefit residents, expanding the audience

group. It further enhances the innovation capability and adaptability of the cultural system, providing a sustainable source of motivation for cultural resilience.

**2. Smart Monitoring Technology Establishes a Co-governance Network in Cultural Development**

Seville's smart monitoring system has established a multi-stakeholder co-governance platform through data sharing and demand response, enabling scenic area managers, tourists and residents to form a synergy in cultural preservation and tourism development.

For managers, the accurate data provided by the system serves as a core basis for scientific decision-making. By analysing data such as tourist flow and experience feedback, managers can optimize the layout of tourism facilities (e.g., adding cultural interpretation signs and rest stops in diversion areas) and adjust the arrangement of cultural activities (e.g., organizing traditional cultural festivals to attract tourists during the off-peak season). This ensures that policies for cultural preservation and tourism development are more in line with actual needs, considered holistically and improving management efficiency.

For tourists, personalized travel recommendations and real-time passenger flow information allow them to avoid crowded areas and enjoy a more comfortable and in-depth cultural experience. Such high-quality experiences enhance the tourists' sense of identity and respect for Seville's culture, prompting them to consciously abide by cultural heritage protection regulations and reduce the potential damage of tourism activities to the cultural system.

For residents, the rational diversion of tourists eases the living pressure in historical urban areas and restores the peaceful atmosphere of communities. At the same time, the tourism income brought by diverse cultural experiences allows residents to feel the direct benefits of cultural preservation and tourism development, stimulating their enthusiasm for participating in cultural inheritance and community governance.

**3. Developing an Innovation Incubation Platform for Cultivating the Sustainable Tourism Industry**

By establishing the Smartspace, a multifunctional platform integrating startup incubation, professional training and collaborative co-creation, Seville not only provides data support, innovation guidance and capacity-building training for sustainable tourism projects but also plays a key role in expanding the urban cultural economy, activating multi-stakeholder participation and transforming the value of cultural heritage.

On the one hand, it opens up data such as the conservation status of cultural heritage and tourist experience feedback to platform participants, helping them develop innovative projects that combine both conservation significance and experiential value. On the other hand, through an online collaboration module, it invites stakeholders including citizens, cultural scholars and industry associations to participate in project design and evaluation, ensuring that tourism development is more aligned with the city's cultural characteristics and residents' needs.

Targeting diverse entities such as tourism enterprises, startup teams, local businesses and cultural heritage inheritors, the platform organizes customized training and exchange activities covering themes like marketing communication, service innovation, product design and cultural heritage activation. This not only helps practitioners accurately grasp market trends and enhance the cultural connotation and market adaptability of tourism products but also provides professional guidance for citizens to engage in tourism entrepreneurship and cultural inheritance. It encourages them to transform local life culture and traditional craftsmanship into distinctive tourism products, effectively expanding the scale of the urban cultural economy.

## Suzhou, China Digital Technology Revitalizing the Millennium-old City[1]

### Case Background

Suzhou was founded on its present-day location over 2,500 years ago. One of the historic water towns, it is known for its traditional landscape and urban layout of bridges, rivers and canals. In 1982, Suzhou was designated as a National Famous Historical and Cultural City due to its unusual wealth of cultural relics of great historical value and significance.

Gusu District is one of five urban areas and the main district of Suzhou. It was created in 2012 through the merger of three former districts — Canglang, Jinling and Pingjiang. Gusu is the ancient

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1   This case study was recommended by the Ministry of Housing and Urban-Rural Development of the People's Republic of China, with material support provided by the Data Bureau of Gusu District, Suzhou.

Source: Data Bureau of Gusu District, Suzhou.

Figure 6–8    The ancient city, Gusu District

name for Suzhou, "A carrier of history of Jiangnan water towns." The ancient city in Gusu District spans 14.2 square kilometres, encompassing 54 traditional neighbourhoods preserving an abundance of historical buildings, ancient wells, trees and other valuable relics. Among these are nine classical gardens including the Humble Administrator's Garden, the Lingering Garden and the Master of the Nets Garden, which were added to the UNESCO World Heritage List in 2000 because of their unique historical and cultural significance, and artistic value.

The ancient city, as shown in Figure 6-8, has a profound cultural heritage but is faced with multiple challenges in efforts to protect it which reflect practical difficulties in cultural governance. The ancient city contains examples of historical significance which are vast in quantity, dispersed in source and difficult to record systematically and to unified data standards. This data fragmentation not only restricts residents' ability to access information and participate in governance but also hinders public recognition of the city's diverse cultural values. Property ownership within the ancient city is complex with a diverse demographic structure comprising original residents, external tenants, tradespeople, administrators and tourists, and an aging population comprising up to

34.04 per cent.[1] Due to frequent flows of migration throughout its long history, some houses have unclear property rights leading to potential disputes. The sheer number of historic buildings within the ancient city also leads to burdensome ongoing maintenance and repairs. Their economic vitality has not been fully released and revitalization mainly relies on government initiatives, with limited participation from social forces. This not only restricts the development of a multi-stakeholder cultural governance framework, but also undermines the accumulation of social capital for urban governance.

Given the immense historical value, complex spatial elements and diverse population, an effective approach for the preservation and revitalization of cultural heritage has been to employ digital technology to aggregate the vast amounts of data into a unified digital twin city model which can be used for planning, construction and management. The Gusu District Urban Information Model + Digital Twin of Ancient City platform project was one of 50 projects showcased by Digital China winning the Gold Award for Chinese Geospatial Industry and Science. The project not only demonstrated the use of digital technology to achieve the digital preservation, protection, maintenance and exhibition of cultural heritage data but also showcases a new model for digital preservation with multi-party participation, which provides an innovative path for exploring the coordinated de-

velopment of cultural heritage protection and public welfare.

### Implementation Process

Led by the government, Gusu District established a unified and authoritative open data foundation, achieving the integration of cross-departmental and multi-type data. This foundation has broken down information silos among various departments, fostering collaboration among stakeholders in the scientific conservation of cultural heritage. The diverse presentations and applications built on this platform have not only improved accessibility to culture but also significantly enriched the pathways and substance of heritage revitalization.

**1. Mapping Heritage to Aid the Development of a Digital Twin of the Ancient City**

In 2018, the Gusu District Ancient City Protection Committee planned to create the first ancient city protection information platform in the country, aiming to organize the ancient city's data into a single system. In 2019, the committee conducted the first comprehensive data collection on 19 categories of protected objects, establishing an initial catalogue in a point-based distribution.[2] In December 2020, it launched the Ancient City Cellular Dissection Project, China's first investigation concept of its kind, which treats various buildings and structures as "cells" that constitute the ancient city and aims for a comprehensive and all-encompassing in-depth survey of the protected objects and historical remnants of the an-

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1　As of the end of 2024, the registered population aged 60 and above in Gusu District was 255,400, with an aging rate of 34.04% (the second highest in Suzhou). The registered population aged 80 and above was 46,200 with a high-aging rate of 18.09% (the highest in Suzhou).

2　Wang Yongfa, Qi Yating. Ancient City Cellular Dissection Project [J]. Architectural Practice, 2022 (8): 88-93.

Source: Data Bureau of Gusu District, Suzhou.

Figure 6−9    The Ancient City Cellular
Dissection Project 3D laser scanning operation,
real scene and scan images

cient city's neighbourhoods. The survey team, comprised of approximately 100 professionals from fields such as ancient architecture, urban planning, history, geography and surveying, also included local dialect-speaking team members and community staff.[1] The team primarily focused on historic buildings for residential purposes and collected information on protected objects, carried out case studies on historical courtyards, explored important cultural resources and established comprehensive information archives for each neighbourhood covering more than 95 per cent of households. Team members used tools such as laser scanners, as shown in Figure 6-9, and drones, see Figure 6-10, to carry out mapping and 3D model building. Local residents fully engaged with oral history collection during home visits, sharing their family archives for digital scanning. This inclusive cultural involvement has not only enriched the historical records but also helped create a shared cultural memory, strengthening community identity and fostering a collective sense of heritage preservation.

With the growth of CIM technology, the development of a unified base map supporting the district's business systems became crucial for better utilizing the results of the Ancient City Cellular Dissection Project. In October 2021, the Data Bureau of Gusu District together with the Gusu Branch of Suzhou Natural Resources and Planning Bureau, launched the CIM + Digital Twin of Ancient City platform (see Figure 6-11) with the development of a unified data standard and the release of platform construction

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1   Liu Chun, Bai Xue. Cell-Level Protection Makes Ancient Buildings "Come Alive" [N]. Xinhua Daily, 2024-6-21 (5).



Source: Data Bureau of Gusu District, Suzhou.

Figure 6–10   Ancient City Cellular Dissection Project drone collecting spatial information

guidelines, and data update and sharing regulations, intending to integrate vertical (various levels) and horizontal (cross-departmental) data and resources. The platform used drone oblique photogrammetry, mobile measurement systems and 3D panoramic technologies to create a high-resolution oblique 3D real-world model covering the entire Gusu District, with a resolution of up to 3 cm. During the process, a multi-scale collaborative approach was adopted, modelling the neighbourhoods, ancient buildings and other important objects at macro, meso and micro levels according to different precision requirements to improve modelling efficiency and resource benefits.

The result is a comprehensive digital platform that demonstrates the historical and cultural heritage of the ancient city. The platform consisting of high-precision, city-level 3D models, contains comprehensive data including historical images of the ancient city, 438 cultural relics and buildings, 204 3D models of ancient buildings, 77 pieces of audiovisual material on intangible cultural heritage and other key elements using descriptive attributes, survey infor-

Source: Data Bureau of Gusu District, Suzhou.

Figure 6−11    Gusu District's CIM + Digital Twin of Ancient City platform

mation, protection areas, VR panoramas, 3D models, frequency profiles and related promotional materials. In addition, the platform provides unified geographic coding, spatial coordinate conversion and other common components. To date, the platform has facilitated the sharing and usage of data from 6 major categories and 268 subcategories across city and district levels, supporting 17 departmental applications. Relevant data and components are accessed over 20,000 times daily and extensively applied in key areas such as protection, planning, construction and management.

**2. Using Digital Monitoring and Multi-stakeholder Collaboration to Safeguard Historic Heritage**

Based on a detailed and comprehensive ancient city database and a platform featuring the high-precision digital twin model, an effective cross-department data-sharing mechanism has been established, breaking down the information barriers between multiple departments such as cultural tourism, emergency response, urban management and housing construction which enables cross-department data interoperability and shared utilization. Multiple stakeholders can now collaboratively carry out data-supported, full-cycle maintenance of the ancient city, promoting safe preservation and heritage renewal.

This in depth integration of digital technology has enhanced the precision of cultural heritage protection. In terms of restoration, taking the classical gardens of Suzhou as an example, elements such as flower windows, pavements and street furnishings have been noted with millimetre-level precision and are regularly checked and updated, creating a refined

dynamic database. The database, for example, can be used by garden protection personnel to conduct dynamic monitoring, ensuring timely and targeted maintenance and restoration. Every step of the restoration process is digitally captured, archived and stored in the database, providing authoritative evidence for future "restore as original" projects.[1] In terms of the management of building restoration projects, three-dimensional rendering of approval, construction and completion stages visualizes project management information with accuracy, improving restoration efficiency.

The platform's data monitoring and EWS, in its interaction with multiple parties including the government and residents, improves the efficiency of building maintenance for safety purposes. Most of the ancient buildings in Gusu District are wooden structures which have weathered over time, requiring special attention for fire prevention, flood control and structural safety. These buildings are equipped with dynamic IoT monitoring systems that track tilt, subsidence, temperature and other conditions in real time. If anomalies occur, the platform sends early warning information to the relevant management personnel's mobile phones and also sends alerts to residents. Community staff or grid officers, upon receiving work orders through the platform, will immediately check the site. Residents can also use their mobile phones to provide real-time feedback on potential risks to buildings or damage to intangible cultural heritage, forming a collaborative mechanism

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1　Wang Weijian. Digital Life of Gardens in Suzhou [N]. People's Daily, June 9, 2025 (12).

for the protection of the entire community.

The platform's multi-temporal display also enhances the scientific decision-making process for the continuation and renewal of the city's landscape. Urban management and planning departments can view historical models of the city, tracing its past appearance, monitoring current data like pedestrian and vehicle traffic, identifying potential for future land development and making site selection decisions, as shown in Figure 6-12. Through repeatable simulations and scenario analysis, future renewal plans can be evaluated and optimized, reducing the impact on architectural heritage. For example, in the planning and design of Jianjinqiao Alley, the design plan was integrated into the digital twin model, preliminary evaluations were conducted, and virtual and real integration for future scenario analysis was performed, effectively reducing the cost of trial and error in planning, see Figure 6-13.

**3. Integrating Digital Tools to Drive Cultural Renewal and Tourism Growth**

The platform fully showcases the cultural value of the city through high-precision 3D models and data, effectively spreading diverse cultural assets to both local and remote audiences, and accurately guiding social capital to recognize the investment prospects of city plots and participation in revitalization and development. Data, once standardized, is listed on the Suzhou Big Data Exchange as special digital products allowing businesses or individuals to purchase it with authorized access and apply the information to a wider range of scenarios. The platform's commitment to openly sharing its achievements has

Source: Data Bureau of Gusu District, Suzhou.

Figure 6–12    Using the CIM + Digital Twin of Ancient City platform—land potential evaluation and site selection



Source: Data Bureau of Gusu District, Suzhou.

Figure 6–13    Using the CIM + Digital Twin of Ancient City platform—future design scenario simulation

Source: Data Bureau of Gusu District, Suzhou.

Figure 6–14　The former Bei family home in Jingwenli renovated into a boutique hotel

vigorously propelled the diversification and upgrading of the city's business landscape, fuelled the growth of sustainable cultural industries and broadened the platform's application fields.

With the assistance of the platform, Gusu District has identified ancient buildings and old houses which have potential for revitalization. In 2023, the district launched the Ancient City Protection and Revitalization Partnership Programme, leveraging the Suzhou Public Resource Trading Platform and the Gusu District "Huigusu" App to promote old houses and attract social forces to participate in the renovation, revitalization and infusion of new industrial formats and urban functions. By July 2025, 121 old houses had been rejuvenated with the focus primarily on headquarters offices, boutique hotels and cultural creativity. For example, developer Vanke turned the old Bei family home in Jingwenli into a boutique hotel, preserving the brick-carved gateway and traditional hall layout, see Figure 6-14. This has supported the cultural tourism industry, promoting a new economic engine. And the century-old brand Laowannian renovated the old Chen family home in Niujiaxiang

into the first gold-themed museum in the Jiangnan water towns, showcasing its long history and the aesthetics of Suzhou's classical gardens.

Digital technology also enriches the off-line tourism experience. Based on laser beam scanning, AR and other digital technologies, a new interactive experience mode combining online + offline virtual and real elements have been created. For example, the Jiuxiang at Pingjiang Fun Walk combines cultural exploration, interactive experiences and consumer scenarios. Participants scan QR codes with their mobile phones to enter a mini-programme where they engage in location-based treasure hunts and challenges along Pingjiang Road.[1] Digital lighting, drones and other technologies have also been used to reshape scenic area experiences. For instance, Tiger Hill used projections, lights, performances by 300 drones and 3D mapping tower shadow shows to create a night-time project, providing tourists with an immersive light

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1　Hu Yuqing. "Fun Walk! A New Digital Play for Young People to Explore the Ancient City" [EB/OL]. (2024-7-27) [2025-6-10]. Available at https://news.2500sz.com/doc/2024/07/27/1097051.shtml.

Source: Tiger Hill Scenic Area.

Figure 6–15   Tiger Hill Night Tour Project

and shadow show, see Figure 6-15.[1] VR interactive technology has been applied to innovate scene experiences such as Dreaming in the Humble Administrator's Garden, a VR immersive journey through paintings project in which tourists wear a VR headset and sit in a custom-designed six-axis dynamic palanquin to interact through virtual role play, see Figure 6-16.[2]

Online tourists can also experience rich cultural activities through digital technology. Immersive remote tours allow visitors – without being there in person – to explore gardens such as the Humble Administrator's Garden and the Master of Nets Garden with 720° high-definition panoramic 3D views, as shown in Figure 6-17, gaining understanding of the historical changes in the ancient city, traditional courtyards and architectural culture, see Figure 6-18. Game-style tours allow players to view the city's scenery, learn about cultural history and participate in community activities through the mobile game Virtual Tour in Suzhou, see Figure 6-19. Cultural assets have been transformed into unique digital collectibles through

1   Zhang Ya. "Tonight, Tiger Hill Opens Night Tour for the First Time!" [EB/OL]. (2022-8-9)[2025-6-10]. Available at https://mp.weixin.qq.com/s?__biz=MjM5OTUwMjY4MQ== &mid=2650085725&idx=1&sn=ca5b118701860e1b66d63e19f-116d473&chksm=bf3bcf6b884c467d637896e5319f4dd0873 4d711c42f802a9177617d01bcee1ec2fc7b5f410c&scene=27.

2   Wang Jiankang. "Dreaming Through Time, The Metaverse Revives Garden Culture" [EB/OL]. (2022-7-28) [2025-6-10]. Available at https://www.thepaper.cn/newsDetail_forward_19210927.

Source: The Paper.

Figure 6–16　Dreaming in the Humble Administrator's Garden: a VR immersive journey through paintings
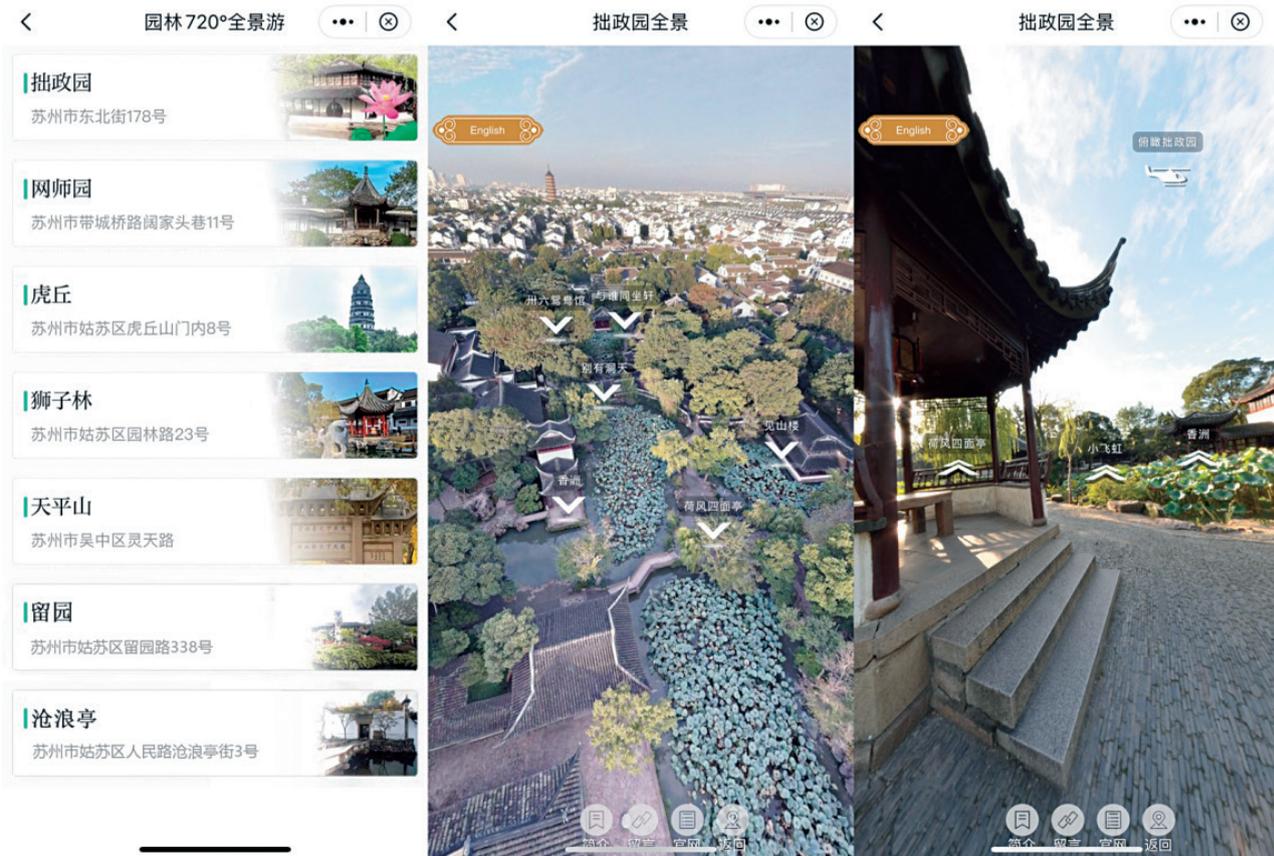


Source: Suzhoudao App.

Figure 6–17　A 720° panoramic tour of the gardens of Suzhou
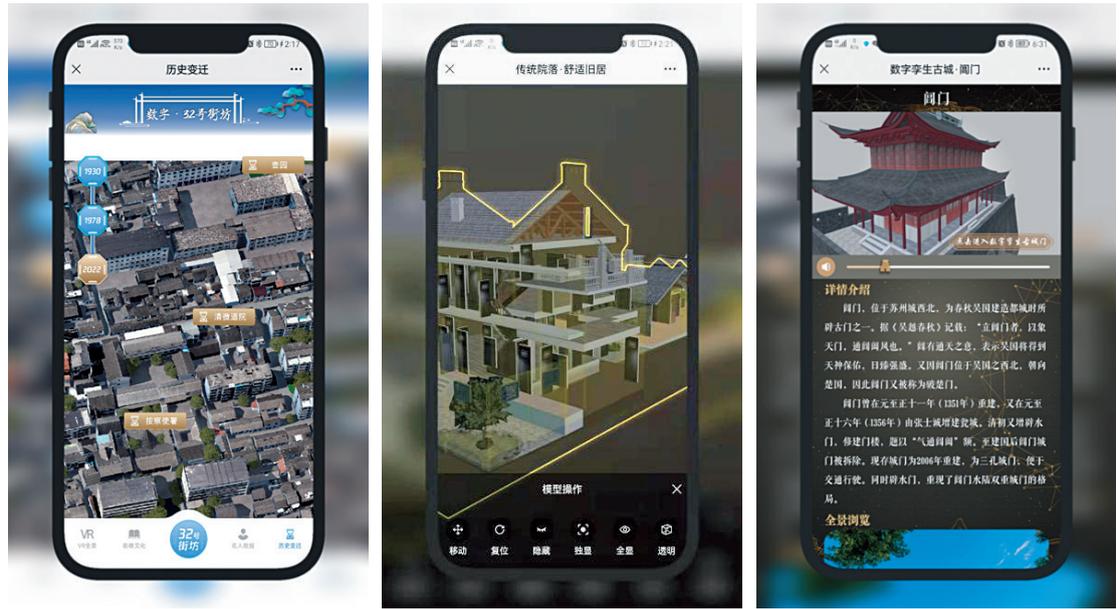
Source: Data Bureau of Gusu District, Suzhou.

Figure 6–18    Historical changes, traditional courtyards and the city gates of Suzhou neighbourhood No. 32



Source: Virtual Tour in Suzhou mobile game.

Figure 6–19    Virtual Tour of Suzhou experience

blockchain technology. The Humble Administrator's Garden, for example, launched a series of digital collectibles titled The Exquisite Humble Administrator's Garden, encouraging collectors and cultural enthusiasts to purchase them all. Innovative publicity via digital "humans", such as the digital persona Suxiaomei, connects local scenic spots, commercial complexes and intangible cultural heritage inheritors through the Suxiaomei Takes You to Explore Suzhou activities. In addition, popular short dramas, promotional videos of new-style cultural tourism and AI-generated content activities, taking viewers on a tour to explore the cultural life of the city, have been created.

## Reference Experiences

Digital technology, multi-stakeholder participation and open platforms are becoming a key path in addressing traditional challenges in the protection and sustainable development of cultural heritage in ancient cities. Suzhou is a great example: the local government has placed high importance on digital technology, with substantial resources invested to promote the construction of a digital twin city, laying a solid foundation for subsequent efforts. This has effectively mobilized various government departments and societal forces for collaborative participation in the development of heritage protection and revitalization applications, further extending historical continuity and stimulating regional economic vitality.

**1. Establishing Comprehensive Digital Twin Models with Unified Standards and Precise Cultural Asset Identification**

Firstly, a thorough investigation of cultural assets was conducted. Various historical elements and cultural anecdotes were documented, leading to the establishment of a complete and standardized database that enables the precise identification and value of cultural heritage, thus laying a data foundation for future asset revitalization. Secondly, a long-term mechanism for the periodic protection of cultural relics was developed where dynamic monitoring tools are used to continuously track their status including data updates and maintenance. Dynamic restoration of cultural relics and building repairs are also recorded and uploaded, providing traceable foundations for future conservation and restoration. These approaches have empowered cultural assets in scientific decision-making, integrating diverse perspectives to foster inclusive preservation and supporting community engagement to strengthen residents' connection to cultural history.

The creation of a digital twin city platform requires high investment and a long construction period, placing significant pressure on the initial human and material resource inputs. Governments can attract social capital cooperation by promoting the value of cultural heritage and, depending on its resources, prioritize key relics and small-scale areas.

Data aggregation is a separate challenge, as cultural heritage may span multiple administrative districts with various data types coming from different departments, making it difficult to standardize and integrate comprehensively. This requires a highly effective action team to establish unified data standards, coordinating and breaking down barriers between departments to lay a solid foundation for subsequent applications.

**2. Digital Empowerment for Multi-stakeholder Participation in the Preservation, Revitalization and Utilization of the Ancient City**

With data gathered across the region and high-precision virtual models built on a unified platform, guiding and empowering societal participation can effectively assist in more precise and scientific protection of buildings, revitalization and more diverse cultural tourism experiences and cultural dissemination, while also generating economic value. IoT sensing devices enable real-time monitoring of the ancient city's safety status. Biologically-inspired simulation and analysis technologies make the decision-making process more intuitive and scientific, thereby promoting more accurate investment planning and more efficient development and utilization models. With regard to the revitalization and industry upgrading of historical houses based on an analysis of the value of cultural heritage, suitable partners and capital forces were introduced to promote industrial iteration and upgrading from a market perspective, transforming cultural resources into development momentum.

In terms of cultural experience and publicity, artificial reality, VR and other digital technologies were proactively integrated to create a rich and diverse range of cultural tourism experiences. By building gamified interactions and digital light and shadow scenes in the ancient city, visitors can experience its cultural charm in an immersive way. Leveraging digital technology to present relevant historical materials and layering historical scenes across multiple times and spaces can significantly enhance visitors' under-

standing of the rich cultural connotations. Additionally, a digital platform can overcome physical space limitations, enabling remote presentations through digital formats such as games and short dramas, thus satisfying the in-depth experience needs of online users and effectively expanding the reach and influence of ancient city culture.

**3. Building an Open Digital Co-creation System to Stimulate Data Flow and Cultural Value Creation**

Building an open and shared system that promotes the orderly flow of data and co-creation of value is a key step in unlocking the potential of digital technology. For one thing, the participation of various stakeholders — residents, visitors and managers — in co-constructing the cultural heritage platform is encouraged. These stakeholders can use convenient interfaces to provide feedback on issues related to the protection of the ancient city's cultural heritage, and even extensively engage in the decision-making process for the city's renewal and protection. This co-creation model not only enriches the data sources but also allows for further in-depth analysis of the flow of data within the process. The full recording of the data flow provides clear and traceable evidence for the protection, management and operation of the ancient city.

Promoting the sharing and utilization of the platform helps spread the ancient city's cultural resources and data information widely through online channels, accelerating the revitalization and utilization of cultural heritage. The clear and vivid presentation of resources effectively attracts market investors to participate, helping the ancient city gain sustainable

economic and social benefits from its rich cultural resources. Historical and cultural conservationists can also use the data to select better maintenance techniques for protecting cultural heritage, while residents and visitors can be more deeply involved in the protection and inheritance of cultural heritage. The data owned and circulated by the platform can be considered as digital assets, with those of higher cultural value being developed into digital products for sale. The resulting revenue can be reinvested locally, providing long-term financial support for the continued protection and development of cultural heritage, thus forming a positive, sustainable development loop.

## Ghent, Belgium
## Collections of Ghent-digitized Cultural Heritage for Cultural Participation and Social Cohesion

### Case Background

The emergence of digital cultural collections has gained traction across many European cities, however, they often lack the tools to fully engage citizens in cultural data. Data is largely stuck within international silos or used on single-purpose digital platforms that fail to reach new audiences due to a lack of open infrastructure. Citizens also possess fewer means to contribute and participate in the creation of digital heritage presented within cultural institutions, yet it remains a critical component to strengthen social cohesion and forge a sense of belonging within cities and communities. Popular history, grassroots knowledge and successive flows of migration also tend to be missing in territories' cultural heritage. Coupled with this, the digitization of cultural data in progress across museum libraries and other cultural institutions struggles to be appropriated and reused by citizens, while a lack of common approaches between cultural institutions of open and accessible platforms stifles the potential to reach out to new and larger parts of the population. The digitalization of cultural data presents an opportunity to tap cultural capital from those institutional silos in which it is currently kept, making it readily available for citizens while unlocking new possibilities for its reuse and creative combination. Digitalization processes hold significant potential in opening up, connecting and organizing the richness and diversity of both tangible and intangible vernacular culture from urban populations themselves, thus enhancing social cohesion and inclusion.

To address these challenges and merge social cohesion and inclusion through digital culture, the Collections of Ghent (CoGhent) project was launched in June 2020. Drawing on the potential for digitalization to stimulate open access to cultural heritage, it was created to aid the transition of cultural heritage institutions into places of community sense making, working to repurpose digitized and digital born cultural heritage data to support its dissemination, reuse and recombination. To enrich and complete a city-wide repository of cultural heritage data, it converged the contribution of different local communities with stories and artefacts. In creating a multi-voiced platform, the project worked to promote social cohesion within the city via a more open, accessible, rich, diverse and representative digital cultural heritage. The project's

aim was to connect citizen-sourced cultural heritage and collections within the city's museums through a central open data system, seeking to strengthen cultural participation and social cohesion in public third spaces. By connecting heritage at city level and using it to capture and highlight stories in cultural public spaces, it sought to innovatively leverage digitized heritage to build shared connections among urban citizens.

## Implementation Process

CoGhent was conceived as a comprehensive, systemic innovation project by Ghent University, the City of Ghent and its museums and archives along with partners from the corporate and cultural world. It was developed in line with the European Union European Regional Development Fund policy objectives centred on open digital innovation, open cultural access, e-inclusion, community-based cultural services and education as well as corresponding technological, social and participatory objectives at national, regional and local levels. It was designed to not only facilitate the repurposing of cultural heritage data, but to also encourage self-contribution from local citizens to revitalize and complete cultural heritage preserved and shared via cultural institutions. Consequently, it was based on two parallel tracks including top-down technological development to make digitally available collections from the city's five cultural institutions, and bottom-up means via citizen participation. Accordingly, it focused on making institutional collections searchable and available online as primarily open heritage data with the aim of digitizing around

100,000 artefacts, stories and documents by June 2023.

As a European Union funded innovation project, a budget of USD 6 million was allocated by the Flemish government and the European Regional Development Fund through the Urban Innovative Actions initiative.[1] A co-creation fund was also set up to stimulate the creative reuse of digitized cultural mediation applications based on the data and digital reproduction published by the CoGhent project. A total of EUR 200,000 was provided with each individual project afforded a maximum of EUR 20,000 each. This helped to ensure that recipients could go beyond prototype development and transform ideas into usable solutions over six months to a year via workshops, meetups and expert support.

**1. Developing Decentralized Data Architecture**

Under CoGhent, the collections of the participating city cultural heritage institutions (Ghent Archives, Design Museum Ghent, Huis van Alijn, Industry Museum Ghent and the Ghent City Museum ) were conglomerated on a technical level. At the preliminary stage of the initiative, open-ended, digital infrastructure was developed from 2020–2021 to enable more streamlined and wider access to institutional culture heritage. As city-wide architecture, it was created to deploy, study, crowdsource, collect, connect and interact with cultural heritage to ultimately enable data sharing, facilitate development and unlock more innovation. In regard to technical design, it focused on the

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1    Eurocities. (2023). Uncovering stories: uniting communities. Available at https://eurocities.eu/stories/uncovering-stories-uniting-communities/ (Accessed: 28/7/2025).

publication and synchronization of data at its source to simplify third party and internal reuse of published data. It was built upon Linked Open Data principles including Linked Data Event Streams (LDES) in order to publish metadata from multiple institutions. This enabled update harvesting, metadata interoperability and the provision of SPARQL language and protocol endpoints for querying. Metadata was also harmonized across the city's five heritage institutions and published under Linked Open Data standards. An LDES API was integrated to allow control over their own data publishing and management for each cultural heritage institution, see Figure 6-20.

The project was also an early adopter of OSLO, a Flemish application protocol that uses international standards to make the data interoperable on a semantic level. This led to the production of data streams linked to external data sources connected to five international sources (RKD, ULAN, AAT, TGN and Wiki-Data) and two Flemish sources (Inventaris Onroerend Erfgoed and Kunstenpunt). Technical architecture also included a decentralized microservice-based system which allowed LDES to be ingested by enriching heritage imagery with metadata concerning the object, and enabled images to be opened up under the International Image Interoperability Framework for image display, as shown in Figure 6-21. It also enabled the use of semantic standards to improve searchability and platform interoperability across content sources.

Alongside the deployment of data infrastructure, project partner iDROPS created a cultural participation toolkit to help mobilize residents and professionals alike. It was created as an adaptable and accessi-
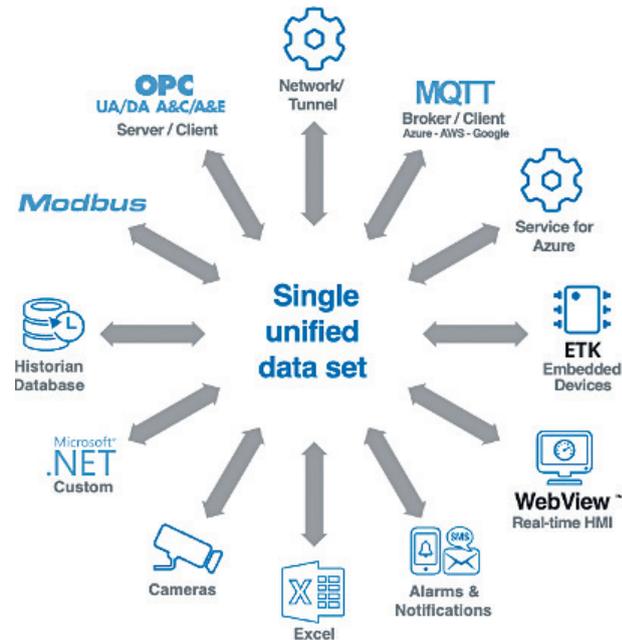


Source: Cogent DataHub™. (n.d.) The Cogent DataHub™ Architecture. Available at https://cogentdatahub.com/connect/architecture/ (Accessed: 3/8/2025).

Figure 6–20　Schematic of the internal CoGhent datahub architecture allowing for single, unified datasets

ble source of inspiration, and a simple structure for developing participatory cultural heritage projects. It was also designed to engage diverse target groups and fit the unique dynamics of different neighbourhoods, serving as a living document continuously refined through resident feedback and heritage expertise. It thus represented a first major step toward collaborative heritage initiatives.

**2. Creating a Cultural Data Hub**

A cultural data lab was established as a physical hub in De Krook library to connect project partners including businesses, research and government institutions with cultural communities. It was set up as an open space for technology testing to experiment and engage technical open data communities and encourage the reuse of heritage data at the city level.

Source: screenshot from the Collections of Ghent promotion movie.

Figure 6–21    Illustration of the interconnections between different cultural data items enabled by the CoGhent technological infrastructure

Following a needs assessment regarding data in the city's heritage museums and institutions, it launched creative events including talks, workshops and hackathons, see Figure 6-22.

A hackathon Hack the box was organized on 15 October 2022 with 137 participants, largely students and companies specializing in technical fields, and individuals with expertise in product design and cul-



Source: Urban Innovative Actions. (2023). Next CoGhent: Searching for CoGhent's follow−up scenarios. Available at https://www.uia−initiative.eu/en/pdf/3024 (Accessed: 3/8/2025).

Figure 6–22    Workshop development: sub−groups discuss the directions of possible evolution for Ghent's museums

Source: Collectie van de Gentenaar. (n.d.) O6.4.1–Cultural Data Lab Framework.

Figure 6–23　Hackathon participants work in teams on specific challenges

tural studies, along with 31 visitors, see Figure 6-23.[1] Participating teams were challenged to design prototypes of new products and services, built upon the assets developed in the CoGhent project. Twenty-eight novel solutions were generated including: conceptual design for an AR application to follow stories and objects on an aerial map; a table-based tangible interface that allows users to feel the heritage artefacts using texture and sounds; and a command-line interface

that produces American Standard Code for Information Interchange versions of heritage objects based on descriptions. In addition, a paint-like drawing-based search engine to explore the collection was proposed along with an immersive experience time machine room to explore heritage based on historic maps of the city.

### 3. Installation of the CoGhent Box: A Mobile Cultural Experience

Building upon the foundational data infrastructure as a first instantiation of the open data platform, the CoGhent Box was developed as an immersive

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1　Metropolis Urban Sustainability Exchange. (n.d.) CoGhent. Available at https://use.metropolis.org/case-studies/coghent (Accessed: 30/8/2025).

digital experience space operating as a "touch point" and first physical demonstrator for the new digital cultural data city service, see Figure 6-24. Designed to operate as a high-tech, travelling structure, it was created to offer innovative ways for local residents who are not necessarily affiliated with cultural institutions, to access and experience cultural content which was traditionally stored in closed-off, institutional archives, whilst also collecting personal stories and memories that help enrich and diversify the city's cultural heritage. The CoGhent Box has helped to facilitate the revival of heritage objects via storylines in which visitors could browse newly digitized heritage artefacts, photographs and documents on a bank of screens, and experience and share their past with other city residents, see Figure 6-25.

The box was piloted across three different neighbourhoods: ① Tolhuis-Sluizeken-Ham; ② Watersportbaan-Ekkergem;  ③ Wondelgem to test the progressive development of the project. From a total of 25 neighbourhoods, these three were selected because of their spread of both long-term citizens, who have been resident for 50 or 60 years, as well as newcomers from different backgrounds. This combination of social diversity ensured that there was both individuals with stories and testimonies along with those who had an interest in the history of their neighbourhood.

By transversing across neighbourhoods, this approach was designed to test and validate the box infrastructure to determine whether it is a feasible method of bringing cultural heritage collections to different parts of the city, see Figure 6-26. Following
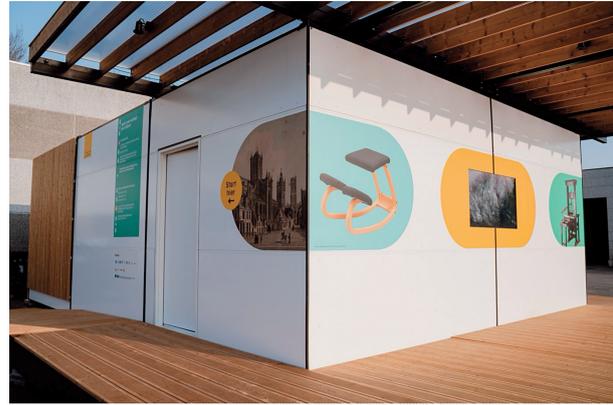


Figure 6−24　The exterior of the CoGhent Box; a modular, mobile museum



Source: Urban Innovative Actions. (2022). CoGhent Box: What's it like?  Available at https://www.uia−initiative.eu/en/news/coghent−box−whats−it (Accessed: 28/7/2025).

Figure 6−25　The CoGhent Box interior included an interactive display through which visitors could navigate stories combining museum collections and citizen memories, providing a means of access for those who were digitally excluded



Source: Urban Innovative Actions. (2022). UIA−CoGhent Journal #2. Available at https://portico.urban−initiative.eu/urban−stories/uia/uia−coghent−journal−2 (Accessed: 28/8/2025).

Figure 6−26　One of the three touchscreens allows visitors to browse digitized elements of the CoGhent Box collections

construction of the prototype in early 2022, the box was first installed in Wondelgem in April 2022 and ended in Tolhuis-Sluizeken-Ham in February 2023, involving over 2,200 participants over the 10-month testing period.[1] Across the three neighbourhoods, project partner iDROPS trained new trainers and set up a Trainers-Network in which they devised a Train-the-Trainer toolkit to provide them with a sense of ownership in the project as well as a reference point for teaching.

The box project was the result of a collaborative design process involving both stakeholders and citizens. Crowdsourcing reflected a key means of collecting and enhancing cultural heritage data, however, the initiative maintained a separation between crowdsourced materials and professional practice to assess which methods are effective and to validate best practices for community engagement among underserved audiences.

The digital Collection of Ghent platform was uploaded online in February 2022 combining collections from the city's five heritage institutions. It continues to function as the legacy platform and digital infrastructure for Ghent's cultural data and has also become a permanent fixture in the Design Museum Ghent. It has set out to rethink and reimagine the role of cultural institutions as open, inclusive public third places. The aim is to enhance access to and participation in cultural and leisure services, promote intercultural exchange and create welcoming spaces where

people from all backgrounds can contribute, connect and feel represented.

## Reference Experiences

**1. Harness Mobile Cultural Third Spaces to Bring Urban Culture Closer to Urban Citizens**

CoGhent demonstrates that cultural participation grows when institutions physically enter communities themselves, reinforcing the value in exploring and experimenting with the evolution of cultural urban institutions. As flexible components, mobile cultural spaces hold significant potential in dismantling barriers to access especially for hard-to-reach groups traditionally excluded from museum life. It thus makes visible the importance of enabling more inclusive means of interpretation for museum collections by involving communities in their development and decision-making processes. The intentional design for flexibility, local relevance and co-creation is an important element to recognize. Before such spaces arrive, organizers can work with neighbourhood groups to collect stories, artefacts and themes that reflect the community's identity, and which help to display and mirror local voices. Lower-cost set-ups can also generate similar impact when paired with active facilitation in which an ongoing presence and meaningful dialogue enable mobile cultural spaces to become catalysts for connection, learning and a sense of urban identity.

**2. Promote Linked Open Data to Unlock Cultural Innovation**

Another key learning is that opening and linking cultural datasets transforms them from static archives into living public resources. By connecting collec-

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1   Metropolis Urban Sustainability Exchange. (n.d.) CoGhent. Available at https://use.metropolis.org/case-studies/coghent (Accessed: 3/8/2025).

tions across institutions and publishing them under interoperable standards, cities can unlock unexpected collaborations. Teachers use them for history lessons, entrepreneurs create heritage-inspired products and developers build interactive maps and games. The transferable approach is to start small, linking a few collections using a shared metadata framework and clear open licences, and to design for reuse from the outset by offering accessible APIs and guidance for non-technical users. Importantly, data openness alone does not guarantee activity; structured opportunities such as hackathons, design challenges or school projects are vital to prompt creative use. Cities adopting this model should view open cultural data not only as an archival service but as civic infrastructure that can power education, tourism, creative industries and social innovation far beyond the cultural sector.

**3. Leverage Micro-grants and Capacity Building to Activate Digitised Cultural Heritage**

CoGhent illustrates how small-scale, targeted funding, when coupled with mentoring and technical guidance, can serve as a catalyst for community-driven cultural innovation rooted in open data. Through the establishment of a co-creation fund, micro-grants were awarded to initiatives ranging from neighbourhood storytelling festivals to digital applications drawing on the city's open cultural heritage collections with the guiding principle that all outputs; whether datasets, exhibitions or learning resources, would be returned to the public domain. The emphasis on a simple and inclusive application process encouraged participation from schools, grassroots organizations and independent creatives, while

tailored capacity-building support enabled recipients to progress from initial ideas to tangible outcomes. Public showcases and festivals provided a further layer of impact by inspiring others, strengthening networks across disciplines and positioning each project as part of a broader civic effort rather than an isolated experiment. For replication elsewhere, the transferable lesson lies in linking financial support to open-sharing requirements, pairing resources with skills development and designing for accessibility so that funded projects bridge traditional cultural practices and digital innovation while reinforcing shared cultural ecosystems.

# Policy Recommendations

**1. Recognize Culture as a Key Catalyst to Drive People-centred Smart City Development**

Smart cities can be understood not simply as technological-driven infrastructures but as ecosystems that are intrinsically shaped by people in which culture exists as a key component to orient people-centred urban transformations. Digital innovation provides long-term value when it strengthens social inclusion, broadens access to urban services and deepens the mutual prosperity that exists between cities and their inhabitants. The experiences from Chennai, Ghent, Seville and Suzhou illustrate that cultural assets such as heritage, education and tourism alongside citizen participation can effectively function as institutional resources that shape the application of

technologies. When framing smart city strategies around cultural values, cities can ensure that technological advancements work to preserve historical memory, reinforce shared identities, strengthen social cohesion and thus facilitate sustainable urban development. Accordingly, cross-sector collaboration between cultural institutions, urban planners, and technology developers and providers, represents an important consideration in urban policy.

**2. Promote Inclusive Learning Opportunities for Equitable Smart City Transformation**

Ensuring urban citizens are informed and equipped with digital skills is key to the successful development of smart cities and delivery of shared urban prosperity. A city's ability to disperse the benefits of digitalization is as dependent on the technological participation and engagement of citizens as the technology itself. As demonstrated by Chennai, the provision of lifelong learning ecosystems that extend beyond classroom instruction to libraries, cultural centres and online platforms, can nurture digital literacy alongside cultural understanding. In addition, as highlighted by Ghent, the involvement of urban citizens in cultural heritage data through open archives, co-creation projects or community storytelling can enhance their knowledge on both citywide and local community cultural heritage, while also reducing their barriers to cultural participation. Such approaches that combine digital technologies with digital skills training and education on local cultural heritage can support citizens, particularly younger generations, to more effectively leverage the technologies and innovate in line with local needs. The provision of open

digital platforms, public third spaces and cultural centres reflect important approaches. It is important to note that alongside adequate funding, the establishment of partnerships with local organizations and use of performance metrics that track both digital skills acquisition and civic engagement are important for cities.

**3. Leverage Digital Empowerment as a Mechanism for the Protection and Creative Reuse of Local Cultural Heritage**

Urban cultural heritage provides cities with unique identities. It serves as both a repository of memory and a source of economic vitality in which digital tools can amplify its value. Suzhou demonstrates the value of digital twin models and strategic monitoring to enhance heritage protection. Seville illustrates the role of smart governance in balancing tourism development and heritage carrying capacity, while Ghent showcases open cultural data as a tool to transform conventional archives into dynamic public resources, providing support for cultural participation, education and awareness. Digitalization and open data frameworks which enable cross-departmental data sharing can allow cities to capture, standardize, update and preserve cultural heritage within publicly accessible data formats. The integration of culture in data and the promotion of data cooperation and interoperability can also help to embed it as a public resource. By combining digital cultural preservation with urban regeneration, cities can better leverage and repurpose cultural heritage to stimulate people-centred urban development via means such as tourism, education and creative in-

dustries development, fostering a virtuous cycle in which cultural preservation supports its production and vice versa.

**4. Apply Evidence-based Governance to Guide Smart Urban Tourism Strategies**

While tourism can be a powerful engine of cultural exchange and urban economic growth, it also carries the risk of eroding the cultural and social fabric that makes cities distinctive. As demonstrated in Suzhou, evidence-based governance that leverages real-time monitoring and predictive modelling can help cities to better manage visitor flows and reduce pressure on sensitive heritage sites. It is equally key that urban tourism strategies prioritize local citizens, strengthen their participation in cultural heritage and transform tourism infrastructure into shared civic resources through innovations such as mobile exhibitions, pop-up theatres and community-led heritage walks. The engagement of residents in the design of tourism experiences ensures that culture becomes a bridge between visitors and local people, fostering greater dialogue and exchange in addition to supporting economic development. In this regard, cities can benefit from synergistic policy approaches that use data to prioritize the management of visitor inflows as well as the participation of citizens in urban cultural heritage, using it as a tool to strengthen social dialogue and inclusion.

**5. Foster Open and Co-created Smart City Ecosystems**

It is evident that cross-sector and multi-stakeholder collaboration across municipal governments, businesses, cultural institutions and grassroots communities remains key to ensure smart cities are developed via co-creation approaches that put people at the forefront. As highlighted across Chennai, Ghent and Suzhou actions such as the deployment of small-scale grants, open-data hackathons and industry incubation platforms can unlock opportunities for urban citizens to experiment with technology, therefore stimulating local innovation while also building shared cultural knowledge. By recognizing cultural data as public infrastructure, it signals that stories, traditions and creative practices are essential civic resources. Cities can support these ecosystems by establishing culture-focused data centres, physical and maker spaces, and interactive digital platforms that connect physical and virtual spaces, allowing institutions and residents alike to collectively shape local technological and cultural futures. By curating urban policy that ensures access to and collaboration in cultural heritage preservation and education, cities can embed culture as an intrinsic component within their development strategies and position local citizens as co-creators in cultural knowledge production.

# Chapter Seven

# Governance: Modernizing Urban Management through Artificial Intelligence

# Introduction[1]

With the acceleration of global urbanization, challenges such as population growth, resource scarcity, environmental pressures and surging demand for public services are becoming increasingly prominent, placing urban governance systems under unprecedented strain. Traditional governance models are proving inadequate for addressing complex and diverse urban issues, thereby necessitating technological innovation and institutional restructuring to enhance urban resilience, service efficiency and sustainability. How to construct a more intelligent, inclusive and efficient urban governance system has emerged as a shared concern for city managers worldwide.

Against this backdrop, AI, as a core driving force of the new wave of scientific and technological revolution, provides powerful support for the modernization of urban governance. According to projections by the McKinsey Global Institute, by 2030 AI will contribute an additional USD 13 trillion to global urban GDP. Through data integration and intelligent analytics, AI not only optimizes decision-making processes and improves the speed and precision of public service responses but also advances the transformation of urban governance towards being more people-centred and collaborative, thereby contributing to the implementation of the core principle of the United Nations 2030 Agenda for Sustainable Development—to "leave no one behind" .[2] However, the widespread and extensive application of AI in urban governance continues to face significant bottlenecks including the persistence of data silos and lack of standards impeding system interoperability; the existence of a digital divide within certain communities and groups; legal and ethical frameworks lagging behind technological development; and insufficient mechanisms for cross-sectoral collaboration.[3] In many cities, smart city projects are often hindered by institutional barriers, limited public participation or an excessive emphasis on hardware deployment and isolated technological applications, resulting in a failure to achieve truly citizen-centred systemic integration and service innovation.

To systematically address these challenges and ensure that AI genuinely empowers people

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1　This chapter was compiled by Peng Zhenwei, Chen Chen, Huang Yi, Chen Shiyun, and Wang Can from Tongji University. The Shanghai case study was contributed by Shanghai Shentong Metro Group Co., Ltd., authored by Xi Xiaodong and Wang Shenghua. The case studies for Espoo, Rio de Janeiro, and India, along with the boxes for Paris and Barcelona, were provided by UN-Habitat. The Shenzhen box was authored by Zhang Weiwei.

2　Available at https://www.un.org/sustainabledevelopment/development-goals/.

3　United Nations Human Settlements Programme (UN-Habitat) and Mila–Quebec Artificial Intelligence Institute. (4 June 2025). AI and the City: Risks, Applications and Governance. EEEWORK. Available at http://eeework.com/.

and serves cities, it is imperative to build an institutionalized, inclusive and sustainable smart governance ecosystem. At its core, this ecosystem should be guided by people's needs and urban sustainable development objectives, promoting data openness and sharing, breaking down administrative and operational silos, strengthening legal safeguards and ethical governance, and fostering the joint participation of governments, enterprises, research institutions and citizens. By enhancing the capabilities of cities in perception, analysis, decision-making and response through AI, governance can evolve from one-way management to multi-stakeholder collaboration, from experience-based approaches to data-driven practices and from reactive responses to proactive foresight.

To further explore pathways for implementation, this chapter, based on the expansion logic "from a single city to regional collaboration", selects seven representative cases to systematically demonstrate innovative practices in which AI empowers urban modernization across different spatial scales and governance levels. The Smart Maintenance project in Shanghai, China, achieved, for the first time in an ultra-large-scale metro network, an enterprise-level digital transformation by applying AI technologies for equipment fault prediction, and intelligent operations and maintenance (O&M). This has significantly enhanced the operational reliability of the rail transit system and improved the passenger travel experience. Through this innovation, Shanghai's metro management has set a benchmark for smart infrastructure management in cities. Shenzhen's "iShenzhen" Mobile Governance Platform has dissolved silos across municipal departments by establishing a unified data hub, applied AI to optimize consultation services, designed differentiated service scenarios for individuals and enterprises, and enhanced both cross-border and age-friendly functions. Simultaneously, it established a closed-loop system for demand response and implemented a "policy benefits without application" mechanism. The platform has effectively improved service efficiency, registered over 10 million users and become a model practice in smart governance. The Espoo Systematic Impact Leadership Strategy in Finland advanced cross-departmental data collaboration and systemic governance transformation. The strategy integrated the SDGs throughout the entire urban decision-making process, enabling Espoo to become a model of smart urban transformation. Espoo's success demonstrates how AI can promote the smart transformation of medium-sized cities and elevate the overall level of urban governance.

The Sandbox.Rio programme in Brazil, as the first municipal regulatory testing mechanism in Latin America, provided real-world testing platforms for innovative technologies such as drone logistics and electric mobility. This programme explored agile governance models adapted

to emerging technologies, offering practical experience in integrating technological innovation with urban governance. The Barcelona vCity project has leveraged digital twin technology to integrate real-time urban data with simulation and scenario analysis, thereby supporting complex policy decisions such as the planning of climate shelters and resource circularity. This project highlighted the critical role of data-driven decision-making in addressing climate change and resource management, advancing the intelligence and precision of urban governance. The National Urban Digital Mission (NUDM) in India promoted a nationwide digital governance transformation by constructing a unified digital infrastructure. Through open-source platforms and standard-setting, NUDM extended e-governance services to more than 4,800 local authorities, successfully achieving inclusive, large-scale empowerment of services and enhancing the effectiveness of digital governance at the regional level. And the Paris Quartiers Métropolitains d'Innovation (Metropolitan Districts for Innovation-QMI) plan broke down innovation barriers across municipal boundaries through inter-municipal collaborative mechanisms. In pilot areas such as Meudon and Sceaux, the implementation of 28 high-impact solutions has driven the building of a Greater Paris innovation community, exemplifying the significant potential of AI in fostering regional innovation and cross-domain collaboration.

These cases demonstrate that AI-enabled urban governance is not merely the application of technology, but rather a systemic transformation of institutions, processes and culture. They highlight that the success of AI depends on top-level design, the integration of data resources, multi-stakeholder co-creation and sustained capacity building. Importantly, these practices are consistently centred on human needs, narrowing the digital divide, enhancing public participation and improving service quality through technological means, hence leveraging technology as a tool for people-centred urban development. The chapter illustrates the role of AI in reshaping both the substance and paradigm of urban governance. Its successful application depends not only on the technology itself but also on its extensive integration with institutional design, public participation and the goals of sustainable development. Cities should be grounded in local realities and citizens' needs, and build an inclusive, open and empowering ecosystem of smart governance, ensuring that technology truly serves people. Looking ahead, it is expected that more cities will draw on global best practices, continuously innovating new models and mechanisms for AI-enabled governance, and advancing together toward a more intelligent, green, equitable and sustainable urban future.

# Reference Cases

## Shanghai, China
## Shanghai Metro Smart Maintenance: A Leading Enterprise Digital Transformation of the Global Rail Transit Industry

### Case Background

As a megacity, Shanghai faces chronic traffic congestion, heavy resource use and environmental strain from continuous population growth. To ensure efficient operations and ecological balance within limited urban space, rail transit expansion has become essential. Since the first line opened in 1993, the Shanghai Metro has grown into one of the world's largest and most technologically advanced urban rail systems. The daily passenger traffic exceeds 10 million, with the highest daily traffic reaching 13.39 million passengers. By the end of 2024, its public transport share had reached 76.9 per cent,[1] making it the preferred choice for urban commuting. By the end of 2025, it will span 896 km across 21 lines and 517 stations, serving both the city centre and surrounding suburbs.

With the continuous growth of passenger traffic, the traditional O&M model which relies on manual inspections, experience-based judgment and decentralized management, can no longer meet the requirements of high-density operations, multi-equipment coordination and long-term upkeep of a megacity subway system. This has led to problems such as delayed responses, inefficient resource use and insufficient risk prediction for safety hazards. At the same time, the pressure of high costs in service experience upgrades also restrict the sustainable development of subway services. Equipment failures in core areas (e.g., multi-line transfer lines, high-passenger-flow lines) are more likely to trigger a network-wide impact. Against this backdrop, the Shanghai Metro and the entire rail transit industry urgently need to introduce a brand-new smart maintenance model. Through deep integration of technologies such as the industrial internet, AI, big data and cloud computing, the maintenance of equipment is shifting from a passive model of "post-repair" and "periodic maintenance" to an active model of "real-time monitoring, intelligent early warning and precise action". This transition focuses on data-driven decision-making, safety maintenance based on proactive risk management, efficient operation based on resource-intensive utilization, and the achievement of cost reduction and efficiency improvement while ensuring the safety and comfort of passengers.

As the key project of Shanghai's rail transit equipment maintenance system and a pioneering demonstration of the smart subway strategy, the Smart Maintenance project is based on the top-level strategic planning of the enterprise, with "omnidirectional perception coverage" as the foundation,

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1 Public Transport Share refers to the proportion of rail transit passenger traffic in the total public transport passenger traffic (rail transit + surface buses) in the city. The calculation formula is: Public Transport Share =

$$\frac{\text{Daily Passenger Traffic of Rail Transit}}{\text{Daily Passenger Traffic of Rail Transit} + \text{Daily Passenger Traffic of Surface Buses}} \times 100\%.$$ Data source: Annual Statistics Report of the Shanghai Municipal Transportation Commission.

systematically advancing the enterprise-level digital transformation of the equipment sector. The project started with pilot exploration and has gradually expanded to full-scale development, continuously pushing the boundaries of its capabilities with significant achievements being made so far. The average disposal time for equipment failures has been reduced from 60 minutes to 20 minutes with efficiency improved by nearly 70 per cent, significantly reducing operational disruptions. Equipment utilization has increased from 65 per cent to 82 per cent, optimizing resource allocation. The most direct result is the improvement in passenger experience. The average passenger delay time caused by equipment failures has decreased from 25 minutes to 8 minutes, increasing passenger satisfaction from 85 per cent to 95 per cent.[1] This allows residents to directly experience the results of "faster processing, better experience and more reliable travel" in the construction of smart subways.

## Implementation Process

The Smart Maintenance project started planning in 2000 and has undergone three rounds of evaluations organized by the Shanghai Municipal Transportation Commission, the Shanghai Municipal Development and Reform Commission, and the Shanghai Municipal Commission of Housing, Urban-Rural Development and Management before it was officially approved in September 2024. The project developed gradually alongside the digital technology evolution of facility equipment and went through four stages:

exploration, pilot, development and planning implementation, fully realizing the digital transformation of rail transit O&M. Specific content includes the pilot of over 80 smart perception technologies, the improvement of 19 first-level business processes, and the smart empowerment of over 100 second and third-level business processes, among other achievements. Through continuous summation and refinement, four implementation methods have been established: resource coordination and networking; on-site maintenance integration; deep repair specialization; and systematization of major repairs and updates. An optimized organizational structure was also developed, creating a three-tier platform system consisting of the business management layer (backend), production command layer (mid-platform) and on-site execution layer (frontend), with a focus on strengthening the company-level backend and professional company mid-platform.

**1. Progressive Development and Phased Implementation**

Initial exploration stage (2000–2010). The primary goals during this phase were rapid fault detection, improvement on daily maintenance efficiency and easy access to equipment data. It was based on the fault diagnostic technology of vehicles and power equipment, as well as online automatic measurement technology for some facilities and equipment components. For example, the signalling specialty began piloting the turnout microcomputer monitoring, achieving timely fault warning for turnouts. However, due to technological limitations, the pilots during this stage focused only on specific equipment or compo-

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1    Data sourced from the third-party survey by Shanghai Municipal Transportation Commission in 2024 (sample size over 100,000).

nents which were fragmented and lacked systematization, and the technological methods were relatively primitive leading to limited actual outcomes.

Professional system establishment stage (2011–2017). During this stage, the establishment of Smart Maintenance pilot platforms for various professional systems, such as vehicles, signalling, power supply, tracks, tunnels and electromechanics, were launched one after another, see Figure 7-1. These platforms utilized the upgrading of data collection and image recognition technologies to gather professional data and perform preliminary analysis, allowing for online monitoring, status tracking and simple fault warning functions for key equipment such as wheels, turnouts and electrical devices. Pilot tests showed that these platforms effectively enhanced equipment reliability, reduced fault handling time, improved maintenance efficiency and reduced labour costs, laying the practical foundation for the further development of the intelligent maintenance system.

Rapid development and effectiveness verification stage (2018–2023). Building on the earlier pilots,



Source: Shanghai Rail Transit Maintenance Support Co., Ltd.

Figure 7–1　Subway train inspection robot

smart platforms for various specialties continued to upgrade, allowing for more extensive collection of key equipment status data and initial exploration of cross-specialty data linkage (e.g., wheel-rail and pantograph-wire relationships). At the same time, unified technical standards and construction plans were developed to promote the implementation of the Smart Maintenance system, significantly enhancing the management of the entire equipment life cycle. Related results have won numerous national awards, and the pilot verification of Smart Maintenance has been widely recognized and affirmed at domestic and international levels. Seven academicians, including Liu Youmei and other well-known experts in the industry, have provided professional evaluations of the system, calling it "internationally leading", "first-class internationally" and "a domestic first".

Overall planning and comprehensive implementation stage (2024–present day). In 2024, building on the lessons of previous pilots and advanced industry practices, and in close alignment with Shentong Metro Group's 14th Five-Year Strategic Plan and digital transformation objectives, Shanghai Metro officially launched the top-level planning and design of the Smart Maintenance project, see Figure 7-2. Through more than 10 rounds of surveys involving both internal departments and subsidiary companies (with over 100 participants), the project team conducted an in-depth study of the practical needs of enterprise digital transformation and engineering construction, ultimately producing a Maintenance and Management Business Research Report. Based on the survey results, the team systematically reviewed the business

system, refined and established the overall frame-work for maintenance operations and, through further business needs analysis, clearly defined the project's construction model: a core structure consisting of one network-level Smart Maintenance platform + six specialized intelligent monitoring systems + support-ing infrastructure. At the same time, business process re-engineering and restructuring were advanced in parallel, gradually building a new business and appli-cation architecture.

As the network-level core platform, the Smart Maintenance project focuses on achieving full life cycle management of equipment, integrating seven core application systems, including control tower, emergency management, and planning and sched-uling. The platform applies unified data standards and connects in real time to the status information of

six specialized monitoring systems, including vehi-cles, power supply and signalling/communications, among others, thus constructing a shared analytical foundation. The core objective of this initiative is to shift from "humans searching for faults" to "faults finding humans". This not only effectively supports cross-disciplinary collaborative decision-making and equipment maintenance management, a feat that frees O&M personnel from passive response and labour-intensive inspections, but also, through intelligent early warning and rapid response mech-anisms, significantly enhances passenger safety and train punctuality, thereby ensuring a reliable travel experience for citizens. The Smart Maintenance sys-tem relies on hardware facilities such as the central control room and joint computer rooms to ensure the platform's efficient and stable operation.
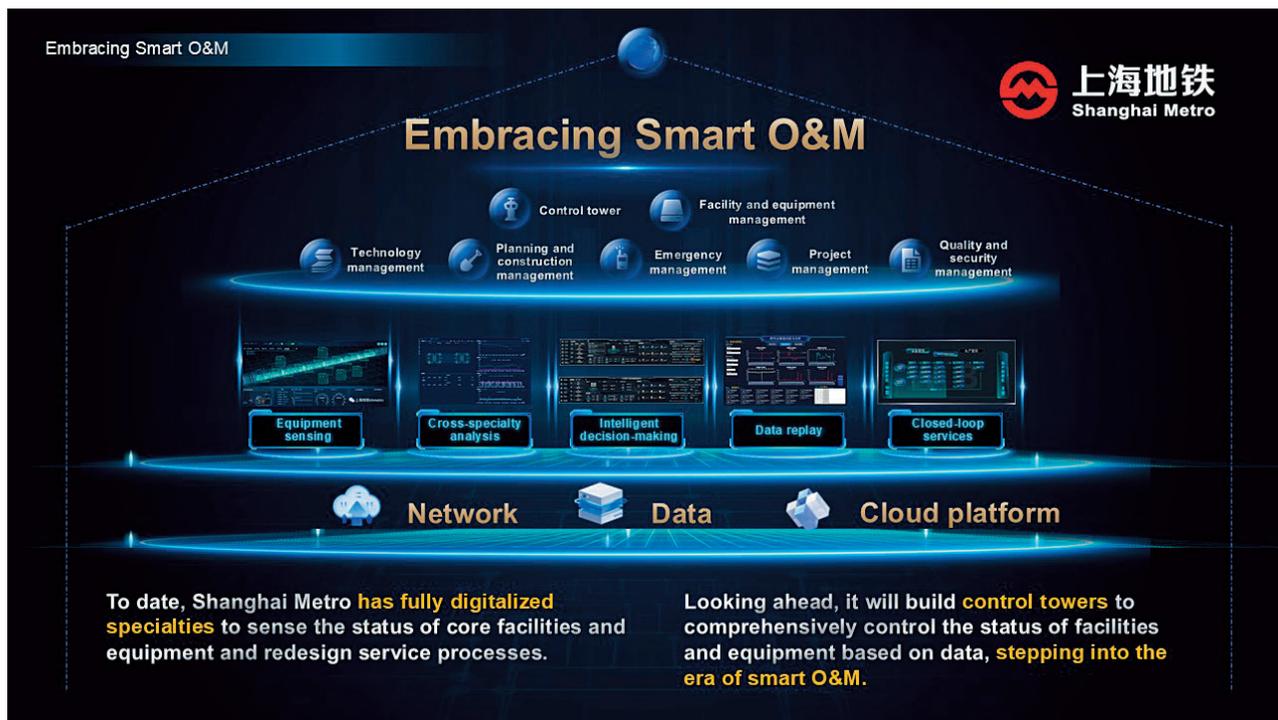


Source: Shanghai Rail Transit Maintenance Support Co., Ltd.

Figure 7–2   The framework of Shanghai Metro's smart operation and maintenance

**2. Orientation of Public Service and Quantifiable Results**

The Smart Maintenance project is driving the transformation of rail transit equipment O&M from the traditional model of planned and fault-based repairs toward a multidimensional model combining expert-led fault repair, perception-driven condition-based repair and experience-based planned repair, thereby achieving full life cycle management of equipment. This significantly improves equipment utilization and production efficiency, optimizes process flows, reduces repair costs and lowers total life cycle costs. Specific results include: in the rolling stock specialty, reliability is expected to increase by 15 per cent; in the communications/signalling specialty, diagnostic and early-warning accuracy exceeds 95 per cent, while maintenance response time has been reduced by 30 per cent; in the power supply specialty, full-process monitoring and traceability of equipment have been realized, substantially reducing the occurrence of major failures; in track, tunnel and bridge specialties, fault diagnosis time has been greatly compressed, optimizing maintenance cycles and costs; at rolling stock depots, reliability indicators are expected to rise by 15 per cent, alarm accuracy has improved by 50 per cent, and the blocking rate of blacklisted individuals and vehicles has reached over 90 per cent, effectively relieving security pressures; in station electromechanical systems, intelligent perception, and O&M service capabilities have been comprehensively enhanced.

## Reference Experiences

Smart Maintenance is not a simple aggregation of multiple technologies but rather the integration of data and status perception through a unified platform, supported by underlying infrastructure to enable decision-making. It is advancing the transformation of rail transit O&M from the traditional "labour-intensive and experience-dependent" model to a "technology-intensive and data-driven" paradigm. While improving system reliability, it has also significantly reduced the labour intensity of frontline maintenance staff, enabling them to focus more on high-value decision-making and emergency response, thereby further ensuring operational safety and enhancing the passenger experience. Its core value lies not only in improving O&M efficiency and reducing safety risks, but also in markedly cutting resource waste — such as spare parts inventory and energy consumption — through "precision maintenance". This provides essential support for the sustainable development of ultra-large metro networks by realizing a fully perceptible, predictable and controllable health status across the entire system from tracks to equipment, thereby achieving a true "O&M as a service" smart upgrade. As the world's first enterprise-level digital transformation project in the field of facility and equipment O&M within the rail transit sector, the Smart Maintenance project exemplifies the highest current level of practice, both in terms of its experience and outcomes, as well as the technical complexity and engineering challenges involved in its implementation.

**1. Build Innovative Systems for Full Life Cycle Management**

With full life cycle management at its core, and in close alignment with Shanghai Metro's 14th Five-Year Digital Transformation Plan, the project has clearly defined the implementation pathways of the Smart Maintenance platform across multiple business scenarios, including functional design, perception coverage, intelligent decision-making and resource dispatching. The platform adopts a "cloud–edge–end" collaborative architecture: the cloud is responsible for centralized data analysis; the edge layer provides real-time responsiveness; and the end devices conduct status data collection. This ensures strong concurrent processing capabilities across the system. A three-stage technology admission mechanism has also been established, requiring all technologies to undergo laboratory validation, line pilot testing and full-network promotion sequentially before being applied comprehensively. Through this process, a large volume of repetitive and high-risk tasks are handled automatically by the system which reduces frontline workload and enables personnel to concentrate on fault diagnosis and emergency handling, thus improving both work value and safety.

**2. Adopt Incremental and Replicable Implementation Pathways**

Adhering to the principle of "pilot exploration, effect evaluation, full-scale promotion and standard formation", the project is being rolled out in batches across all lines and the entire network, guided by the results of pilot projects. Particular emphasis is placed on ensuring the industry maturity and acceptance of equipment perception technologies, guaranteeing that they are not only technically feasible but also practically beneficial for frontline operations, delivering tangible O&M benefits. During promotion, attention is also given to staff training and the adaptation of operational practices. By organizing multiple rounds of hands-on training, compiling visualized operation manuals and establishing expert consultation hotlines, the project assists maintenance personnel in rapidly familiarizing themselves with the system, reducing anxiety and resistance during the transformation process, and embodying the principle of "technology serving people".

**3. Provide a Human-centred Paradigm for Digital Transformation in the Industry**

Against the backdrop of resource constraints faced by megacities and developing countries, the implementation of the Smart Maintenance project offers valuable lessons for the industry. It is necessary to conduct extensive and scientific research to systematically identify business pain points and process bottlenecks, propose feasible optimization recommendations and fully validate these measures within actual production environments. Business processes should be thoroughly streamlined, resource allocation optimized, and both quality and safety requirements balanced. Upgrading of aging facilities should be advanced according to the principles of phased implementation and minimal disruption, while standardized concepts must be fully applied in the construction of new lines. At the same time, this case places particular emphasis on the human dimension: it not only focuses on the implementation of technology but also on enhancing the dual experience of both O&M personnel and passengers. Through intelligent early

warning and rapid response mechanisms, it reduces disruptions to passenger travel caused by equipment failures, while systematic and data-driven O&M models enhance frontline staff efficiency and decision-making capabilities. This has effectively created a virtuous cycle of "smart systems serving O&M personnel, and O&M personnel serving passengers".

The Smart Maintenance practice has become a benchmark for China's urban rail transit, with its technical pathways and experience now being disseminated nationwide and internationally. Looking ahead, with ongoing technological iteration and policy support, the Smart Maintenance project will evolve from "preventive maintenance" to "autonomous maintenance", providing core support for the safe and efficient operation of ultra-large rail networks, contributing the "Shanghai experience" to the digital development of international rail transit.

## Shenzhen, China
## Building a Mobile Service-oriented Government through the iShenzhen App

Shenzhen, a megacity adjacent to Hong Kong, had a permanent resident population of nearly 18 million as of the end of 2024.[1] Shenzhen's population density is high,[2] and the demand for public services has surged, creating dual pressures on urban management. Shenzhen's traditional public service model faces two main pain points: ① spatial and temporal limitations. For example, prior to 2018, 63 per cent of high-frequency services required in-person visits[3] and citizens made an average of 3.2 trips per year;[4] and ② digital divide. For senior citizens over the age of 60, the social security business processing rate was below 30 per cent.[5] Cross-border residents from Hong Kong and Macao were required to make over three trips to complete tasks, and 58 departments had independently built 127 government platforms[6] leading to data silos that caused a 45 per cent rate of repeated document submissions.[7]

To address these challenges, Shenzhen officially launched the unified mobile government service platform iShenzhen App in January 2019.[8]

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1  Shenzhen Special Zone Daily. Shenzhen's Permanent Resident Population Growth in 2024 Ranks First in the Country. Available at https://www.sz.gov.cn/cn/xxgk/zfxxgj/zwdt/content/post_12097381.html.
2  Planning and Natural Resources Bureau of Shenzhen Municipality. The population density is 15,000 people per square kilometre, Shenzhen Land Use Overall Plan (2021–2035).
3  Bureau of Government Services Data Management of Shenzhen Municipality. 63% of high-frequency services required in-person visits prior to 2018. Three-Year Action Plan for Government Service Reform (2019–2021).
4  Shenzhen Digital Government and Smart City Development Report (2019). Citizens had an average of 3.2 trips per year.
5  Civil Affairs Bureau of Shenzhen Municipality. For elderly citizens over the age of 60, the social security business processing rate was below 30%. Smart Elderly Care Survey Report (2020).
6  Shenzhen Municipal People's Government. 58 departments had independently built 127 government platforms. Smart City Construction Problem Diagnosis Report (2018).
7  Bureau of Government Services Data Management of Shenzhen Municipality. Data silos that caused a 45% rate of repeated document submissions. Data Governance Special Audit Report (2019).
8  Xinhuaapps. Shenzhen launched the "iShenzhen" app in January 2019.

Shenzhen uses the iShenzhen App to integrate resources from various districts and departments into a unified platform, avoiding information silos and enabling citizens to efficiently complete a task. The process started with technology-driven service upgrades. iShenzhen constructed a city-level platform linking the databases of 58 departments with an average of 2.3 million data interface calls per day,[1] supporting over 8,600 services available through One App for All, allowing over 95 per cent of personal matters and over 70 per cent of corporate matters to be handled via mobile.

iShenzhen is practical software aimed at improving people's daily lives and is now being used by many citizens. Scenario-based services reshape the user experience. iShenzhen features dual-page designs for "resident access" or "business access", precisely matching the needs of both individuals and companies. It covers public rental housing applications, traffic accident handling and other public services, as well as business areas such as complete business setup within one day, and unified coding for cross-border payments. In terms of cross-border service innovation, the Hong Kong-Macao section offers 180 Bay Area Unified Services,[2] with a 60 per cent improvement in the processing time for cross-border financial services. The platform also provides an accessibility service matrix, including screen reader functions, voice navigation and enlarged font sizes for seniors. Its senior-friendly redesign has been certified by the Ministry of Industry and Information Technology.[3] Additionally, the platform has launched multi-language versions.[4]

Institutional innovations drive governance efficiency. iShenzhen launched a public demand service WeChat mini-programme, allowing residents to submit requests online. Once accepted by the platform, their progress is tracked in real-time.[5] A "good/bad review" feedback loop mechanism has also been established with a 100 per cent rectification rate for negative reviews and a satisfaction rate of 98.7 per cent.[6] To further promote the immediate services without application policy, iShenzhen has launched a policy subsidy direct platform, achieving an efficient policy fulfillment model.[7] For example, the child of Ms. Wang, a resident of Shenzhen, is eligible to receive subsidies for compulsory education at private schools each year. Before the implementation of the "automatic entitlement without application"

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1　Bureau of Government Services Data Management of Shenzhen Municipality. An average of 2.3 million data interface calls per day. "iShenzhen" Technical Architecture White Paper (2023).

2　Guangdong-Hong Kong-Macao Greater Bay Area Development Office. 180 Bay Area Unified Services, Cross-border Government Service Data Sharing List (2024).

3　Ministry of Industry and Information Technology. Its senior-friendly redesign has been certified by the Ministry of Industry and Information Technology, Report on Special Actions for Senior-friendly Redesign of Mobile Applications (2023).

4　Xinhuaapps. Shenzhen Online Service Platform Expands Multi-Language Services for an Upgraded International Business Environment .

5　Shenzhen. The only city in the world! Shenzhen wins "China Smart City Award".

6　Bureau of Government Services Data Management of Shenzhen Municipality. Availability of Good/Bad Review feedback with a 100% rectification rate for negative reviews, Government Services Good/Bad Review System Operation Report (2023).

7　Xinhuaapps. Shenzhen: Immediate services without application makes policies more people-centered.

reform, Ms. Wang had to prepare multiple documents annually for subsidy application and submit them through various levels, with the funds taking several months to be disbursed. Now, she only needs to log into the iShenzhen app to verify the amount of the subsidy entitled and can wait for the funds to be credited directly.[1]

iShenzhen has currently accumulated over 17.3 million registered users.[2] The mobile service penetration rate is 89 per cent, saving citizens more than 150 million hours of service time.[3] The seniors area receives an average of 420,000 visits per month, with a satisfaction rate for elderly services reaching 96 per cent.[4] The number of registered users from Hong Kong and Macau has exceeded 1.5 million, with a 92 per cent positive feedback rate for cross-border services.[5] A city-wide points system, Shen i Points, has also been established allowing users to accumulate points through activities such as check-ins, completing tasks and displaying codes, which can be redeemed

for cultural and sports coupons, performance tickets, parking discounts and other benefits.[6] On the iShenzhen app, you can also check the information of government service outlets throughout the city, including addresses, phone numbers, etc., for convenient offline consultation or business processing.

On 22 February 2025, the Shenzhen Municipal Government Service and Data Management Bureau launched the AI government assistant Shenxiaoi on the iShenzhen app for a one-month trial. The app provided more than 580,000 rounds of consultations and answers, serving over 60,000 people, and achieved policy answers and service guidance for the whole city covering all areas.[7]

Shenzhen has achieved significant results in serving enterprises and talents, improving work efficiency and streamlining costs. As Shenxiaoi has upgraded its intelligent service module for enterprises and talents, it gathers enterprise and talent service policies. Currently, it has stored more than 20,000 policy documents and over 8,000 declaration items, making it not only more convenient to handle affairs but also more intelligent for policy consultation. In addition, after upgrading to version 2.0, Shenxiaoi has been elevated from a "Q&A assistant" to a "versatile assistant". For issues related to handling affairs, the

1　Shenzhen Special Zone Daily. Shenzhen: The City's Thinking Services Exhibit Warmth.

2　Emergency Management Bureau of Shenzhen Municipality. iShenzhen Platform: Extending Online Government Services to Mobile Platforms.

3　Statistics Bureau of Shenzhen Municipality. Mobile service penetration rate reaches 89%, Digital Economy Development and Livelihood Service Survey Report (2024).

4　iShenzhen app operational backend data (as of June 2024). The Elderly Area receives an average of 420,000 visits per month.

5　Hong Kong and Macao Affairs Office of Shenzhen Municipal Peoples Government. Number of registered Hong Kong and Macau residents exceeds 1.5 million, Report on Cross-Border Collaborative Development of Government Services in the Guangdong-Hong Kong-Macau Greater Bay Area (2024).

6　Xinhuaapps. From Solo Performance to Chorus – Shenzhen Upgrades to a Comprehensive City Mobile Service Platform.

7　Xinhua News Agency Client Report, March 22, 2025. Shenxiaoi AI Government Assistant Goes Online for 1 Month, Serving Over 60,000 People.

system not only embeds a handling link in the reply but also actively pushes a handling card, allowing users to directly access the handling entrance with one click. Shenxiaoi has accumulated 1.2 million localized language materials,[1] with an 89 per cent one-time resolution rate for high-frequency tasks and over 50,000 enquiries answered daily.

The Shenzhen Municipal Government has also considered risk prevention and control. For example, in order to ensure more authoritative and accurate answers to Shenxiaoi, the system strictly limits the source of reply content, only uses verified official knowledge base data and prohibits internet information retrieval. In terms of security, the system attaches great importance to the protection of user personal information and content security. Relying on domestic solutions, strict data security policies and multiple protection architectures are adopted to comprehensively safeguard user privacy security and large model content security.[2]

iShenzhen is one of Shenzhen's key initiatives in digital transformation and smart city development, showcasing a typical Shenzhen experience. It is designed with a demand-oriented approach, annually iterating and updating high-frequency services. It covers all aspects of personal life, including health, education, housing, transportation and tourism, allowing citizens to "enjoy life smartly on one screen".[3] An ecosystem co-construction mechanism invites internet enterprises to participate in the development, fostering a government innovation laboratory. This collaboration optimizes the business environment for enterprises while also partnering in technological innovation. An "all-age-friendly" service system is a necessity for a smart city. The seniors area focuses on services related to transportation, epidemic prevention, healthcare, elderly care and cultural tourism, which are closely linked to the daily lives of older adults, see Figure 7-3.[4]

There are two requirements for implementers to build a convenient and practical unified government service app. On the one hand, it requires interconnection, data sharing and business collaboration among different departments. Breaking down data barriers is an important part of this, and the key behind it is for the government to improve its system. On the other hand, technical support is needed to utilize new technologies such as blockchain, AI big data and cloud computing to improve functionality and ensure the security of government data applications.[5]

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1 Ping An Smart City. Shenxiaoi has accumulated 1.2 million localized language materials, AI Government Assistant R&D Progress Report (2024).

2 Xinhua News Agency Client Report, August 26, 2025. Being both a 'policy expert' and a 'steward of affairs', the 'Shenxiaoi' AI government assistant is revitalized and upgraded.

3 Shenzhen. The only city in the world! Shenzhen wins China Smart City Award.

4 Xinhuaapps. Senior-friendly and Barrier-free Upgrades: Shenzhen's Speed Adds Human Touch to Government Services.

5 Qingdao Daily, November 16, 2021. What should 'Qinge Office' learn from 'iShenzhen' when the wind comes from Pengcheng?

Source: iShenzhen App.

Figure 7–3　Screenshot from the seniors' area of the iShenzhen App

## Espoo, Finland
## Systematic Impact Leadership Strategy

### Case Background

As a network city comprising of five urban centres, Espoo is the second-largest city in Finland and constitutes part of the Helsinki Metropolitan Area. With more than 320,000 inhabitants it has experienced rapid population growth and is faced with a number of challenges including the prevention of social exclusion among young people, securing employment and integration, and providing multilingual and accessible municipal services, as well as the need to accelerate climate action, attract investment and boost tax revenues to ensure companies remain in the city. To address these issues, the city has provided substantial investment into digitalization, robotics and AI to stimulate social innovation, customer-oriented services, partnerships, productivity improvements and cost savings. Launched in 2019 in collaboration with the VTT Technical Research Centre of Finland, the Systemic Impact Leadership Strategy was established to integrate data-driven decision-making across municipal departments to enhance the efficiency and sustainability of urban management. Following a holistic approach to urban management, it has reflected a cross-administrative initiative that promotes business unit-specific and human and operation-centric pilot projects that are built upon system theory and training.

## Implementation Process

Espoo's impact leadership strategy is guided by the "Espoo Story", a co-created strategic city vision that embeds sustainability, innovation and citizen participation into the future of local development. To realize the Espoo Story within the city's evolving operating environment, an indicator database was developed by VTT foresight leaders via a systems thinking approach, generating precise metrics to monitor and evaluate urban strategy implementation. As a future oriented methodology, it has ensured that urban development within Espoo is not only responsive to current challenges but also anticipatory of future needs, fostering a resilient and sustainable urban environment.

**1. Integrating Data, Artificial Intelligence and Digital Tools to Guide Urban Recovery**

Designed as a long-term recovery programme, the ReStart Espoo programme emerged from the COVID-19 pandemic in which the city relied on open-source data and AI to assess its needs, public spending and financial resources to bounce back, drive business growth and return to normal operations. As a mechanism for knowledge transfer, this informed the development of an urban community-level impact map and tested VTT's CityTune impact tool. Designed as a solutions package, the tool simulates the possible impacts of major urban decisions using modelling tools and analytics to support data-driven planning and decision-making, and in turn provides a framework for impact leadership, laying out a road map for implementation.

Utilizing Digia's integration services (a Finnish IT services and software company), Espoo streamlines and automates work through a modern, secure cloud-based integration platform which supports the production and management of integrations using the Integration Competency Centre model. This has enhanced the speed, reliability and security of urban operational integrations, and thus the planning and implementation of urban services. Espoo has also explored the potential for AI to be used to identify emerging service needs and predict future social service requirements in collaboration with Tieto, a company focused on IT services and software. Leveraging anonymized social, healthcare and early education client relationship data from 2002–2016, the system aimed to enable early identification of individuals at risk within child welfare, allowing for more proactive and targeted interventions. This approach has represented a significant step towards data-driven decision-making within public services, combining technological innovation with a focus on privacy and ethical considerations.

Espoo's Digital Agenda 3.0 promotes the digitalization of municipal services, use of novel technology, introduction of electronic services and adoption of new operating methods. It reflects a citywide framework for the use of data, digital services and smart infrastructure, and underpins the impact leadership strategy by facilitating data-driven, participatory and transparent urban decision-making. It is based on experiments which run from several months to a year, which test produce and service ideas to develop them with companies, educational and research institutes, and customers via a process of co-creation. Digital

agenda experiments help to identify future solutions in the market that support the growth of Espoo's core services to enhance quality for customers and user groups. This not only introduces new digital services to customers but also strengthens a culture of urban experimentation which provides significant value for startups.

**2. The Sustainable Espoo Development Programme**

The Sustainable Espoo development programme supports the implementation of Espoo's impact leadership programme and consolidates these pilots within the wider city's framework. As a cross-sectoral programme it promotes five core goals: ① to pioneer the implementation of the SDGs; ② to achieve carbon neutrality by 2030; ③ to ensure community residents act sustainably; ④ to serve as a model city for sustainable urban development; and ⑤ to serve as a leading developer partner for sustainable and smart urban solutions. In line with the framework of the SDG Cities Leadership Platform, Espoo is committed to fulfilling the SDGs by the end of 2025 and works in close collaboration with businesses and other stakeholders to design and implement solutions that are facilitating carbon-neutral urban futures. Development activities, experimentation and cooperation associated with the programme are largely undertaken through externally funded projects, which help to identify solutions that facilitate the daily life of Espoo's citizens and promote actions to solve challenges such as low-carbon mobility, clean energy and circular economy development. These initiatives support the creation of practical, locally anchored solutions while simultaneously promoting innovative solutions that address the forthcoming challenges of urban development. It operationalizes impact leadership by eliminating silos, engaging residents and partners, and connecting urban services to long-term strategic goals.

**3. Impact Leadership Pilot Projects and Training**

To embed impact leadership across the city, Espoo invests not only in pilot projects but also in the capacity of its staff. Impact assessment training has become a cornerstone of the implementation process, equipping municipal employees with the skills to apply systems thinking, interpret complex datasets and anticipate the broader impacts of policymaking decisions, positioning them as skilled facilitators able to bridge stakeholders, foster experimentation and scale up citizen-centric innovations across the city. By strengthening internal expertise, Espoo ensures that new digital tools and pilot projects are not isolated experiments but part of a scalable model for data-driven leadership. Training also supports knowledge transfer between projects, enabling staff to learn from co-creation processes with residents, businesses and research partners, allowing the city to align organizational learning with urban transformation processes.

Several pilot projects have been launched that support the city's strategic goals and develop new models for data-based leadership. These projects build upon system theory and gather data from both new and existing sources that enable the city to analyse impacts and refine decision-making. Impact assessment has proven a key component to the city's

success whereby it offers employees impact assessment training to allow them to deepen their skills and learn how to navigate increasingly complex social challenges through data-driven approaches. Such impact leadership not only strengthens the day-to-day operational management of the city but encourages green business and innovation to sustainable urban development.

As flagship urban transformation projects, the Kera District Transformation, LuxTurrim5G, and Sustainable Energy Positive and Cero Carbon Communities projects have reflected key cross-sectoral city pilot initiatives. Serving as living laboratories, each project has been designed to test how different systems such as energy, mobility, data, business ecosystems and governance interact, in which they are evaluated not only by their efficiency or outputs, but by their systemic impacts in line with the system-theory approach under the impact leadership strategy. The Kera District Transformation is converting a former logistics hub into a vibrant, low-carbon neighbourhood for 14,000 residents and 10,000 jobs, functioning as a living lab for circular economy solutions and sustainable mobility.[1] It integrates material reuse, green infrastructure and renewable energy, and fosters a participatory approach to governance to generate a replicable models for sustainable urban development. In parallel, the LuxTurrim5G project, led by Nokia



Source: LuxTurrim5G+. (n.d.). LuxTurrim5G+ (2019−2021). Available at https://www.luxturrim5g.com/project−partners (Accessed: 26/8/2025).

Figure 7−4   A smart bus stop and autonomous vehicle provide smart city services via the LuxTurrim5G project

in collaboration with the city, is transforming urban infrastructure in the Nokia Campus area and the Kera district via smart digital infrastructure, see Figure 7-4. It deploys 19 smart poles, two smart bus stops, drone and docking station, and autonomous vehicles with more than 250 connect IoT devices such as cameras, radars, weather sensors, lidars, air quality sensors and positioning devices with fast, low latency 5G connectivity. Data from sensors such as those monitoring air quality, traffic and safety is then translated into operational improvements across urban services.

Complementing these local pilots, the European Union-funded Sustainable Energy Positive and Cero Carbon Communities project launched in 2019 positions Espoo as a European Lighthouse City, developing energy-positive districts, testing integrated mobility systems and engaging residents in climate-neutral solutions.[2] The project developed a co-creation model which instils participatory management and design

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1   Circle Economy Foundation. (2025). Kera district: Transformation of a Traditional Industrial Area into a Low-carbon, 20-minute Neighbourhood. Available at https://knowledge-hub.circle-economy.com/article/30050?n=Kera-district-Transformation-of-a-Traditional-Industrial-Area-into-a-Low-carbon%2C-20-minute-Neighbourhood (Accessed: 25/8/2025).

2   City of Espoo. (n.d.). SPARCS. Available at https://www.espoo.fi/en/sustainable-development/sparcs (Accessed: 28/8/2025).

principles for the transformation of sustainable, smart urban areas.

## Reference Experiences

### 1. Leverage Digital Tools to Streamline Urban Operations

Espoo's strategic deployment of digital tools and data-driven systems has served to enhance connectivity and integration across the city's urban operations, while enhancing decision-making. By integrating cloud-based platforms across municipal departments, the city has highlighted how such tools can support the automation of routine processes, improve reliability and enable real-time coordination between municipal services, reinforcing the capacity for digital technologies to reduce operational silos and accelerate response times. The use of AI and predictive analytics has enabled Espoo to proactively allocate resources, target interventions, and prevent social and operational challenges before they escalate. Complementing these capabilities, smart urban infrastructure pilot projects such as LuxTurrim5G have unlocked real-time data on elements such as mobility, energy use and public safety, translating complex information into actionable insights for urban decision makers. Critically, the city pairs these technological innovations with staff training and participatory approaches to project development and implementation, ensuring that they can interpret data effectively and that community perspectives guide urban interventions. The initiative demonstrates that predictive analytics, digital automation and real-time monitoring combined with sufficient human capacity and citizen engagement can enhance municipal operational efficiency and service delivery to drive sustainable urban development.

### 2. Recognize Co-creation as an Essential Process to Integrate Citizen-centric Thinking into Urban Development and Decision-making

Within the framework of the impact leadership programme, co-creation emerges as a fundamental pillar in driving smart urban transformation projects. The approach underscores the critical role of community engagement in shaping urban strategies and ensuring they are rooted to local realities and responsive to the need of citizens. By employing mechanisms such as structured workshops, iterative feedback cycles and participatory design processes, cities can ensure that citizens are involved in decision-making and also enhance the quality of policymaking. In this regard, co-creation is not only a participatory exercise but a strategic governance tool by transcending traditional public consultation. By embedding citizen perspectives into planning and implementation phases or project development, cities can move beyond top-down development approaches and create urban solutions that are aligned to local contexts.

### 3. Foster a Culture of Experimentation and Continuous Learning within Urban Governance

The initiative demonstrates that urban innovation is most effective when staff capacity-building is embedded directly within pilot projects, allowing lessons learned to be captured, institutionalized and applied across municipal operations. Under the impact leadership strategy, municipal officials receive structured training in areas such as systems thinking, impact

assessment and data-driven decision-making which equips them with the skills to navigate complex urban challenges and evaluate the wider effects of city interventions. This approach enables staff not only to implement innovations but also to assess their systemic impacts, identify opportunities for improvement, and translate experimental findings into scalable policies and services. In practice, pilot projects function as living laboratories in which municipal teams collaborate to co-design, test and refine sustainable urban solutions. This hands-on experimentation allows staff to observe real-world outcomes and adjust strategies dynamically, while also develop practical skills in adaptive, impact-focused urban governance. By integrating workforce development into operational initiatives, municipalities can strengthen cross-departmental collaboration, retain institutional knowledge and facilitate the replication of successful practices. Systematically documenting insights and providing structured training enhances operational capacity, ultimately accelerating the delivery of sustainable, inclusive and citizen-centric urban solutions.

## Rio de Janeiro, Brazil Sandbox.Rio–A Regulatory Test Lab for Urban Experimentation

### Case Background

Rio de Janeiro faces a convergence of urban challenges that require innovative and adaptive policy responses. Rapid technological change often outpaces existing regulations, leaving promising solutions such as drone deliveries, micromobility services and smart infrastructure unable to operate legally without long bureaucratic delays. This creates a barrier for startups and innovators who face high compliance costs and uncertainty when trying to introduce new models in the city. Traditional policymaking tends to be reactive and rigid, making it difficult to experiment with novel approaches before they are fully regulated.

To address these gaps and improve the regulatory framework for the city, Sandbox.Rio was launched as Brazil's first municipal regulatory testing environment. Inspired by experimental environments used with the financial technology sector and the national level, and adapted for the urban context, it offers a controlled space in which companies, research institutes and non-profits can test new products, services or processes that do not yet comply with existing municipal laws via temporary authorizations granted by the municipality. This model allows the city to observe real-world performance, assess social and economic impacts, and gather evidence before deciding on permanent regulations – aiming to position Rio as a living laboratory for innovative urban solutions. The sandbox directly tackles challenges such as regulatory lag, innovation bottlenecks and the risk of inefficient or unsuitable laws. For example, emerging mobility technologies often require quick adaptation to ensure safety without stifling market entry and similarly, urban logistics innovations need to be trialled in real conditions to evaluate traffic, environmental and community impacts. By granting temporary exemptions under close monitoring, Sandbox.Rio lowers barriers to entry for innovators, accelerates the introduction of beneficial technologies and reduces the risk of in-

vesting in solutions that might later face regulatory shutdown.

## Implementation Process

### 1. Conceptual Design and a Public Call for Proposals

To initiative conceptual design of the sandbox, benchmarking studies were conducted to learn from international examples including the United Kingdom's Financial Conduct Authority sandbox and Singapore's Urban Solutions Lab, which provided key insights into operational structures, risk management, monitoring mechanisms and regulatory flexibility. In tandem, municipal departments, legal teams, academic institutions and innovation-focused companies engaged in workshops and consultations to define the sandbox's scope and core priorities. Feasibility studies were also performed to assess the legal and socioeconomic implications of introducing temporary regulatory relief, ensuring that pilot projects would comply with national laws and target areas with a high potential for positive impact. The Rio.Sandbox programme was formalized through Municipal Decree No. 50.697/2022 and published on 26 April 2022, via the Undersecretariat for Regulation and the Business Environment, and the Municipal Secretariat for Urban and Economic Development of the City Hall, which established the governance structure, operational rules and eligibility criteria for participants.

The resulting draft regulatory framework created the basis from which a public call for proposals was announced by the Secretariat on 2 May 2022 inviting legal entities including private-sector companies, re-

search institutes and non-profits to submit proposals for innovative projects for regulatory experimentation. Project areas include mobility, logistics, energy transitions and smart cities, with selection criteria emphasizing project innovation potential, alignment with existing urban priorities, financial and technical capacity, and implementation feasibility as well as the ability to measure impacts. Project participants were also required to provide an orderly exit plan to ensure compliance with legal, regulatory and contractual obligation at the end of the testing period. The selection and approval phase was managed by a technical committee that reviewed submissions for regulatory relevance and readiness for testing, see Figure 7-5.

### 2. Piloting Experimental Solutions

Following the launch of the first cycle, nine proposals were submitted and four were selected by Rio.Sandbox. Once approved, the projects entered controlled experimentation phases in which participants received 12-month regulatory exemptions to operate within predefined geographic or service boundaries. Each project was closely monitored by municipal agencies, with data collected on elements such as technical performance and safety as well as public acceptance. The evaluation and reporting phase concluded each testing cycle whereby the city compiled results into a technical report for each project, including a regulatory impact analysis. Reporting thus served as the basis for deciding whether the tested innovation should be incorporated into permanent municipal regulations, adjusted for broader rollout or discontinued, with lessons learned fed back to improve the next public call and further refine the
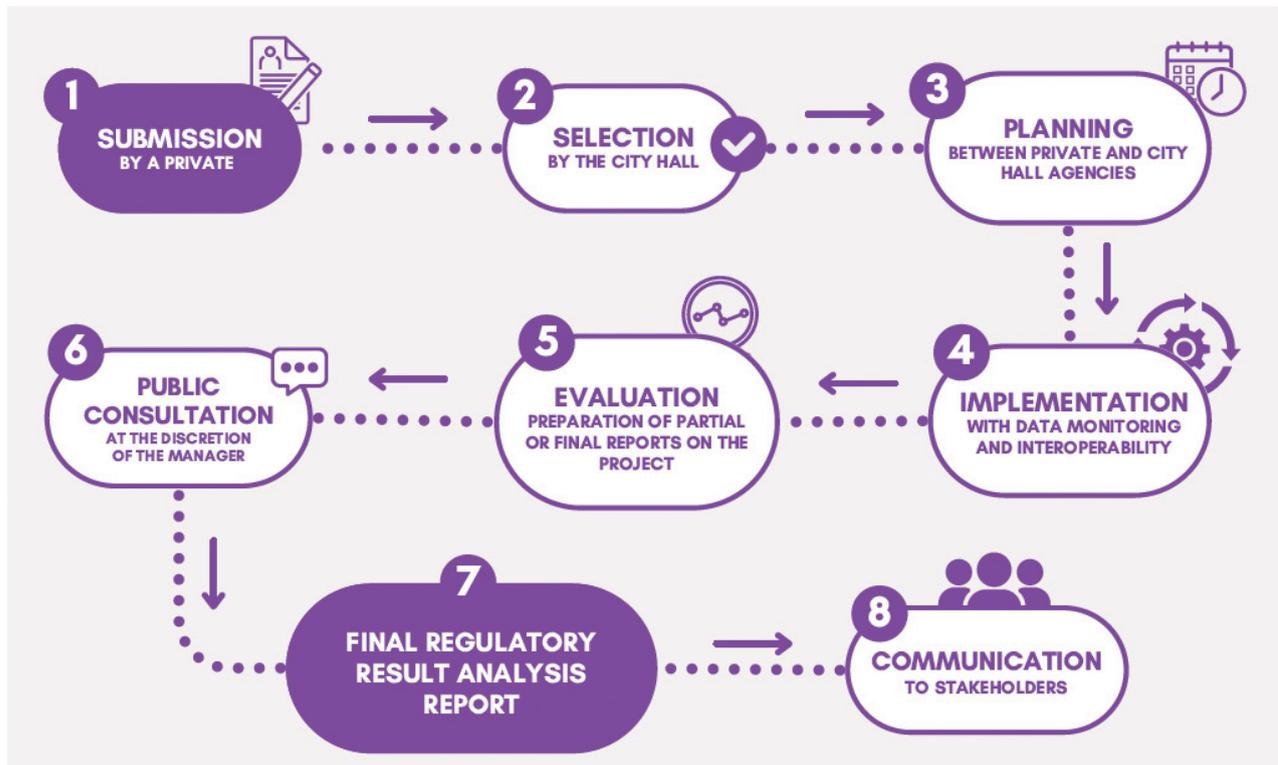
Source: Rio de Janeiro City Hall.

Figure 7–5   The Rio.Sandbox project selection process

sandbox's operational model and associated urban policy development. At the same time, the process of continuous learning supports the city in further understanding the project innovations and facilitating a regulatory framework that is receptive and compliant with new technologies.

For the first project proposal, the city experimented with the delivery of beverages via unmanned vehicles; a strategy that faced regulatory challenges related to aviation safety, public security and operational integration. It supported the startup Ambev, a beer and soft drink manufacturer, in partnership with the drone service SpeedBird Aero to pilot drone-based beverage deliveries under the Ze Delivery application throughout the city. Using the DLV2 model

authorized by the Airspace Control Department, the project tested up to 25 daily flights from drone ports in non-populated areas, carrying loads of up to 6.5 kg at an average speed of 50 km/h and a maximum altitude of 120 m, between 8 a.m. and 6 p.m.[1] Using two city routes authorized by the National Civil Aviation Agency, the experiment enabled the assessment of drone flight capabilities when travelling over sea to reach the boardwalk and leave the cargo near beachside kiosks, aiming to enhance beverage logistics, reduce emissions through electric transport and provide valuable operational data to help the National Civil Aviation Agency and the Airspace Control

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1   Sandbox.Rio. (n.d.). Available at https://www.sandboxrio.com.br/em-andamento/ambev.html (Accessed: 5/8/2025).

Department develop a regulatory framework aligned with urban drone innovation.

The EZVolt Brasil EV Charging Station proposal represented the first initiative in Latin America to generate carbon credits from EV charging, supporting Rio de Janeiro's low-carbon development pathway and objective to achieve net-zero emissions by 2050. While already active in housing blocks and commercial areas of the city, it utilizes Sandbox.Rio to pilot the development of a public network of fast-charging stations for electric and hybrid vehicles including taxis at designated locations. Designed to address regulatory gaps that currently limit public charging infrastructure, it has trialled an operational model for installation on public roads, covering technical integration with the power grid, concession and management models, user accessibility, payment systems and energy demand impacts. It thus aims to develop a set of regulatory guidelines for large-scale deployment, improved access to charging infrastructure to encourage EV adoption and $CO_2$ emission reductions as well as the development of a replicable model for other regions to accelerate e-mobility options and roll-out. Although testing still remains ongoing, the first charging hub was opened on 15 February 2025 in Barra da Tijuca with support from the Laneshift initiative and the city government, see Figure 7-6.

The My View proposal was selected to help test delivery solutions for local trade such as restaurants and markets. It has tested teleoperated land-based drones called D4 (Door-to-Door Drone Delivery) designed to travel along city pavements at restricted times to improve the logistics of short-haul deliveries, reducing costs, time and greenhouse gas emissions, with testing taking place at the Petrobras Research, Development and Innovation Centre.



Source: C40 Cities. (2025). Laneshift supports Rio de Janeiro in launching its first public fast-charging station. Available at https://www.c40.org/news/laneshift-rio-de-janeiro-in-launching-public-fast-charging-station/ (Accessed: 1/8/2025).

Figure 7-6　The EZVolt charging hub in Barra da Tijuca, Rio de Janeiro

Following an unsuccessful initial entry of electric scooter-sharing in Brazilian cities from 2018–2019, a second wave proposal emerged from 2023 following the Contran Resolution 966/23 which established national safety guidelines. This allowed municipalities to retain their autonomy over local rules and generated a more structured regulatory environment. Rio.Sandbox allowed operators such as Whoosh to launch under temporary authorizations, gather real-world data and work with city authorities to refine regulations, particularly for parking and circulation. They collected usage patterns, parking behaviour and safety metrics, which directly informed municipal guidelines for micromobility zones and curb management, see Figure 7-7. This approach addressed the failures of the first wave where operations began without adequate rules and public management struggled to adapt. By enabling controlled experimentation and dialogue between pri-

vate operators and public authorities, Rio.Sandbox has helped to align urban mobility objectives with business models, reducing conflicts and improving safety and space management.

Favela Delivery piloted the installation of "mini-buses" in Rio's favelas to improve product delivery logistics while fostering inclusion and income generation by linking microentrepreneurs, delivery workers and residents with major market players. The model covers marketplace services, last-mile delivery and reverse logistics. Key tests include optimizing address identification in hard-to-map areas and creating operational support bases in public spaces to organize routes, enable temporary storage and reduce delivery times. The initiative faces the challenge of securing accessible collection points in partnership with the city. Expected outcomes include developing logistics standards for difficult-access areas, generating jobs



Source: Globo G1. (2025). Rio tests electric scooter model before releasing service expansion beyond the South Zone and Center. Available at https://g1.globo.com/rj/rio−de−janeiro/noticia/2025/04/20/rio−testa−modelo−de−patinete−eletrico−antes−de−liberar−expansao−do−servico−para−alem−da−zona−sul−e−centro.ghtml (Accessed: 15/8/2025).

Figure 7−7　Whoosh scooters in Rio de Janeiro

and business opportunities, improving delivery speed and service quality, and creating a replicable model for other Brazilian cities advancing both economic empowerment and urban logistics innovation.

## Reference Experiences

### 1. Promote Local Experimentation as an Urban Governance Tool

While still a relatively new instrument of experimentalism, the Sandbox.Rio model demonstrates that urban regulation can be approached as a flexible, evidence-driven process rather than an inflexible set of rules. By enabling controlled, real-world testing of policies and innovations at the neighbourhood level or within sectors, the tool demonstrates that city governments are able to collect detailed empirical data before scaling interventions citywide. This approach reduces the risk of unintended consequences, improves policy responsiveness and strengthens the capacity of the city to adapt to rapidly evolving technological, social and economic conditions. In practice, it encourages urban decision-makers to view regulations not as constraints but as enablers of innovation, supporting iterative problem-solving and cross-department collaboration while fostering a culture of continuous learning. Local experimentation also surfaces contextual insights such as behavioural, infrastructural or cultural factors that would otherwise remain invisible under conventional top-down approaches, allowing regulations to be tailored to the city's unique realities.

### 2. Leverage Sandboxes as Mechanisms to Train Regulators and Build Institutional Learning

The adoption of the tool demonstrates that experimentation can strengthen not only policies but the governing capacity of municipal teams themselves. By actively participating in iterative testing, regulators develop skills in risk identification, rapid learning and anticipatory problem-solving, while coordinating across departments and responding dynamically to emerging challenges. The sandbox functions as a training ground for city officials, transforming governance from a static, compliance-focused activity into a proactive, knowledge-generating process. This equips administrators with the capacity to manage uncertainty, experiment safely with emerging technologies and continuously refine regulatory frameworks, a critical advantage in fast-changing urban contexts where traditional linear policy processes often fail.

### 3. Recognize the Potential for Sandboxes to Map and Manage Urban System Complexity

Sandbox.Rio allows cities to observe and understand the interconnections between multiple urban systems, including mobility, digital services, environmental management and social programmes. Traditional siloed policymaking often overlooks these dependencies, resulting in ripple effects and unintended consequences. By testing solutions in a controlled environment while monitoring systemic interactions, the sandbox reveals hidden interdependencies, bottlenecks and cascading impacts. This enables regulators to design interventions that are innovative, resilient and coordinated across sectors. For urban governance, the sandbox highlights the value of treating the city as a complex adaptive system where policies are continuously informed by empirical evidence and systemic insights rather than assumptions, ensuring interventions are contextually grounded, effective and sustainable.

## Barcelona, Spain
## vCity: A Human-centric Platform for Urban Digital Twins

Modern urban centres worldwide are grappling with a series of complex and interconnected challenges, including the pressures of rapid urbanization, the escalating impacts of climate change (such as the urban heat island effect), persistent issues of social inequality and the overarching imperative to achieve sustainable development. Addressing these multifaceted problems requires innovative, integrated and forward-thinking solutions. While the concept of smart cities often focuses on integrating advanced technologies to enhance urban efficiency and livability, the vCity project in Barcelona introduces its core philosophy that a city's true "smartness" lies in its capacity to make human-centric, evidence-based "smarter decisions".

Spearheaded by the Data Visualization Group at the BSC, vCity is positioned as a pioneering human-centric urban digital twin platform to seamlessly integrate real-time urban data with sophisticated digital simulations, enabling urban planners to visualize and predict the potential impacts of policies before they are actually implemented. The project has secured substantial funding of approximately EUR 4.1 million from the Next Generation European Union funds as part of Spain's Digital Agenda 2026,[1] showing

government's acknowledgement of its long-term strategic value in addressing complex urban futures and achieving sustainable development.

### 1. Empowering Data-driven Urban Governance

At its core, vCity's most innovative feature is its ability to create a dynamic digital twin of the city. This sophisticated virtual replica is constructed by combining real-time data streams from various urban systems with advanced simulation models. A wide array of environmental, social and economic data consolidates into a coherent and interoperable system, thereby providing a holistic view of the urban landscape with its high-performance computing and advanced data analytics capabilities. Urban planners can explore and compare different potential outcomes of their decisions within a simulated virtual environment, thereby significantly reducing risks and optimizing policy effectiveness prior to real-world deployment. This capability is crucial for modern foresight and evidence-based policy design.

At the same time, a defining characteristic of vCity's human-centric approach is its proactive integration of feedback from established digital platforms for citizen participation, notably Decidim. This crucial feature ensures that urban solutions are genuinely rooted in the expressed needs and opinions of citizens, thereby fostering equitable and responsive governance. vCity also

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1    OECD Observatory of Public Sector Innovation. vCity, a human-centric platform for urban digital twins (OPSI, n.d.). Available at https://oecd-opsi.org/innovations/vcity-a-human-centric-platform-for-urban-digital-twins/ (Accessed: 16/7/2025).

demonstrates a strong commitment to transparency by pursuing open-sourcing and auditing of urban decision-making processes, aimed at encouraging widespread adoption by any city globally.[1]

**2. vCity's Application 1: Improving Climate Shelter Accessibility**

Barcelona, like many urban centres globally, is significantly affected by the urban heat island effect. These extreme heat conditions pose serious risks to public health, disproportionately impacting vulnerable populations, with the elderly and children identified as among the most affected groups. In response, Barcelona has actively established an extensive network of climate shelters to provide free, accessible and comfortably cool spaces (maintaining a maximum temperature of 26° Celsius).

Based on official data from the City Council, vCity identified the locations of existing climate shelters and simulated physical accessibility to these climate shelters for the elderly and children in the summer. Through its calculation, vCity estimated that more than 90 per cent of the most vulnerable residents could reach a climate shelter within a 10-minute walk, supporting 75 per cent overall. The assessment concluded that Barcelona's current climate shelter coverage is good and supports the city council's goal of all residents being able to reach a shelter within 5 minutes by 2030.[2] By presenting sociogeographic data, vCity provides strong evidence support for Barcelona's policy of developing a network of climate shelter leading to city resilience.

**3. vCity's Application 2: Driving a Circular City Model**

The concept of circularity is recognized as crucial for maintaining and enhancing the quality of life for Barcelona's inhabitants and for building a more sustainable urban environment for future generations. The City Council has firmly committed to progressively increasing circularity across its various districts. To effectively advance this commitment, a clear and detailed understanding of the current state of circularity within each district is essential. vCity has played a pivotal role in supporting the development and application of a new circular urban model specifically tailored for Barcelona. The core analytical tool utilized for this comprehensive assessment is the Circular City Index (CCI).

Through the urban data set of vCity, the model can provide specific indicators for CCI measurement of each dimension to judge the degree of resource circulation in various areas of Barcelona. An example is the "water efficiency" factor, which is calculated based on litres per inhabitant per day, with the darker districts as

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1   OECD Observatory of Public Sector Innovation. vCity, a human-centric platform for urban digital twins (OPSI, n.d.). Available at https://oecd-opsi.org/innovations/vcity-a-human-centric-platform-for-urban-digital-twins/ (Accessed: 16/7/2025).

2   vCity, How can climate shelters accessibility improve? Available at https://es.slides.com/vcity/climate-shelters_english#/7 (Accessed: 16/7/2025).
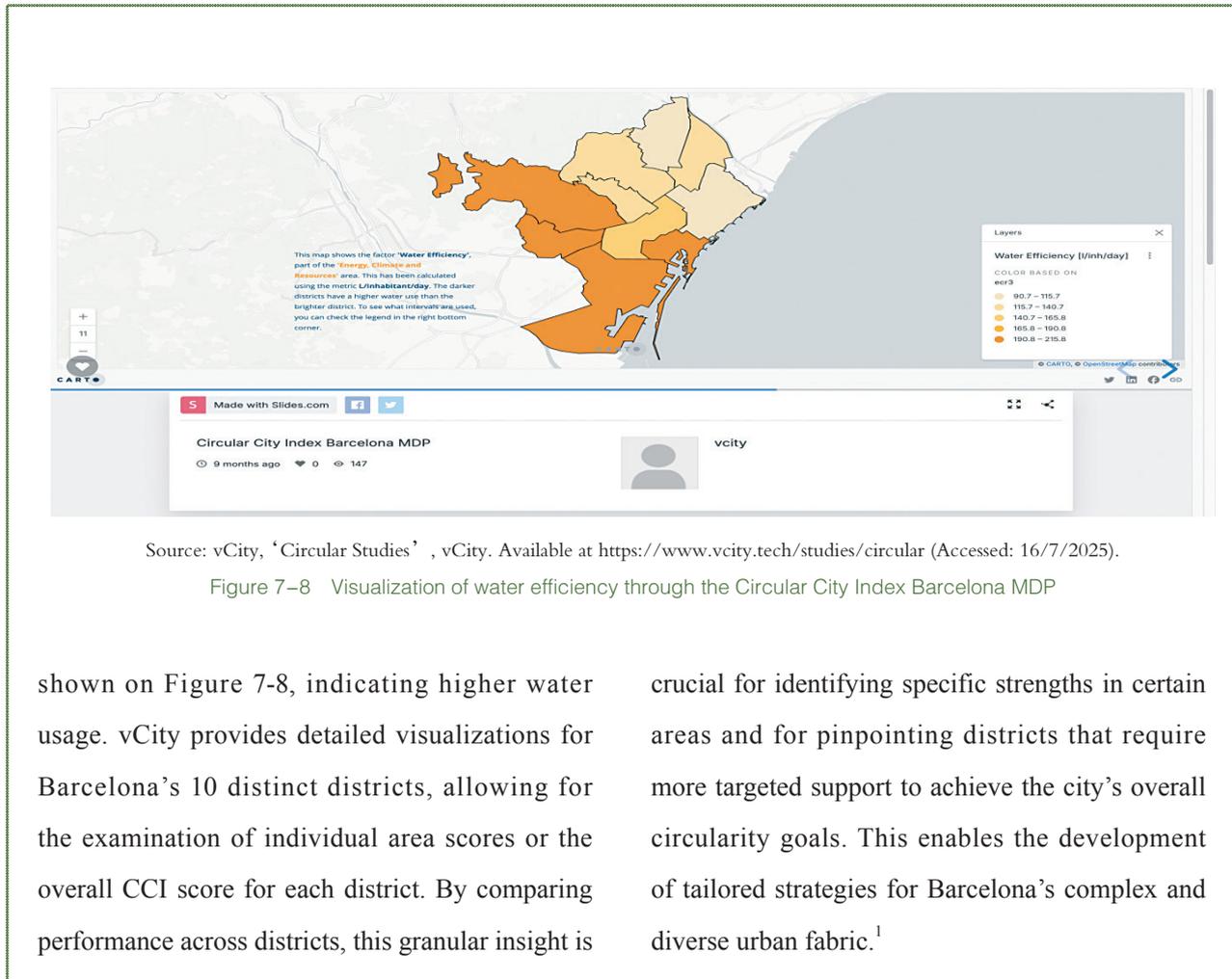
Source: vCity, 'Circular Studies', vCity. Available at https://www.vcity.tech/studies/circular (Accessed: 16/7/2025).

Figure 7−8    Visualization of water efficiency through the Circular City Index Barcelona MDP

shown on Figure 7-8, indicating higher water usage. vCity provides detailed visualizations for Barcelona's 10 distinct districts, allowing for the examination of individual area scores or the overall CCI score for each district. By comparing performance across districts, this granular insight is crucial for identifying specific strengths in certain areas and for pinpointing districts that require more targeted support to achieve the city's overall circularity goals. This enables the development of tailored strategies for Barcelona's complex and diverse urban fabric.[1]

## Pan−India
## The National Urban Digital Mission

### Case Background

India has emerged as the fastest-growing major economy globally, recording an average annual growth rate of 7 percent between 2017 and 2019; steadily increasing its proportional share in global GDP. With ambitions to become a USD 10 trillion economy by 2030, addressing urban challenges has become a national imperative given the critical role that cities play as engines of economic growth. [2] Existing systems such as Aadhaar–the Unified Payments Interface, and the widespread use of mobile and internet connectivity through the Jan Dhan bank account, Asdhar unique identity number and mobile phone trinity, have provided India with a strong underpinning of digital public infrastructure which has enabled the country to condense a 47-year

1    vCity, 'Circular Studies', vCity. Available at https://www.vcity.tech/studies/circular (Accessed: 16/7/2025).
2    Government of India. (2023). National Urban Digital Mission. Available at https://socialwelfare.vikaspedia.in/viewcontent/social-welfare/urban-poverty-alleviation-1/national-urban-digital-mission?lgn=en (Accessed: 6/7/2025).

journey into a decade and set the foundations for urban governance transformation. While digital governance has reached larger towns and cities, however, over 4,800 municipalities still lack access with limited coordination between urban digital ecosystem component parts. Infrastructure deficiencies mean that there is no consolidated overview of urban data to monitor and improve service delivery, while human resource and funding shortages also present major barriers.

In anticipation of an urban population expected to reach 600 million by 2030 which will constitute 40 per cent of the national population, India's Ministry of Housing and Urban Affairs launched NUDM in February 2021.[1] Designed as a shared digital infrastructure, it was developed to extend e-governance services to less developed municipalities and enhance the local, distributed and decentralized capacity of municipal systems to address complex development challenges at speed and scale. It was built as a public good in the form of a free, open-source urban software platform, targeting municipalities nationwide via an IT-enabled, citizen-centric approach that leverages digital technology as a means to improve productivity and capacity within local governments. It provides ecosystem stakeholders with the foundational digital infrastructure building blocks to manage core digital urban data, generating an urban national open digital ecosystem (u-NODE) that uses NUDM to build new platforms and create innovative urban solutions. As

it is developed to provide e-governance access across municipalities of differing developmental maturities, it ensures that all are provided with a minimum set of urban digital services to enhance quality of urban life and improve business environments. Where the initiative promotes collaboration among state governments, union territories and Urban Local Bodies (ULBs), it also instills principles of cooperative governance in which national and state governments work in partnership with shared responsibilities.

## Implementation Process

### 1. Building a People-centred E-governance Foundational Framework

First launched in February 2019 by the Ministry of Housing and Urban Affairs, the National Urban Innovation Stack provides a national references framework upon which NUDM is built, serving as a fundamental digital infrastructure with a deep understanding of the urban ecosystem and its needs. It was subsequently launched as a pilot in 2021 and NUDM was formally introduced as a new scheme in 2024 in line with initial design guidance under three pillars, See Figure 7-9: ① people; ② process; and ③ platform. In regard to the pillars, it prioritizes citizen-centric digital urban governance in which empanelled implementation partners support the development of tailored urban governance plans for each state and urban territory. Accordingly, capacity-building initiatives and proven best practices can be scaled up nationally to support a holistic digital transformation that benefits urban citizens themselves. As a process, NUDM emphasizes flexibility whereby

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1 Observatory of Public Sector Innovation, (2021). National Urban Digital Mission (NUDM) Available at https://oecd-opsi.org/innovations/national-urban-digital-missionnudm/ (Accessed: 6/7/2025).

states and ULBs can choose implementation models that are suited to their own context and supported by standardized tools and benchmarking to ensure streamlined roll-out. And with regard to e-platform development, services are made freely available and municipalities can choose engagement models tailored to their own local contexts.

### 2. Delivering Digital Governance Platforms

Under the National Urban Innovation Stack, the development of the Urban Platform for deliverY of Online Governance (UPYOG) was developed to provide a free, open-source software platform for municipalities and collective states. The platform was designed to not only leverage digital opportunities but also to ensure a sustained improvement in the delivery of municipal services, improve information management among municipal bodies, and enhance transparency and citizen involvement in participatory governance. In addition, it provides municipalities with one year of free cloud hosting to support the acceleration of local digital governance capacities.



Source: Centre for Digital Governance. (n.d.). NUDM team in Tamil Nadu. Available at https://niua.in/cdg/ (Accessed: 7/7/2025).

Figure 7–9　The NUDM team discussed project implementation in the state of Tamil Nadu

UPYOG is supported by a framework of reference modules, platforms, software and data reporting standards, along with a panel of service providers and programme implementation guidelines. Supplementary to its reusable and extendable components, the platform also offers centralized telemetry, data exchange and analytical capabilities. As it is generated from a set of open-source code and APIs, code is available on GitHub under open licensing terms. A SmartCode platform was also built to allow ecosystem users to contribute to this repository of open-source code meaning municipalities can customize existing code to suit their needs, rather than develop new solutions from scratch.

APIs and coding thus form the building blocks for stakeholders across the "quadruple helix" of government, industry, academia and civil society to harness the technology. In addition, UPYOG hosts nine reference modules including: ① Property Tax Assessment and Payment; ② Trade Licence Issuance and Payment; ③ No Objection Certificate Issuance; ④ Building Plan Approval; ⑤ Water and Sewerage Connection Management; ⑥ Public Grievance Redressal; ⑦ Birth and Death Registration; ⑧ Municipal Accounting and Finance; and ⑨ Miscellaneous Collections. As a flexible tool and choice-based model, it is designed to benefit municipalities at different levels of development and preserves their existing investments. Accordingly, it can be applied to greenfield states with no existing e-governance systems, brownfield states with few discrete systems, as well as mature states which accommodate sophisticated systems, see Table 7-1.

The three engagement models for states and urban territories          Table 7–1

| Model | Description | Affordability | Suitability |
|-------|-------------|---------------|-------------|
| Model 1 | Adopt UPYOG in a centrally hosted platform (service model – PaaS). | Start at a low cost of adoption with a short time to go live. | Suitable for greenfield states. |
| Model 2 | Adopt UPYOG with a state or urban territory – hosted (data centre/cloud) setup. | Moderate cost and higher control. | Suitable for brownfield states with discrete systems or apps. |
| Model 3 | Continue using existing systems including those developed under AMRUT 2.0. | Use NUDM standards and APIs to obtain an integrated view of services. | Suitable for states and urban territories with mature systems already in place. |

Source: Adapted from Agnihotry. D., (2025). National Urban Digital Mission (NUDM) 2024: A Framework for Integrated Urban Governance. Available at https://www.impriindia.com/insights/nation-urban-digital-mission/ (Accessed: 7/7/2025).

While strengthening existing urban systems and applications has been important to maintain their efficiency, ensuring they conform to defined standards and integrate seamlessly with the NUDM framework has been equally critical. NUDM therefore develops and enforces the adoption of open standards by national digital urban stakeholders in which states and ULBs can create and host their own instances on specific cloud servers. It also formulates dedicated registries at local levels to create single source truth for urban assets, services, data and actors. The National Institute of Urban Affairs then publishes standards for the urban e-governance system including those on data reporting and open APIs, in which states and ULBs are obligated to report data digitally ensuring compliance with these standards. As it is a nationwide programme, each state and urban territory is steered via a State Programme Directorate, an institutional mechanism supported by programme monitoring units. Subsequently, within individual ULBs, a dedicated programme cell comprising of at least two members is designated to manage the platform under the supervision of the Commissioner of the Municipal Corporation.

Establishing digital capacity building tools for more effective urban decision-making to unlock a space in which stakeholders can digitally consolidate skills, and local governments can enhance knowledge and capacities, NUDM designed the National Urban Learning Platform (NULP) to empower urban ecosystem actors. It integrates learning, content and collaboration for urban leadership with 12 actively participating states, 449 ULBs and more than 150,000 NULP community members.[1] NULP provides educational courses and facilitates peer-to-peer and blended learning from other cities and domain experts to advance skills and facilitate a prosumer approach to knowledge and skills development, see Figure 7-10. At present, it hosts 10 domains and 114 courses with 70 knowledge partners having generated 200 urban solutions.[2]

The UPYOG architecture also hosts a consolidated decision support system composite tool, Urban Monitoring for Efficient and Effective Decision-Mak-

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1    National Urban Learning Platform. (n.d.) National Urban Learning Platform. Available at: https://nulp.niua.org/ (Accessed: 7/7/2025).

2    Ibid.

Source: National Urban Learning Platform. (n.d.) National Urban Learning Platform. Available at https://nulp.niua.org/ (Accessed: 7/7/2025).

Figure 7–10    NUPL state activation workshop at Ranchi, Jharkhand

ing. This provides a real-time, customizable and interactive dashboard that empowers administrators to make data-driven decisions by providing visualization on key metrics regarding municipal services delivery. More than 2,000 cities have enabled push live data on the platform, and it has published six standards guidelines' specifications across urban e-governance domains to promote elements such as data usage, data-driven governance and data, processes and systems interoperability within ULBs. The tool allows for state-wise project tracking, key performance indicator overviews across modules and states, key performance indicator insights, data points definitions, filters to customize data views, as well as the ability to personalize analytics and share or download dashboards. At present, 14 states are inputting data into Urban Mon-

itoring for Efficient and Effective Decision-Making from over 2,000 ULBs, with several states and urban territories in process, see Figure 7-11.[1]

The India Urban Data Exchange, built as a digital public infrastructure for secure and authenticated data exchange between different municipal departments, government agencies, citizens and the private sector, also reflects a key initiative under NUDM. It serves as an exchange platform to share data across applications and services in a unified and common format in which municipal departments can share and open up data to third party developers to stimulate innovative new applications and citizen services, see

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1    National Urban Digital Mission. (n.d.) Urban Monitoring for Efficient and Effective Decision-making (UMEED). Available at https://www.nudm.mohua.gov.in/umeed/ (Accessed: 7/7/2025).
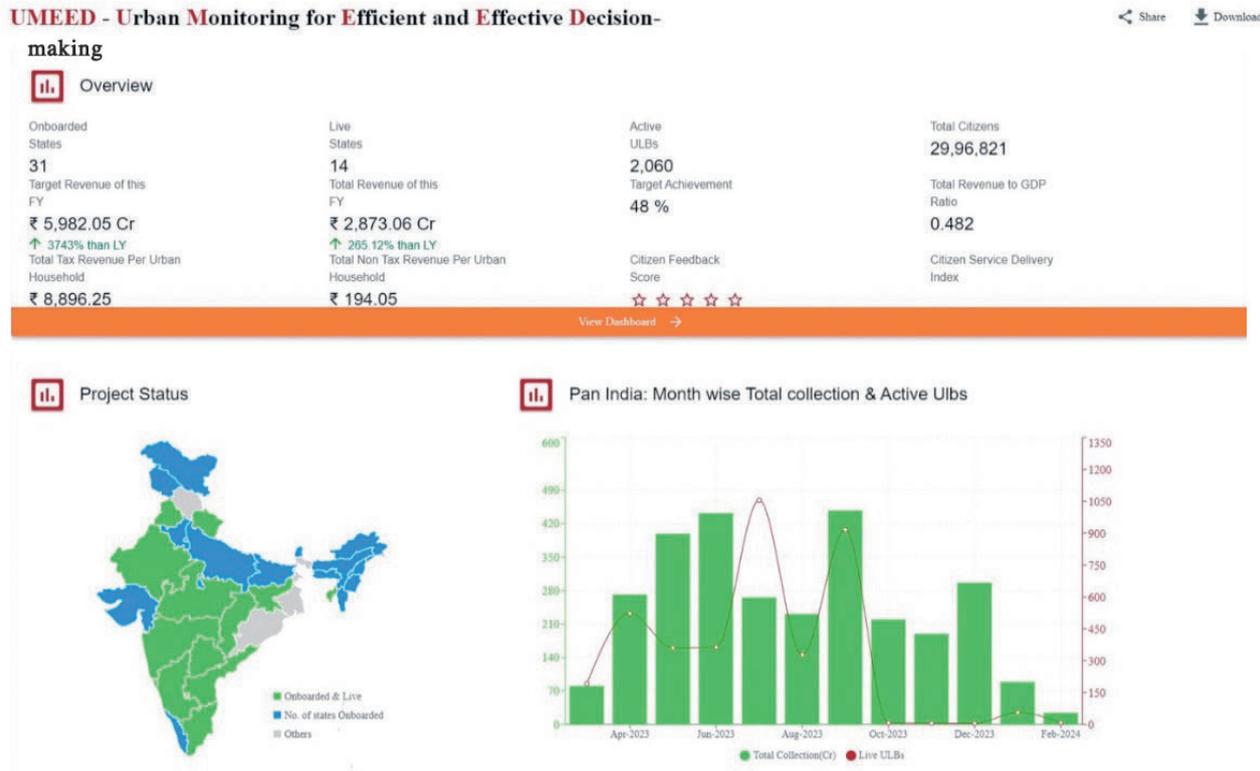
Source: National Urban Digital Mission. (n.d.) Urban Monitoring for Efficient and Effective Decision−making (UMEED). Available at https://www.nudm.mohua.gov.in/umeed/ (Accessed: 7/7/2025).

Figure 7−11　Urban Monitoring for Efficient and Effective Decision−Making dashboard data visualization

Figures 7-12 and 7-13. By increasing efficiencies within urban decision-making, it enables the roll-out of smart city initiatives, enhancing services and revenues, and reducing municipal costs. Fifty cities have currently been onboarded onto the India Urban Data Exchange with 15 industry engagements, 8 use cases and 776 data resources. [1]

To connect cities with innovators to generate new solutions for urban challenges, NUDM also launched the City Innovation Exchange. This initiative has marked the first step in creating innovation zones within ULBs, embodying principles of open innovation to direct knowledge and ideas into urban territories to close innovative capacity gaps in ULBs, and enrich the design and delivery of products and services. Integrating 104 cities at present, it functions as an open innovation platform that supports city administrators to discover and scale up innovations in order to identify and remove systemic bottlenecks, blind spots and inefficiencies. To date, it contains 11 challenge sectors with 882 challenges, 1,083 innovators and has generated 343 solutions. [2]

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1　India Urban Data Exchange. (n.d.) India Urban Data Exchange. Available at https://iudx.org.in/ (Accessed: 7/7/2025).

2　National Institute of Urban Affairs. (n.d.). City Innovation Exchange. Available at https://cityinx.niua.org/ (Accessed: 8/7/2025).
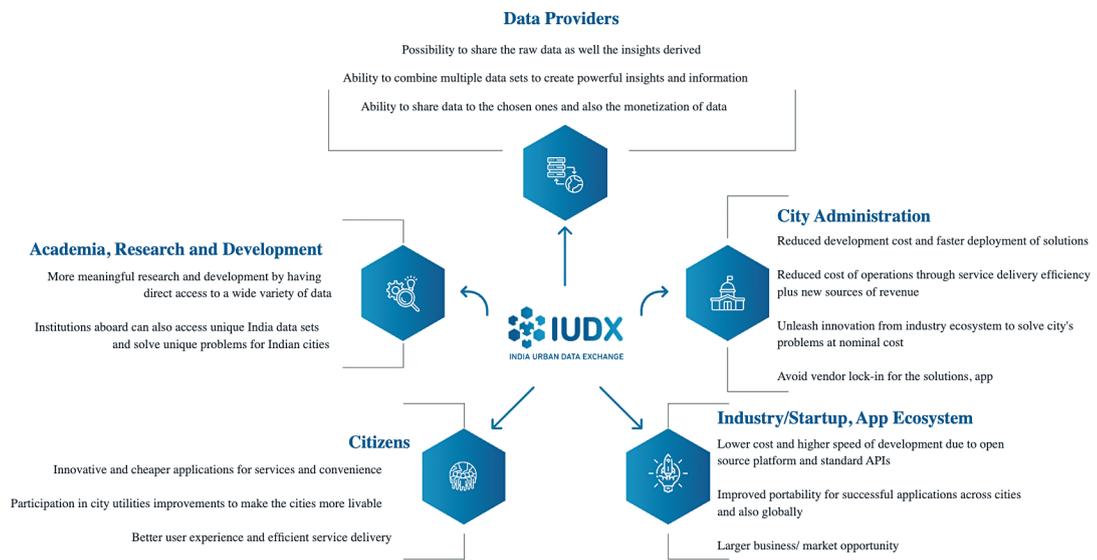
Source: India Urban Data Exchange. (n.d.) India Urban Data Exchange. Available at https://iudx.org.in/ (Accessed: 7/7/2025).

Figure 7–12    The role of the India Urban Data Exchange across different urban stakeholders



Source: Ministry of Housing and Urban Affairs, Government of India. (n.d.) India Urban Data Exchange (IUDX). Available at https://smartcities.gov.in/India_Urban_Data_Exchange (Accessed: 7/7/2025).

Figure 7–13    India Urban Data Exchange situation room

## Reference Experiences

**1. Strengthen Interdepartmental Coordination to Improve Urban Service Delivery**

NUDM has underscored the ongoing challenge of siloed operations among urban service departments, highlighting the need for continued coordination and direct communication to streamline governance efforts. In India, a lack of technical expertise and digital literacy among municipal staff emerged as a key barrier to effectively implement the initiative with an urgent need to undertake capacity-building and practical, hands-on training to upskill municipal officials. As more cities engage with NUDM, the need for increased financial and human resources will grow, reiterating the importance of long-term institutional support to ensure that digital transformation efforts are inclusive, scalable and sustainable. NUDM demonstrates that for successful digital transformations within governance structures, cities must stimulate new collaboration, investing in capacity-building and building cultures that value digital service delivery. Sustaining long-term impact also requires reliable funding and strong institutional support to ensure inclusive and lasting impact.

**2. Build Flexible Mechanisms to Operationalize Digital Governance across Diverse Municipal Contexts**

The initiative reaffirms the importance of ensuring inclusive and adaptive e-governance frameworks that fit municipalities at all levels of development maturity. As is evident in India and the global south, municipalities vary widely in their administrative, technical and financial capacities. Implementing a linear, top-down e-governance solution without considering these disparities can lead to system failures, low adoption rates and deepening inequalities between well-resourced and under-resourced municipalities and regions. Successful urban e-governance transformation, therefore, requires more than just technology, but a strategic, phased and locally responsive approach. For municipalities with reduced capacities, initial investments in digital literacy, basic infrastructure and simple service digitization can establish a foundation for future growth, while more developed municipalities can further enhance integrated platforms, open data and participatory digital governance mechanisms to their own needs. Institutional support and policy alignment here remains critical including incentives for innovation, frameworks for inter-municipal collaboration and capacity-building programmes that target both technical staff and leadership. It is important for national-level coordination to strike a balance between providing unified standards and allowing for contextual customization. By ensuring that e-governance systems are accessible, scalable and flexible, this empowers all municipalities to improve service delivery, increase transparency and foster citizen trust, regardless of their starting point on the development spectrum.

## Paris, France
## The Metropolitan Districts for Innovation Programme–Smart Governance for Urban Fragmentation

While the smart city concept has emerged as a key strategy to address various issues in the process of rapid urbanization, its implementation is perceived as overly technology-driven, lacking a truly people-centred approach and frequently struggling to scale successful pilot projects to a larger scope, leading to fragmentation in the urban innovation landscape. Greater Paris, as a vast and complex metropolitan area composed of numerous independent municipalities, faces inherent complexities in achieving coordinated urban planning, efficient service delivery and equitable development across its diverse districts. This multi-jurisdictional structure exacerbates the issue of innovation fragmentation. Historically, urban experimentation in Greater Paris has been characterized by a multitude of isolated pilot projects and, while often innovative individually, these projects frequently operated in silos.

To tackle the fragmentation, the QMI plan was designed and has been implemented since 2023.[1] QMI is led by the Métropole du Grand Paris and operated by Paris&Co, a prominent innovation agency in the region. QMI positions itself as a governance innovation — a solution to a systemic organizational and policy challenge. Its ambitious and comprehensive vision is to fundamentally transform Greater Paris into a "dynamic urban innovation laboratory". The ultimate goal of this transformative process is to significantly enhance the overall quality of life for residents, actively contribute to urban sustainability on both environmental and social levels, and proactively drive economic development across the entire metropolitan area.

**1. Human-centred Open-air Labs**

QMI strategically designates selected pilot communities across the Greater Paris as "open-air labs" or "innovation districts". These real, inhabited urban environments serve as testing grounds where solutions are developed and rigorously experimented with, directly addressing specific, identified local challenges, ensuring that innovations are inherently socially relevant and responsive to real-world needs. Through testing in real communities, it consciously bridges the gap between theoretical innovation and practical application in the full spectrum of urban complexity, significantly increasing the likelihood of successful adoption and real impact. In its initial phase, QMI has successfully deployed 28 high-impact solutions in the first four metropolitan areas (Aulnay-sous-Bois, Meudon, Noisy-le-Grand, Sceaux), see Figure 7-14. As of February 2024, more than 20 per cent of the projects are already in use.[2]

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1   Métropole du Grand Paris. (n.d.) Quartiers Métropolitains d'Innovation. Available at https://metropolegrandparis.fr/en/quartiers-metropolitains-dinnovations (Accessed: 15/7/2025).

2   Métropole du Grand Paris. (n.d.) Quartiers Métropolitains d'Innovation. Available at https://metropolegrandparis.fr/en/quartiers-metropolitains-dinnovations (Accessed: 15/7/2025).

Source: Métropole du Grand Paris. (n.d.) Quartiers Métropolitains d'Innovation. Available at https://metropolegrandparis.fr/en/quartiers−metropolitains−dinnovations (Accessed: 15/7/2025).

Figure 7−14　Distribution of cities participating in the two rounds of QMI

**2. Multi-stakeholder Co-creation**

Concurrently, QMI actively fosters unprecedented collaboration among a diverse range of stakeholders, including startups, academic researchers, public authorities at all levels, citizens, civil society organizations, SMEs, cooperatives, educational institutions and professional designers, who collectively co-develop and design innovative solutions. In this co-creation approach, innovative solutions are not simply presented to stakeholders but are co-developed and designed from the outset. This ensures a high degree of local relevance and significantly increases adoption rates as solutions are tailored to the real needs and preferences of the community. For example, Choose Paris Region, Banque des Territoires and Institut Paris Region all provide essential support, expertise and guidance on project financing and critical impact assessment.[1] The "co-creation" in QMI means active joint development, fostering a deep sense of belonging and shared responsibility among all participants. It enables long-term success and sustainability of urban innovation.

**3. Phased Adaptive Implementation and Scalable Rollout**

The QMI programme follows a carefully structured phased implementation process, which includes clearly defined stages such as calls for projects, systematic stakeholder engagement and dedicated project incubation services. Support for participating municipalities is provided in phases

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1　Métropole du Grand Paris. (n.d.) Quartiers Métropolitains d'Innovation. Available at https://metropolegrandparis.fr/en/quartiers-metropolitains-dinnovations (Accessed: 15/7/2025).

and meticulously tailored to their specific needs, including specialized training modules like the Pass Expé training programme which focuses on enhancing local capacities in urban experiment management and effective project communication. This phased support and training enables local municipalities to effectively manage urban experiments, aiming to build local innovation capacity rather than just project delivery.

In tandem, a key component of the programme is the ongoing monitoring of each project's impact and its scalability. This ongoing evaluation helps identify successful innovations that can be effectively replicated and adapted elsewhere in the metropolitan area, thereby maximizing their broader utility. The successful renewal of the programme for a second cohort and the integration of six new municipal districts is a strong demonstration of its commitment to sustained,[1] adaptive implementation, addressing the common challenge of pilot projects failing to scale up due to a lack of ongoing support and adaptive management.

# Policy  Suggestions

## 1. Promote Cross-departmental and Cross-sectoral Data Sharing to Advance Collaborative Applications of Artificial Intelligence

Data sharing and collaboration across departments and sectors can support the development of intelligent urban governance. AI-enabled platforms can analyse large datasets to extract insights that inform evidence-based decision-making. Standardization and interoperability of data enhance the potential of AI to improve the efficiency and quality of public services. Cross-departmental collaboration can reduce information silos, increase the value of shared data and promote a more integrated approach to smart city development, contributing to more intelligent and effective urban governance.

## 2. Advance Artificial Intelligence-enabled Smart Infrastructure to Accelerate Digital Transformation

Smart infrastructure reflects a key element of smart city development. AI, big data and IoT demonstrate capacities to enable real-time monitoring, fault prediction and automated optimization across urban systems. For example, AI-driven transportation systems can analyse traffic flows to support real-time scheduling, improving mobility efficiency, reducing congestion and lowering accident rates. Similarly, smart grids and water systems can use real-time monitoring to enhance resource efficiency. Integrating AI into urban infrastructure supports higher efficiency and sustainability in city operations. It is evident that by integrating AI into urban infrastructure, the technology can contribute to more efficient, sustainable and resilient city operations, providing a foundation for adaptive and forward-looking urban governance.

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1　Métropole du Grand Paris. In 2024, 6 new metropolitan innovation districts to join the QMI scheme, 2024. Available at https://www.metropolegrandparis.fr/en/2024-6-new-metropolitan-innovation-districts-join-qmi-scheme (Accessed: 15/7/2025).

**3. Provide Flexible Testing and Regulatory Environments for Emerging Technologies to Foster Innovative Artificial Intelligence Application**

Flexible testing and regulatory environments can facilitate the development and novel application of AI and other emerging technologies. Regulatory sandbox mechanisms, for example, allow technologies to be tested and evaluated in controlled settings, providing opportunities for refinement while limiting excessive intervention. Such approaches can help align innovation with urban governance needs and support the sustainable development of AI. Ongoing monitoring of technological advances and adjustments to policies can ensure that emerging technologies are deployed under conditions that maintain public safety and regulatory compliance, contributing to the modernization of urban governance.

**4. Integrate Artificial Intelligence-based, Big Data Decision-support Systems into Municipal Governments**

AI-based, big data decision-support systems enable comprehensive analysis into diverse real-time urban data, offering evidence-based insights to inform urban policymaking. AI technology holds immense potential in aiding decision-making among municipal governments, enabling cross-sector and multi-dimensional integration of information to detect key insight, capture trends and generate forecasts to address key urban challenges. Accordingly, cities can tap AI as a governance tool to optimize urban strategic development and policy formulation.

**5. Strengthen Digital Skills Training for Citizens to Promote and Scale the Inclusive Use of Artificial Intelligence**

As AI becomes more integral to urban governance, citizens' digital skills and understanding of AI are important for realizing smart city benefits. Digital skills training, in particular for vulnerable groups, can support broader understanding and use of AI in daily life. By combining both online and offline learning approaches, cities can build capacity for digital participation and foster equitable access to smart city services. In this regard, a broadened public awareness and comprehension of AI has significant potential to contribute to strengthen inclusive adoption of AI and associated technologies, thus narrowing the digital divide and promoting equitable forms of technological governance within cities and municipalities.

**6. Embed a People-centred Approach to Artificial Intelligence-driven Urban Governance**

A people-centred perspective is fundamental to AI-driven urban governance. Via the equitable application of AI and promotion of human-centric technological design, such components will play a pivotal role in connecting smart city development with the needs of urban citizens themselves. With a multitude of benefits for cities, AI can improve the efficiency and quality of public services to ensure that all citizens, including disadvantaged groups, can access the benefits of smart urban systems. Considering this, it is important to acknowledge the importance of leveraging these tools within urban governance systems as a means to integrate the perspectives and needs of citizens, and facilitate people-centred urban development.

Chapter Eight
International Cooperation: Scaling Smart City Solutions through Global Networks and Knowledge Exchange

# Introduction[1]

Globally, there is no single blueprint for smart city development. Each city evolves within its own historical context and faces distinct needs among local citizens, infrastructural capacities and technological maturity. To fully harness the potential of digital innovation, city-to-city learning serves as a key tool to provide inter-city exchange, enabling cities to learn from diverse global experiences and adapt knowledge in line with local priorities and unique cultural identities.

As a complex development process, the creation of people-centred smart cities requires cross-sector and multi-stakeholder cooperation in addition to strategic financing and technological integration. Effective post-construction governance is equally critical and, as cross-border connections become more decentralized with a growing involvement of regional and municipal actors, international cooperation is ever more pivotal to ensure smart city initiatives deliver equitable outcomes leaving no one behind. Where international cooperation for smart cities involves the exchange of technological developments across borders, it also strengthens coordination among actors, helping establish shared standards and collaborative platform mechanisms. As it requires active participation, the process encourages constructive dialogue among multiple stakeholders and stimulates collaborative innovation in the design of people-centred smart city initiatives.

The logic of international cooperation in smart city development is grounded in the theories of urban agglomeration and synergy theories. Cities, through their economic linkages and social networks, naturally generate flows of people, capital and information that stimulate growth. Urban agglomerations amplify these effects, creating hubs of technological innovation amid global economic integration. Recognizing these dynamics, many countries, including the United States via its Strategy for American Innovation, the United Kingdom through its Innovation Nation and Germany via its High-Tech Strategy 2020 have made urban innovation a national priority. Synergy theory further underscores that coordinated action across borders yields benefits greater than the sum of individual efforts.

A people-centred approach ensures that international cooperation in smart city development ultimately serves urban citizens. It prioritizes basic needs, equitable access to services and improved quality of life while enhancing urban environmental quality. Through multi-lateral frameworks and regional partnerships, governments, private enterprises, academia and community organizations hold significant potential to collectively drive technological research, implement projects and exchange policy expertise to meet the current challenges of urbanization. These activities not only help establish common smart city standards but also guarantee that technological solutions are co-created, and reflect social inclusion and local aspirations.

Framed under the lens of people-centred approaches to international cooperation for smart city development, this chapter presents case studies from Chengdu and Nanning in China, and Bangkok. It explores different pathways to leverage cross-border cooperation as a mechanism to drive people-centred smart city development, with particular emphasis on projects that serve the needs of urban citizens, improve the quality of life in cities and encourage diverse participation in smart city development in line with the SDGs.

# Reference  Cases

## Bangkok, Thailand
## Technological Implementation and Local Innovation in a Multi-layered Smart City Cooperation Network

### Case Background

Dating back to 2017 and promoted by the Smart City Thailand Office under the Digital Economy Promotion Agency (DEPA), Thailand's smart city initiatives are committed to the facilitation of urban innovation and integrated development with a reliance on Thailand 4.0 and the Twenty-Year National Strategy. With Bangkok, Phuket and the Eastern Economic Corridor (EEC) as prominent pilot regions, the initiatives set to achieve intelligent transformation in transportation, urban environment development and governance leveraging IoT, 5G technology and open data to establish a nationwide City Data Platform, see Figure 8-1.[1]

In 2019, Bangkok was chosen by DEPA and the Smart City Thailand Office as a national smart city pilot. DEPA empowered local government by providing technological tools, such as sensors, integrated data systems and digital twin technology, for real-time monitoring and predicting potential natural



Source: "Criteria for Smart City Development" by Digital Economy Promotion Agency. Available at https://www.depa.or.th/en/digitalservice/smartcity/promotion%20criteria.

Figure 8-1   Areas covered under DEPA Smart City Project

or man-made disasters. Since then, Bangkok has been advancing the construction of its smart city ecosystem in various fields, with continuous breakthroughs each year. Through multinational cooperation and public-private partnerships, Bangkok has steadily improved in terms of sustainability and economic growth with plans to achieve full smart city certification by the end of 2025.

### Implementation Process

Based on its own economic development and development objectives, Bangkok places importance on two main areas in terms of smart city construction: infrastructure development and environmental quality improvement.[2] Investments in infrastructure have prioritized improvements of the living environment and expansion of the transportation network, easing Bangkok's current municipal challenges and transforming the city into a hub for Thailand and the Association of

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1   Digital Economy Promotion Agency of Thailand launched its smart city project, fully committing to advancing the smart city movement. It introduced the Smart City Thailand logo and welcomed participation from cities nationwide in the development of smart city prototypes. Available at https://depa.or.th/th/article-view/smart-city-th.

2   ASEAN Smart Cities Network, "Monitoring & Evaluation Report", 2024, 2024-ASCN-ME-Report-Final_25Sep2024-for-public.pdf.

Southeast Asian Nations (ASEAN). Large-scale investments in the environment are primarily based on Thailand's current economic development model.

**1. Building Multi-layered Partnerships for Technological Cooperation**

As a founding member of the ASEAN Smart Cities Network, Thailand has been collaborating with ASEAN countries such as Singapore since 2018 in areas like e-governance, urban resilience and digital infrastructure, and has also played a leading role in developing the Southeast Asia Smart Cities Interoperability Standards which promote cross-border sharing of technology, data and governance experience. Involved in smart city construction are a broad range of sectors and techniques, high financial demand and long construction duration, making discussions with external partners, acquisition of external funding and attraction of foreign investment in smart cities one of the key steps in ASEAN's implementation of the Smart Cities Network project. In recent years, Thailand has established a smart city international cooperation network with multiple countries through MoU and cooperation agreements. Key partners include Canada, China, the European Union, Japan, the Republic of Korea and the United States.

As the capital and largest metropolis, Bangkok is rapidly developing into a transportation hub for the ASEAN region through a series of strategic projects, realizing the urban connectivity envisioned in Thailand 4.0. In collaboration with EEC, Thailand's other major high-tech industrial area, Bangkok is co-developing a Smart Transportation Corridor whose core project is the Bang Sue Grand Station, Southeast

Asia's largest railway hub which will connect high-speed rail, commuter rail, the subway and the airport express line. The project involves the use of technologies such as GPS, closed-circuit television video surveillance, Bluetooth and microwave radar to build a real-time traffic situation awareness system, providing planners and the public with a visual interface for road conditions, accident-prone areas, freight vehicle trajectories and traffic violations, as shown in Figure 8-2.

Additionally, information interconnection is achieved through Vehicle-to-Everything communication and urban Apps. This system provides travel planning advice, congestion warnings and accident prevention support for regional transportation.[1] Dahua
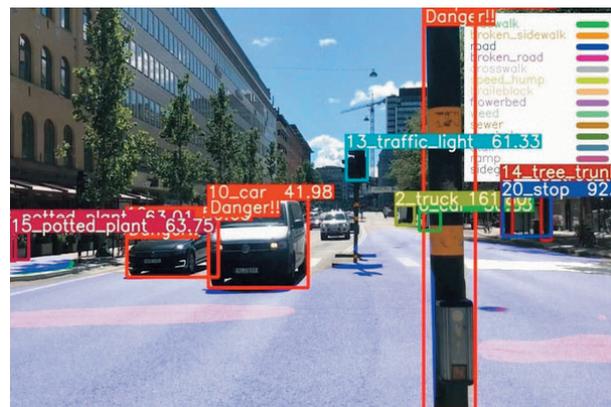


Source: Smart Cities World. Bangkok to deploy AI-based traffic prediction technology. https：//www.smartcitiesworld.net/ai-and-machine-learning/bangkok-to-deploy-ai-based-traffic-prediction-technology

Figure 8-2 Bangkok AI real-time traffic Perception System image

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1    Thai Government, "Driving Forward: Web Application for Traffic Management in EEC Advancing Smart Transport Policy," 2025. Available at https://thailand.go.th/issue-focus-detail/-web-application--eec-; Silklegal, "Driving High-Tech and Sustainable Economic Growth in the EEC". Available at https://silklegal.com/thailands-eastern-economic-corridor-eec-a-strategic-hub-for-innovation-and-investment.

Technology has deployed high definition cameras and AI video analysis equipment in the Sukhumvit Road public safety monitoring system to enable smart inspections and real-time warnings.[1] In addition, Google supports Bangkok's smart city initiative through Google Cloud, providing cloud computing and AI technologies to assist with traffic planning, environmental monitoring and emergency management, utilizing its maps and location services to optimize urban services.[2]

Based on stable global and regional cooperation, Bangkok's smart city "circle of friends" has provided reliable city-level collaboration. In 2013, Yokohama, Japan was the first to sign an MoU with Bangkok for meteorological cooperation. Through the Y-PORT project, Bangkok initiated a series of intercity flood disaster prevention and climate adaptation collaborations. When developing the Bangkok Climate Change Master Plan (2013–2023), Yokohama provided technical support and experience sharing, including climate risk assessments, low-carbon urban transportation strategies and green infrastructure development.[3] Yokohama also actively promoted Bangkok's membership in the Overseas Environmental Cooperation Center (OECC)-led Asian Cities Green Alliance, forming a collaborative network of climate resilience policies between cities. On 15 November 2023, at the 12th Asia Smart City Conference in Yokohama, Bangkok, Yokohama and 43 other Asian cities jointly signed the Yokohama Declaration: Asian Cities Together Towards Zero Carbon committing to achieving a zero-carbon future and promoting green infrastructure, community participation and carbon-neutral practices.[4]

Climate workshops are a key field of this collaborative declaration. Since the launch of Japan's Y-PORT project and the City-to-City Cooperation (low carbon smart cities cooperation) mechanism in 2013, Bangkok and Yokohama have held several decarbonization and climate action seminars and trained over 200 Bangkok municipal officials covering flood management, climate policy formulation and other areas. A series of climate resilience and low-carbon development workshops are also regularly held through continued collaboration with the Japan International Cooperation Agency and OECC under the Ministry of Environment in Japan and the Bangkok Metropolitan Administration. Bangkok officials have visited Yokohama's smart pump stations, green embankments and eco-coastline designs. In 2024, Bangkok and Yokohama co-hosted three city-level Decarbonized City Collaboration Workshops, discussing decarbonization and climate action, intercity technology exchanges,

1    RYT9 Press, "Dahua Technology Opens Showroom in Thailand Setting to Be the Largest One in Southeast Asia", 2024. Available at https://www.ryt9.com/en/prg/278469.

2    Reuters, "Google to invest $1 billion in Thai data centre, cloud infrastructure", 2024. Available at https://www.reuters.com/technology/google-invest-1-billion-thai-data-centre-cloud-infrastructure-2024-09-30.

3    Bangkok Metropolitan Administration, "The 2nd Comprehensive Review of the Progress of Implementation and Achievement of the Bangkok Master Plan on Climate Change 2013–2023. Available at https://climatechange.bangkok.go.th/ccs-blog/wp-content/uploads/2024/10/CR2_ENG_Sum_180123.pdf. OECC, "Cities where dense populations live and work can lead the world in climate action. The OECC supports city-to-city collaborations and promotes the development of sustainable cities." Available at https://www.oecc.or.jp/en/project/climate_change/mitigation/city.

4    Global Covenant of Mayors for Climate & Energy, "43 Cities and Organizations Join Forces in Landmark Declaration, "Asian Cities Together Towards Zero Carbon," led by Yokohama and Bangkok," 2024. Available at https://www.globalcovenantofmayors.org/press/43-cities-and-organizations-join-forces-in-landmark-declaration-asian-cities-together-towards-zero-carbon-led-by-yokohama-and-bangkok.

early warning mechanisms and organizing field drills. The Mayor of Yokohama, representatives from the Japanese city of Osaka and the Mayor of Bangkok attended.[1]

As cooperation matures and stabilizes, Bangkok has firmly embedded itself in the global smart city ecosystem. In 2023, Bangkok signed an MoU with Moscow, establishing knowledge transfer goals for smart city innovation and clean energy transportation solutions for 2023–2025.[2] In May 2023, the Bangkok Metropolitan Administration signed an MoU with Incheon Metropolitan City of the Republic of Korea to jointly advance smart city development. This agreement includes collaboration in digital governance, disaster risk reduction technologies and integrated urban planning.[3] In April 2024, Bangkok renewed its MoU with Kunming, China expanding their partnership to include public works, environmental management and smart transportation systems.[4]

**2. Establishing Global Partnerships to Drive Local Innovation and Talent Development**

The development of innovation capabilities is a

significant step for Bangkok in its journey toward becoming a smart city and remains a fundamental guarantee for the city's sustainable development. In recent years, many global tech companies have chosen to set up regional R&D and training centres in Bangkok, encouraging the younger generation to actively engage in the technological field, not only by providing them with opportunities but also by fostering their skills for long-term growth.

Currently, the One Bangkok mega-project, located in the city, integrates smart infrastructure, green buildings and human-centred experiences. It is one of Thailand's largest integrated development projects and a model for smart city development in the ASEAN region. Under the One Bangkok project, international companies from China, Japan the United States and other regions have played a key role, providing advanced technologies and solutions for Bangkok's smart city initiatives.

With more than 20 years of investment in Thailand, Japanese companies have played a leading role in Bangkok's smart city development. Hitachi Consulting, as the project designer, implemented an IoT-based integrated urban system, which covers energy management, water regulation, traffic monitoring, building maintenance, security, environmental monitoring and other key areas, see Figure 8-3. The system enables intelligent connectivity and highly automated management of urban infrastructure.[5]

1    Yokohama City Asian Office, "Yokohama Mayor Yamanaka and Bangkok Governor Chadchart to Co-create the Path to Net Zero: City-to-City Cooperation Spreads to Business Partnerships," 2024. Available at https://businessyokohama.com/blog/2024/06/25/yokohama-and-bangkok-co-create-path-to-net-zero.

2    Public Relations Office, Bangkok Metropolitan Administration, "Bangkok makes pact with Moscow to collaborate on 6 aspects", 2023. Available at https://pr-bangkok.com/?p=102502.

3    BMA Data Center, "BMA links up with Incheon on smart city development, tourism" 2023. Available at https://www.nationthailand.com/thailand/general/40027843.

4    Thaiger, "Bangkok Council signs MOU with Kunming City Council to enhance cooperation in various fields," 2024. Available at https://thethaiger.com/hot-news/politics/bangkok-council-signs-mou-with-kunming-city-council-to-enhance-cooperation-in-various-fields.

5    PR Newswire, "Hitachi Consulting Selected to Design 'Smart City' Services for One Bangkok, Thailand's Largest Private Sector Property Project", 2018. Available at https://www.prnewswire.com/news-releases/hitachi-consulting-selected-to-design-smart-city-services-for-one-bangkok-thailands-largest-private-sector-property-project-300602638.html.
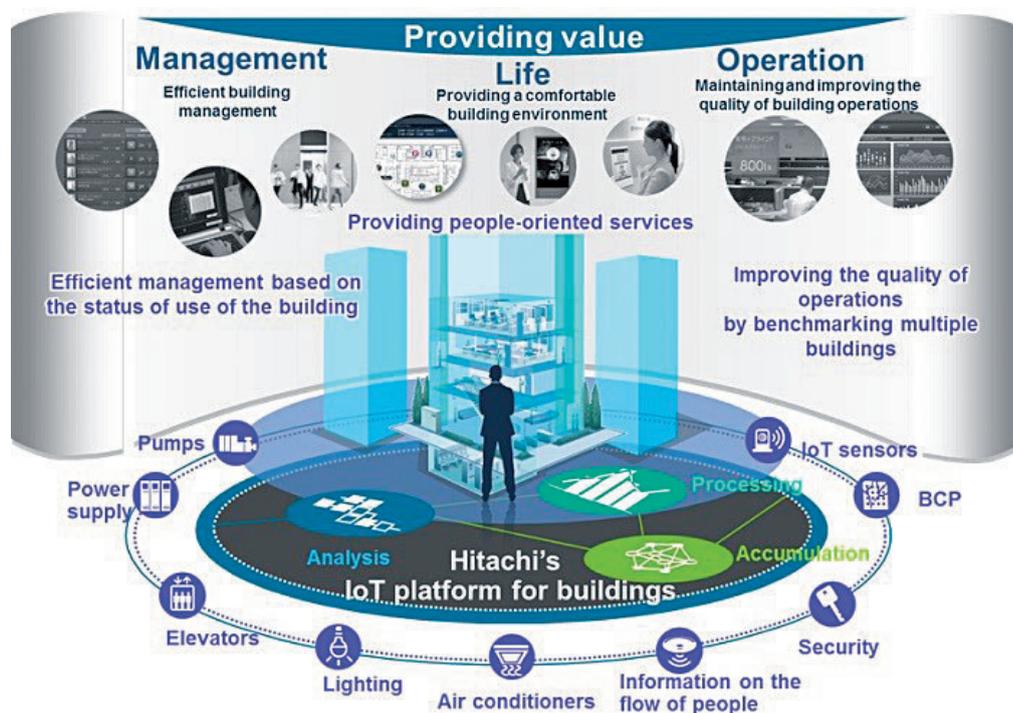
Source: Hitachi Asia Project Handbook. Available at https://www.hitachi.asia/hitachi−to−launch−full−scale−smart−building−solution−in−thailand/.

Figure 8−3    Hitachi's IoT smart building solution for Bangkok

Hitachi's Lumada Center Southeast Asia, located in EEC Thailand, provided the technological support necessary to achieve these goals. The core component of the system is the smart city sensor network (Smart City Sensor Grid) that covers the entire One Bangkok area. This sensor network consists of over 250,000 assorted sensors distributed throughout streets, buildings, public spaces and key infrastructure, collecting multidimensional environmental and operational data in real-time. The sensors monitor parameters such as air temperature, humidity, noise intensity, light brightness, air pollution levels and carbon dioxide concentration, as well as pedestrian density and vehicle movement. All the data collected by the sensors is transmitted securely and at high speed to a central IoT platform, which integrates big data processing, cloud computing and AI technologies, and then performs real-time analysis and deep data mining. With advanced machine learning algorithms, the platform can not only detect abnormal patterns and potential risks but also predict equipment failure, energy waste and traffic congestion, enabling predictive maintenance and proactive management. Additionally, the platform incorporates various emergency response mechanisms. In the event of incidents such as fires, floods or air pollution, the system can quickly trigger alerts and disseminate information to relevant departments and the public through multiple channels, reducing response times and minimizing potential losses.

With a relatively comprehensive and mature smart city infrastructure in place, Bangkok is collaborating with EEC to cultivate the next generation of

digital talent in fields such as smart manufacturing, AI, robotics and IoT using a "training + practice" model. Through the establishment of joint innovation labs, organization of smart city training camps and hosting of entrepreneurial competitions, both regions are advancing Thailand's innovation ecosystem. Projects, particularly the Huawei ASEAN Academy (Thailand), have promoted digital courses and cloud developer training in Bangkok. It is expected that by 2025, about 10,000 ICT talents and 5,000 cloud and AI developers will be jointly trained.[1] Hitachi, as the "chief designer" of One Bangkok, has also established the Lumada Center Southeast Asia in EEC, providing IoT and AI co-creation and on-site training services.[2] Microsoft Thailand's TH AI Academy and Amazon AWS Academy have collaborated with local universities to offer AI and cloud computing skills courses.[3] In March 2025, DEPA and local business Techsauce launched Techsauce Academy, Thailand's first Enterprise Lab dedicated to providing internships and job opportunities for digital skills practitioners.

Under the complementary development dynamics with EEC, Bangkok serves as both a testing ground for smart city development in Thailand and an ASEAN knowledge and technology hub. With One Bangkok, the largest and most mature smart community in Thailand, Bangkok is complementing the young EEC by accelerating talent development, promoting the transformation of research achievements, and enhancing the country's overall digital competitiveness. This cross-regional collaboration has not only promoted knowledge sharing and interconnectivity between Bangkok and EEC but has also showcased Thailand's strategic ambition to build an ASEAN smart city cluster.

**3. Data Platform Integration to Connect Citizens, Government and Regional Services for Smart Urban Development**

A core element of Bangkok's smart city development is the creation of the City Data Platform driven by DEPA. The City Data Platform serves as a central hub for data exchange between the government, businesses and citizens, ensuring that key urban data is securely shared, managed and readily accessible in real time. It operates under the ASEAN Data Management Framework (DMF) and the ASEAN Cross-Border Data Flows Mechanism (CBDFM), which together ensure secure data governance and provide compliant pathways for data transfer between enterprises and nations. Public, business and research organizations can access categorized data provided by government department, in accordance with established regulations.[4]

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1　Xinhua Silk Road: Thai Government Partners with Chinese Company Huawei to Promote Digital Talent Training, 2024. Available at https://www.yidaiyilu.gov.cn/p/0F3HE1RQ.html.

2　Hitachi, "Co-Creating at Lumada Center Southeast Asia, Transforming the Manufacturing Industry through Smart Data Analytics and AI". Available at https://social-innovation.hitachi/en-sg/innovationhub/lumadacenter_sea/.

3　Businesswire Press, "AWS Launches Infrastructure Region in Thailand". Available at https://www.businesswire.com/news/home/20250107963455/en/AWS-Launches-Infrastructure-Region-in-Thailand.

4　ASEAN Data Management Framework and Model Contractual Clauses on Cross-Border Data Flows, 2021. Available at https://www.pdpc.gov.sg/news-and-events/announcements/2021/01/asean-data-management-framework-and-model-contractual-clauses-on-cross-border-data-flows.

Source: Official Website of National Science and Technology Development Agency (NSTDA). Available at https://www.nstda.or.th/sci2pub/traffy−fondue−feature−update/.

Figure 8−4  Traffy Fondue publicity poster

The Traffy Fondue platform launched in Bangkok is a successful example of data sharing under the DMF framework, see Figure 8-4. Developed by the National Electronics and Computer Technology Centre, this chatbot-based public fault reporting system was launched in 2022, allowing citizens to quickly report urban construction issues. Users simply upload photos and descriptions via a mobile interface, and the system automatically analyses the problem type and forwards the case to the responsible local agency for processing. The platform integrates AI-based classification and priority recognition technology, providing real-time feedback on issue resolution,

significantly improving public service response efficiency. By the end of 2022, over 1,700 local agencies including district governments, industrial parks and public hospitals in Bangkok, had joined the platform.[1]

According to data from the National Science and Technology Development Agency, Traffy Fondue has helped the Thai government save over THB 78 million, with citizen satisfaction reaching 89 per cent. Entering 2024, the platform further integrated an AI enhancement module for in-depth semantic rec-

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1  Hansen, Michael Motet and Bharat Dahiya. "Traffy Fondue: a smart city citizen engagement." Frontiers in Sustainable Cities 7 (2025): 1491621.

ognition of image and text content. It simplified the reporting process into three steps, increasing the success rate of problem resolution to 77 per cent.[1] The government is also actively expanding the platform's coverage, which is now being implemented in over 2,000 local government units across the country, with more than 1.37 million cases processed. The big data collected by the platform has become an essential reference for optimizing urban renewal, traffic safety, environmental cleanliness and drainage systems, further assisting municipal departments in early warning and maintenance.[2]

Mature data governance is boosting confidence and determination in Bangkok's data channels. Some hospitals in Bangkok have tested electronic medical record systems, receiving requests from Singapore or Malaysia to shorten emergency medical response times across borders. This supports queries for core projects like patient information, medication history and vaccinations, reducing the approval and data verification time for cross-border healthcare.[3] Through the CBDFM certification mechanism, Thailand's hospital system can safely share patient basic medical records with neighbouring countries under unified standards for emergency healthcare, joint epidemic responses

and regional healthcare collaboration. The DMF's data classification and governance principles ensure privacy protection and quality standards during the sharing process. Although related mechanisms are still in the early stages, Bangkok is actively engaging with ASEAN's digital health framework, poised to rise as a regional healthcare hub.

## Reference Experiences

**1. Ensure Cross-border Urban Cooperation Prioritizes Human-centric Development Outcomes**

Bangkok partners with cities such as Kunming and Yokohama to address urgent urban issues through practical, challenge-driven collaboration. Joint climate workshops focus on flood prevention, technology transfer and professional training, translating international expertise in decarbonization and resilient infrastructure into solutions tailored to local conditions. This model demonstrates how global partnerships can remain people-centred by grounding cooperation in specific local needs, prioritizing capacity building and ensuring that knowledge exchange strengthens local community safety and environmental quality.

**2. Harness Digital Tools to Facilitate Two-way Engagement for Locally Responsive Urban Development**

Through digital open-data platforms such as Traffy Fondue, Bangkok residents can report and track municipal issues in real time, transforming technology into a two-way communication channel as opposed to a top-down government tool. AI-powered classification can be deployed to accelerate municipal

1　Advanced AI in Traffy Fondue Platform Enhances Problem-Solving Efficiency, 2024. Available at https://info.traffy.in.th/Advanced-AI-in-Traffy-Fondue-Platform-Enhances-Problem-Solving-Efficiency-2dd8050ea9654b069f68cb200d85d714.

2　BANGKOK (NNT), "Traffy Fondue platform to enhance efficiency of public services", 2022. Available at https://www.nstda.or.th/en/news/news-years-2022/traffy-fondue-platform-to-enhance-efficiency-of-public-services.html/.

3　Cindy Peh, "Snapshot of EMR progress in ASEAN", 2025. Available at https://www.hospitalmanagementasia.com/th/tech-innovation/snapshot-of-emr-progress-in-asean.

government responses and offer transparent feedback to users. Simultaneously, multinational companies such as Hitachi and Huawei are establishing local innovation hubs and training programmes in IoT and cloud computing. Such approaches ensure that cutting-edge technologies are translated into local employment opportunities and homegrown digital skills, reinforcing urban development that provides tangible social benefits for local people.

**3. Strengthen Regional Coordination on Data to Ensure Inclusive Approaches to Healthcare**

Under ASEAN DMF and CBDFM, Bangkok illustrates the potential for cross-border healthcare data to shorten emergency medical response times. In turn, this highlights the role of regional cooperation in data sharing to strengthen urban public health. While safeguarding data security, by acknowledging specific livelihood needs the case of Bangkok demonstrates the value of cross-border data sharing as a means to strengthen essential urban services, disaster response and enhance public health within cities.

## Chengdu, China
## Sharing E-government Practices through the World Smart Sustainable Cities Organization

### Case Background

Globally, smart city development still faces significant imbalances. Most leading practices are concentrated in northern cities, while many emerging cities encounter difficulties with technology implementation, a lack of institutional pathways and insuf-

ficient channels for sharing experiences. In this context, the World Smart Sustainable Cities Organization (WeGO), which aims to establish mechanisms for South-South knowledge flow and co-building of governance experiences between cities at different stages of development, has become a crucial institutional bridge connecting cities in the Global South. By setting up regional offices, sharing policy tools and promoting cross-city capacity building, WeGO injects key momentum into the co-building and shared governance of smart cities.[1]

Leveraging the WeGO East Asia Regional Office platform based in Chengdu, the city government continues to promote the institutionalized operation of "smart mobility and logistics", focusing on key topics like smart transportation, urban logistics and digital governance. This has resulted in a systematic layout in fields including policy dissemination, capacity building and international technical cooperation.[2] The WeGO office in Chengdu has also become a key anchor in expanding WeGO's global influence.[3]

### Implementation Process

Since its 13th Five-Year Plan, Chengdu has focused on smart city construction with an adherence

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1    World Smart Sustainable Cities Organization (WeGO), 2025 Annual Report. Available at https://we-gov.org/portfolio/wego-annual-report-2025/.

2    WeGO Successfully Hosted the 2024 WeGO-Chengdu Smart City Training Program, WeGO, 2024. Available at https://zh-cn.we-gov.org/New2023/wego 2024 Chengdu Smart City Training Program Successfully Concluded/ (Accessed: 15/6/2025).

3    The Korea Times, "Seoul's Smart City Award Launched to Bridge Urban Digitization". Available at https://www.koreatimes.co.kr/foreignaffairs/20230221/seouls-smart-city-award-launched-to-bridge-urban-digitization (Accessed: 15/6/2025).

to the improvement of the modernization of urban governance. The Chengdu New-Type Smart City Construction Three-Year Action Plan (2021–2023) released in 2021 further clarified key tasks including digital governance, intelligent transportation and urban sensing systems.[1] In the Key Points of 14th Five-Year Plan for Chengdu's Opening-up, Chengdu proposed "attraction of permanent international organizations and participation in multilateral mechanisms", with the goal of enhancing the city's institutional participation and platform influence in global issues. This served as the core logic for the establishment of the WeGO regional office in Chengdu. WeGO's mission aligns with Chengdu's strategic vision for "smart city" development. Chengdu has not only made the leap from infrastructure-oriented to institution-empowered development but also provided a replicable experience for cities in the Global South to expand the institutionalization of "people-centred" smart governance.

**1. Building Global Smart City Capacities Through Chengdu's Long-term Training and Knowledge Sharing**

Chengdu has maintained an open stance in the process of building a smart city and has embedded itself within the global urban governance network. Its strategic cooperation with WeGO serves as a key pillar in enhancing its international collaborative capacity.[2] Since 2015, the city has worked hands on with WeGo, launching the Smart City Training Program that aims to promote global sharing of urban governance experiences through regular training platforms and to facilitate the cross-border dissemination of smart city experience, see Figure 8-5. By the end of 2024, the programme has involved city managers, ICT technicians and policy researchers from over 50 countries and regions including Africa, Asia, Eastern Europe and Latin America, making it one of the most representative capacity-building initiatives within the WeGO framework.

Each session focuses on core topics such as digital governance, smart transportation, urban sensing system construction, big data governance, AI and public service innovation, sustainable cities and inclusive development. Every session of the programme combines lectures, field visits and roundtable discussions to help participants understand the portability and local adaptability of smart city tools. To date, multiple cities from Africa and Southeast Asia have introduced partial functional modules of Chengdu's Tianfu Smart Platform for local governance reforms after attending the training. In 2024, Chengdu hosted an international training event on Smart Transportation and Logistics, attracting urban representatives from seven countries in Central and Eastern Europe, Africa and Southeast Asia. The event showcased smart governance models across various sectors including government services, traffic control, logistics coordination and public service digitization.[3]

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1　Chengdu's 14th Five-Year Plan for the Construction of a New Smart City by Office of Government Service Management and Network Governance. Available at https://www.smartcity.team/policies/smartcitypolicies/chengdusmartcityplan/.

2　WeGo. Available at https://we-gov.org/regional-offices/.

3　WeGO, WeGO-Chengdu Smart City Training Program 2024. Available at https://we-gov.org/wp-content/uploads/2025/01/Information-Note-for-the-WeGO-Chengdu-Smart-City-Training-Program-2024-final-version-shared-with-all-participants.pdf.

Source: WeGO Successfully Hosted the 2024 WeGO−Chengdu Smart City Training Program, WeGO, 2024. Available at https://zh−cn.we−gov.org/New2023/wego (Accessed: 15/6/2025).

Figure 8−5    Chengdu Smart City Training Program 2024



Source: WeGO, WeGO Successfully Concluded the WeGO−Chengdu Smart City Training Program 2024. Available at https://we−gov.org/news−2023/wego−successfully−concluded−the−wego−chengdu−smart−city−training−program−2024/?utm.

Figure 8−6    WeGO members visit CRRC Chengdu and other companies

In addition, Chengdu leverages technical capabilities from companies such as CRRC Chengdu, JINGDONG Logistics and Southwest Jiaotong University, combining policy, practice and communication in site visits and case demonstrations, see Figure 8-6. By establishing mechanisms such as the International Project Joint Meeting System, Chengdu's smart city development has acquired the capability for sustainable and institutional output in international cooperation.[1] Representatives from participating cities visited main sites such as the Chengdu High-tech Zone Smart City Operations Centre, the Rail Transit Dispatch Platform and the Smart Train Manufacturing Base, promoting cross-cultural integration of Chengdu's solutions.[2]

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1    Sohu, Representatives from Nine Countries Come to Chengdu to Learn About Smart City Development. Available at https://www.sohu.com/a/824958776_121106884.

2    WeGO, WeGO Successfully Concluded the WeGO-Chengdu Smart City Training Program 2024. Available at https://we-gov.org/news-2023/wego-successfully-concluded-the-wego-chengdu-smart-city-training-program-2024/?utm.

## 2. Engaging Youth as Co-creators of Smart City Innovation

Chengdu considers youth participation as a key driver for the sustainable development of smart cities. Through policy guidance and the establishment of international practice platforms, the city encourages youth and other stakeholders to interact and establish connectivity, developing their knowledge and capabilities in sustainable urban development and smart cities.

As the leading city of the WeGO East Asia Regional Office, Chengdu has hosted events such as the World Youth Smart City Innovation Competition and the Diplomat Tomorrow project, encouraging youth from different countries to propose innovative solutions around topics like digital infrastructure, data governance and urban sustainability, while enhancing their cross-cultural understanding and institutional design abilities through the co-creation process. The Diplomat Tomorrow project, through modular course design, invites university students from various

Figure 8–7    International Future Envoy Contest, 2020

countries to engage in scenario exercises, thematic discussions and jointly draft policy recommendations on smart city topics, exploring the formation of white paper-style institutional outcomes, see Figure 8-7. This aims to provide pathways for youth involvement in future urban governance. The project not only expands channels for youth governance capacity building but also becomes an important attempt to strengthen intergenerational cooperation within the WeGO smart city capacity building system.[1]

With policy guidance at its foundation, Chengdu has institutionalized the key role of youth in smart city construction by issuing the Implementation Plan for the Pilot Program of a Youth Development-Oriented City in Chengdu (2022–2024). This provides

policy protection and resource support for youth participation in urban governance.[2] Simultaneously, leveraging the WeGO platform, the city has hosted the World Youth Smart City Innovation Competition, attracting young people from around the world to propose innovative solutions for urban sustainability and other topics. This encourages youth leaders to enhance their cross-cultural understanding and technological application abilities, injecting a youthful perspective into smart city development.

### 3. Establishing Chengdu as a Laboratory for Smart City Governance

Chengdu, through its cooperation with WeGO,

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1    WeGO, WeGO 2021 Annual Report. Available at https://we-gov.org/wp-content/uploads/2022/02/WeGO-2021-Annual-Report.pdf.

2    Implementation Plan for the Pilot Program of a Youth Development-Oriented City in Chengdu (2022–2024) printed and published by Service Website of Chengdu Municipal People's Government. Available at https://cds.sczwfw.gov.cn/art/2023/2/6/art_15395_208563.html?areaCode=510100000000.

has transitioned from a recipient of technology aid to an experience exporter, shaping itself as a city governance laboratory for the future. Through its institutionalized cooperation with WeGO, Chengdu has gradually risen to become the vice-chair of the organization,[1] successfully re-elected as the operating city of the WeGO East Asia Regional office. This co-operation has driven Chengdu's transformation from a technology recipient to a governance experience exporter, significantly improving its urban governance capabilities.

From a global third-party evaluation of Chengdu in 2024, the city ranked 93rd among the 142 smart cities worldwide with a smart city rating of CCC (above average) in the Human Development Index. With regard to residents' satisfaction, 86.6 per cent of users engage in cashless transactions regularly, 83.7 per cent support facial recognition to improve security, and over 85 per cent are willing to share personal data in exchange for more efficient traffic management. In areas such as health and safety, mobility, employment and education, and government transparency, Chengdu demonstrates strong technical integration, diversified applications and quick governance responses, reflecting its institutional advantages and governance technology maturity in the process of transitioning toward high-quality development as a megacity.[2]

## Reference Experiences

Through institutional cooperation with WeGO, Chengdu has redefined traditional urban governance approaches. By leveraging open data and knowledge sharing, the city has created an international system of mutual support and learning between cities, which has allowed Chengdu to transition from a recipient of technology to a generator of its own governance solutions; exporting experiences that strengthen urban management and global influence. The integration of youth into smart city initiatives has further promoted intergenerational collaboration and embedded resilience into urban development.

**1. Foster an Open Data Culture and Knowledge Sharing for Effective Global Governance Network Development**

Chengdu's cooperation with WeGO has broken down the traditional technological barriers in smart city development, creating a bi-directional knowledge flow mechanism of "Bringing In" and "Going Global". Through activities such as the WeGO East Asia Regional Office exchange seminars in Chengdu,[3] Chengdu Smart City Training Programme and the WeGO World Youth Smart City Innovation Competition,[4] Chengdu has built an exchange platform for experts and government officials from around the world to engage in mutual learning, co-creation and shar-

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1 Office of Foreign Affairs Committee of Chengdu Municipal Committee of the Communist Party of China, Chengdu Elected Vice President City of the World Smart Sustainable Cities Organization Executive Committee. Available at https://cdfao.chengdu.gov.cn/cdwqb/c146828/2021-10/19/content_5f6471c5c7d64c-96982d18e1cf4ba749.shtml.

2 WeGo, IMD Smart City Index 2024. Available at https://we-gov.org/wp-content/uploads/2024/07/WeGO-IMD-Smarti-Cities-Index-2024.pdf.

3 Diplomat Tomorrow: How to Embrace Smart Cities? See how Chengdu and WeGO "meet online" and the answers they found. Available at https://mp.weixin.qq.com/s/F2KK9VPTEZ9uxkm-0h1axmA.

4 International Chengdu, WeGO World Youth Smart City Innovation Competition officially launched. Available at https://mp.weixin.qq.com/s/KJMLK8BgLpEsEZyp7VkuCg.

ing.[1] These activities have helped Chengdu learn the latest global smart city construction achievements, promoting the integration of advanced technologies with local realities. In addition, they have systematically shared Chengdu's successful experiences in smart transportation, grassroots governance and digitalization of public services. This bi-directional interaction has not only promoted the global spread of Chengdu's governance model but has also used international feedback to optimize local governance, creating a virtuous cycle. Establishing structured knowledge-sharing platforms anchored by international organizations ensures that both local adaptation and global scalability are prioritized. Cities can rely on regional or international organizations to establish a normalized knowledge sharing platform, ensuring the implementation of experience through a composite model of training, on-site visits and joint meetings. It is also important to establish a verification mechanism similar to an "application scenario laboratory", allowing foreign technology solutions to be tested first and then promoted in local practical scenarios, achieving precise adaptation of cross regional experience.

**2. Empower International Youth to Drive Intergenerational Smart City Governance**

Chengdu's practice fully demonstrates that including youth in the governance agenda of smart city construction not only broadens the policy toolbox but also sparks social innovation, fostering the in-

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1　International Chengdu, Representatives from nine countries come to Chengdu to learn about smart city development. Available at https://mp.weixin.qq.com/s/KJMLK8BgLpEsEZyp7VkuCg.

tergenerational transfer and innovation of smart city concepts, thereby laying a foundation for long-term international talent that can drive the implementation of sustainable development goals. This initiative provides a practical paradigm for empowering youth participation and achieving urban sustainability goals for cities worldwide. Particularly for urban groups facing challenges such as rapid urbanization, youth disenfranchisement and governance resilience gaps, youth participation mechanisms will become a crucial complementary path for smart city development and the achievement of sustainable development goals. Cities can absorb the wisdom of young people through a combination of policies clarifying their participation status, building platforms for international innovation competitions and modular capacity training. Youth proposals can be transformed into institutional achievements such as white papers and, supported by entrepreneurship funds and mentorship systems, to transform youth innovation from ideas into sustainable governance practices.

## Nanning, China
## Development of the China-ASEAN Cross-border Credit Service Platform

### Case Background

China and ASEAN's trade relations have deepened, with ASEAN being China's largest trading partner for four consecutive years. With increasing cross-border business cooperation, the demand for credit information of cross-border partners has been growing. However, due to the under-development

and utilization of data resources, businesses face uncertainty in understanding the operational credit status and legal risks of cross-border partners, which in turn creates significant uncertainty in financial and business decision-making. Advancing the establishment and operation of cross-border credit cooperation mechanisms represents an important avenue for the promotion and full development of the credit economy. It can also aid the creation of an open, transparent and fair business environment, facilitate international trade and financial flows, and promote more effective global cross-border trade, financial and social governance.[1]

As the gateway for China-ASEAN open cooperation, Guangxi has significant regional and resource advantages in advancing digital credit technology, inclusive finance and cross-border finance with a reliance on the support of the China-ASEAN Information Harbour. As the closest provincial capital city to ASEAN and an important node in the New International Land-Sea Trade Corridor, Nanning is at the forefront of China-ASEAN open cooperation, connecting the domestic market on one side and the ASEAN market on the other, building a streamlined "Nanning Channel" for trade and industrial cooperation between China and ASEAN countries.[2]

In 2004, the China-ASEAN Expo was perma-

nently settled in Nanning[3] and in 2023, the Nanning area was rated as one of the first high-quality implementation demonstration zones for Regional Comprehensive Economic Partnership projects in Guangxi.[4] Nanning's position as the core hub for China-ASEAN cooperation continues to strengthen. In 2021, The Development Plan for Guangxi on the "Digital Silk Road" for ASEAN (2021–2025) proposed to optimize the digital financial cooperation ecosystem with ASEAN through the construction of a China-ASEAN cross-border credit service platform along with third-party credit institutions and the establishment of the China-ASEAN Credit Union.[5] Under the guidance of the People's Bank of China Guangxi Branch and the Nanning area of the China (Guangxi) Pilot Free Trade Zone, the Guangxi United Credit Co., Ltd. collaborated with local credit agencies from 10 ASEAN countries to establish the China-ASEAN Cross-Border Credit Union in efforts to address the asymmetry of cross-border trade and investment information. Together, they developed the China-ASEAN cross-border credit service platform, improving bilateral digital infrastructure connectivity and explored cross-border credit cooperation between China and ASEAN, thus driving the development of bilateral trade and eco-

1    Deepening Cross-Border Credit Cooperation to Promote Global Economic Integration by "Fareast Credit" WeChat Official Account, April 29, 2025. Available at https://mp.weixin.qq.com/s/haUrhy8zUD4l6SaIlQ-5UA.

2    Hu Guanglei: Unlock Nanning's "Strategic Values" and Smoothening the "Nanning Channel", NANZNINGZ YIZBAU, Page 03, December 15, 2024.

3    Wei Jing: China-ASEAN Expo: Playing the "Win-Win Tune" of China-ASEAN Cooperation, NANZNINGZ YIZBAU, Page 001, October 6, 2024.

4    Public Announcement on the Identification of the First Batch of Guangxi High-Quality Implementation RCEP Demonstration Project Clusters by the Department of Commerce of Guangxi Zhuang Autonomous Region, 2023-10-20. Available at http://swt.gxzf.gov.cn/zfxxgk/fdzdgknr/tzgg/t17309256.shtml.

5    Huang Senshen, Lu Xiaoqian: China-ASEAN Cross-Border Credit Cooperation and Prospects Under the New Situation published by Journal of Regional Financial Research, 2025, Issue 2, Pages 81–88.

nomic relations.[1] As a financial infrastructure platform for ASEAN, the China-ASEAN cross-border credit service platform focuses on three digital application scenarios: ① digital finance; ② digital supply chains, and ③ digital regulation. Under the bilateral legal framework, the platform builds three core products: ① systems — credit reports; ② precision marketing, and ③ intelligent risk control providing safe, trustworthy, efficient and convenient cross-border credit services for governments, banks and enterprises engaged in cross-regional cooperation.[2] The platform legally introduces foreign credit data, establishes an online service portal and integrates local development strategies to provide bilateral, convenient credit information services for domestic and foreign enterprises, boosting China-ASEAN economic and trade cooperation to higher levels. Since its official operation in 2021, the platform has promoted the digital upgrading of regional finance and trade, enhancing the stability and sustainability of bilateral economic cooperation, becoming a model for international digital cooperation.

## Implementation Process

Guangxi United Credit Co., Ltd. (hereinafter referred to as United Credit), as a corporate credit institution registered with the People's Bank of China, adheres to the strategic concept of "relying on scenarios, based on big data and using artificial intelligence

as a tool". By leveraging digital credit technology, United Credit empowers inclusive finance and has built a full-scene digital credit product system that includes credit reporting, precision marketing and smart risk control. At the same time, United Credit is actively exploring new models for cross-border financial services and promoting the construction of cross-border credit platforms. It successfully established and operates China's first cross-border credit service platform, the China-ASEAN platform based in Guangxi, covering the whole country and linking ASEAN. In addition, United Credit actively participates in the market-oriented reform of data elements, establishing multiple regional financing service platforms based on data empowerment. It also promotes the aggregation and authorized development of public credit data and has significantly contributed to the development of digital finance and inclusive finance.

### 1. Developing a Nationwide Credit Ecosystem through Data-driven Innovation

Since its establishment, United Credit has relied on the industry scenario platform to integrate multi-dimensional data resources such as corporate invoices, retail merchants, electricity, foreign trade and shipping, judicial risks, financial reports and business flows. The company continues to leverage the advantages of credit institutions, focusing on empowering credit in five key areas: financial technology; green finance; inclusive finance; pension finance; and digital finance. United Credit has developed a portfolio of credit products, including corporate invoice, retail merchant, corporate electricity, ship valuation, construction labour and foreign trade enterprise. The

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1   China-ASEAN cross-border credit service platform, homepage. Available at https://cdm.credit.caih.com.
2   Wumei Qiaohong: Utilizing Data Information to Help Enterprises Go Global by Guangxi Daily, Page 011, September 21, 2024.

operation scale of credit reports continues to grow and the usage rate steadily increases. As of the end of March 2025, United Credit's service coverage had expanded to 33 provinces, municipalities, autonomous regions and special administrative regions in China. It has established partnerships with over 90 financial institutions nationwide, providing 31.91 million enterprise credit reports and facilitating financing of over CNY 400 billion, in which a total of 8.57 million small and micro enterprises have benefited.[1] United Credit's client base and service capacity rank among the top licensed corporate credit institutions in the country, becoming a new force in the field of digital inclusive financial services.[2]

**2. Promoting New Models for Cross-border Financial Services and the Construction of Cross-border Credit Platforms**

In 2020, United Credit delved deeply into market participants' credit information and launched the China-ASEAN cross-border credit service platform based in Guangxi, serving the whole country and linking ASEAN, See Figure 8-8. As a financial infrastructure for ASEAN, the platform integrates domestic and foreign enterprise credit data and industrial transaction data through cross-border credit cooperation and industrial data integration. Under a bilateral legal framework, it provides secure, efficient and convenient market-based cross-border credit services

for inter-regional exchanges and cooperation among governments, banks, enterprises and credit agencies, both domestically and internationally, contributing to the mutual promotion and high-quality development of China-ASEAN economic and trade cooperation.

In July 2024, the China-ASEAN cross-border credit service platform project stood out among more than 200 national applications and became the only project in Guangxi selected as one of the first typical cases of Digital China development, see figure.[3] In March 2025, the platform successfully joined the Asia-Pacific and Middle East Credit Association. This not only highlights United Credit's commitment to participating in the global commercial credit market but also demonstrates the international recognition of United Credit's "credit +" solutions in areas such as business layout, project development, technical accumulation and operational experience in the global commercial credit information sector.[4]

Relying on Guangxi's geographical proximity to ASEAN and the policy benefits of the Regional Comprehensive Economic Partnership, the platform actively promotes cooperation between local credit institutions and globally leading credit agencies to facilitate the sharing of economic and financial information, see Figure 8-9. The platform collaborates

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1　Tan Zhuowen: Data-Driven, Enabling Micro and Small Enterprises to Sprint Quickly by Guangxi Daily, Page 010, May 22, 2025.

2　Huang Biqin & Lin Xiaoting: Digital Credit Technology Empowering Inclusive Finance, Promoting High-Quality Development of the Real Economy published by Finance Computerizing, Second Half of March Issue, 2025. Available at https://mp.weixin.qq.com/s/VvE6AzTxJVQGdeAejEdlhg.

3　China-ASEAN Cross-Border Credit Service Platform Selected as One of the First Typical Cases of Digital China Development by Guangxi Big Data Development Bureau, September 2, 2024. Available at dsjfzj.gxzf.gov.cn/dtyw/dtywzwyw/t18928069.shtml.

4　Good News! Guangxi United Credit Joins the Asia-Pacific & Middle East Credit Association and Actively Integrates into the Global Commercial Credit Ecosystem published by China-ASEAN Information Habor (CAIH) Official WeChat Account, March 11, 2025. Available at https://mp.weixin.qq.com/s/lRCcFog6X-wOV9mGyTvuWBg.

Source: China—ASEAN Cross—Border Credit Service Platform Honoured as One of the First Typical Cases of Digital China Development published by China—ASEAN Information Harbour (CAIH) Official WeChat Account, September 2, 2024. Available at https://mp.weixin.qq.com/s/lX71nCfqD1sa3qnSmNktOw.

Figure 8–8　The China—ASEAN cross—border credit service platform project selected as one of the first typical cases of digital China development

with international credit groups such as Crif, Dun & Bradstreet, ASEAN's largest credit agencies like the CTOS Digital Berhad, the Lao Credit Information Company and leading credit tech service providers including Trust Decision, See Figure 8-10. These partnerships support the query of credit reports for over 200 million companies across more than 230 countries and regions, including 7.87 million ASEAN companies. The overseas version of the platform provides three main service sectors: report query sector including enquiries, translation and verification; security monitoring sector – system security and transaction counterpart risk; and the foreign trade industry map. The platform continues to provide services in border cities such as Baise in Guangxi and Chongzuo

in Fangchenggang for domestic and international due diligence scenarios in investment, financing and foreign trade. It has established cross-border credit cooperation with 11 domestic bank branches including the Bank of China, the Agricultural Bank of China, the Guangxi Beibu Gulf Bank, the Guilin Bank and five foreign bank branches including the Standard Chartered, the Development Bank of Singapore and the Nanyang Commercial Bank.

United Credit continues to work to export Chinese solutions to data standards and the establishment of credit systems. Relying on the capabilities the platform has built; it actively collaborates with ASEAN countries in the construction of credit information platforms to help build social credit systems in ASEAN nations. In August 2024, the first national level overseas credit information platform based on China's technical framework was officially launched in Vientiane, the Lao People's Democratic Republic, see figure 10. The Laos Enterprise Credit Information Platform facilitates the query of credit reports for 58,500 local enterprises in Lao and online verification of reports for Chinese enterprises.[1] The collaboration with the Laotian government to build the Laos Enterprise Credit Information Platform marks the first overseas market validation of China's characteristic credit service model and explores a pathway for replicating and promoting China's social credit system model to the Belt and Road Initiative co-building countries. As a benchmark case for the

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1　Source: Liao Xin, Wei Jinxi: Nurturing the Credit "Fresh Force" and Activating New Service Momentum, NANZNINGZ VANJBAU, Page 003, September 22, 2024.

Source: Liao Xin, Wei Jinxi: Nurturing the Credit "Fresh Force" and Activating New Service Momentum, NANZNINGZ VANJBAU, Page 003, September 22, 2024.

Figure 8−9    Display screen of the China−ASEAN cross−border credit service platform

China Solution in credit information service models, the successful implementation of this platform has significant international demonstrative value. It provides a practical and replicable path, as well as valuable experience, for the scaled promotion of credit services to more Belt and Road Initiative co-building countries and other regions globally. This showcases China's contribution in the construction of the global credit governance system. In the future, United Credit will gradually promote the application of credit data standards, data utilization and data security technologies in ASEAN countries, relying on overseas service bases.

**3. Promoting the Development and Use of Public Credit Data based on Provincial Financing Integrated Service Platforms**

Within the broader context of the digital trans-formation of governance and regulation, United Credit has actively participated in and explored the construction of provincial-level integrated financing service platforms. This has included undertaking the construction and operation of Guangxi's SMEs Credit Easy Loan integrated service platform and the Beibu Gulf Economic Zone financial service platform. By consolidating public data through these platforms, and leveraging big data and AI technologies, United Credit has developed public credit technology products to accurately match financial institutions with small and micro enterprises, effectively connecting business needs with financial services. The platform has integrated data from various sources including market regulation, taxation, social security, housing funds and electricity. It has also incorporated 39 categories, 133 data directories and 693 data resources,

Source: Laos Enterprise Credit Information Platform Officially Released published by Xinhuanet, August 9, 2024. Available at https://english.news.cn/20240809/fe43dc73ec8d41b7b8f377f54432a8e9/c.html.

Figure 8–10　Launch ceremony of the Laos Enterprise Credit Information Platform

and has accumulated approximately 44.7 billion business-related data entries, covering 8.09 million market entities in Guangxi.[1] By linking the industry internet platforms in Guangxi's districts and municipalities via an open platform, regional pillar industries can be served with scenario-based services. Enterprises can access financing services from any of these platforms, further enhancing the financial service capabilities for regional economic development. This also effec-

tively addresses issues like "financing difficulties and high costs" for small businesses and "information asymmetry" between banks and enterprises, helping regulatory departments with digital service provision and offering financial support for the high-quality development of Guangxi's economy.

## Reference Experiences

The China-ASEAN cross-border credit service platform integrates global data resources through market mechanisms, breaking down cross-border information barriers. It concurrently establishes a product system and standardized cross-border credit

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1　Huang Biqin & Lin Xiaoting: Digital Credit Technology Empowering Inclusive Finance, Promoting High-Quality Development of the Real Economy published by Finance Computerizing, Second Half of March Issue, 2025. Available at https://mp.weixin.qq.com/s/VvE6AzTxJVQGdeAejEdlhg.

system covering the full spectrum of enterprise financial needs. The platform also pioneers a regional cross-border credit portal, driving the efficient circulation of resources. This has created a collaborative development ecosystem that extends from Guangxi and radiates to ASEAN, offering a replicable practical model for border credit system construction and cross-border data flow, while presenting the China experience and China solution.

**1. Integrate Cross-border Data Resources to Strengthen the Foundations for Cross-border Credit Platform Construction**

The global optimization of resource allocation is the main driving force behind cross-border credit demand. Cross-border credit cooperation helps break down physical barriers and national separations, promoting the efficient flow of resources across borders. Due to varying development conditions for the credit information industries in ASEAN countries, a linked credit system has not yet been formed and there is a lack of market credit channels. As a result, businesses face significant information barriers in obtaining reliable and efficient cross-border credit information. The China-ASEAN cross-border credit service platform innovatively solves the institutional barriers to transnational credit cooperation through a market-oriented mechanism, forming a rare domestic cross-border data application cooperation platform. Through compliant data collection technologies and data ecosystem collaboration, the platform legally aggregates, integrates, governs and analyses diverse domestic enterprise credit data, building enterprise-specific credit models for invoices, retail merchants, electricity,

"issues of agriculture, farmer and rural area" shipping and other sectors. The platform organizes and utilizes existing data, transforming scattered data resources into credit assets.[1] At the same time, the platform deeply integrates credit information resources from China and ASEAN countries, offering one-stop services with "one-click query + one-click translation". It also synchronizes the business, information, logistics and capital flow data of Guangxi's foreign trade industrial chain, generating in-depth enterprise credit reports. By optimizing the cross-border credit information exchange mechanism, it solves the problem of asymmetric cross-border trade information, significantly enhancing the efficiency of cross-border credit data flow and creating a collaborative effect where "data flows faster and enterprises run less errand".

**2. Match Enterprise Needs through a Full Life Cycle of Cross-border Credit Services**

The platform focuses on three areas to form a closed-loop service for cross-border financial cooperation, precisely targeting the information needs of enterprises engaged in cross-border trade. Firstly, in regard to the development of a full life cycle product system, the platform co-creates multiple digital financial benchmark products with financial institutions such as invoice loans, merchant loans and electricity loans. It also develops full lifecycle risk control products for financial operations, covering pre-loan access verification, in-loan big data risk control and

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1    Digital China Construction Typical Case No. 40 | China-ASEAN Cross-Border Credit Service Platform Construction by National Data Administration, November 17, 2024. Available at https://www.nda.gov.cn/sjj/ywpd/sjzg/1118/202411180922162661893005_pc.html.

post-loan credit risk tracking. Secondly, it provides customized product solutions, in which the platform conducts in-depth data mining of enterprise data and vertical industry comparisons, creating 360-degree enterprise profiles. It provides refined digital marketing services such as customer segmentation analysis, potential customer mining and incremental expansion, while developing a cloud-based credit risk warning platform. This platform helps users quickly establish localized, customized risk control models and dynamic risk monitoring systems, enabling efficient pre-warning and precise identification of transaction risks. Thirdly, by building a standardized cross-border credit system, the platform introduces international authoritative resources, selecting global top credit institutions like Crif and Dun & Bradstreet, and integrates ASEAN enterprises' basic information, risk profiles and operating data through a market-driven cooperation mechanism. It outputs standardized credit reports to address cross-border trade information asymmetry. At the same time, it provides cross-border credit assessment support for financial institutions, helping them efficiently conduct cross-border trade settlements, financing and other businesses by accurately identifying the credit risks of foreign trading entities. The standardized credit evaluation system enhances the efficiency of cross-border fund circulation and risk prevention capabilities, forming a closed-loop service for cross-border financial cooperation.[1]

## 3. Strengthen Regional Cooperation to Drive the Development of Collaborative Development Hubs

The China-ASEAN cross-border credit service platform adheres to the strategic positioning of "empowering inclusive finance and assisting enterprises in going global", continuously consolidating its presence in the ASEAN market.[2] As China's first cross-border credit service platform, this platform not only provides access to enterprise credit ratings and development potential information, but also includes cross-border service records, credit profiles, risk monitoring and other details. It offers security for SMEs engaged in cross-border trade and facilitates mutually beneficial economic and trade cooperation between China and ASEAN.[3] The platform has pioneered a regional cross-border credit reporting portal and leveraged the geographical advantage of Guangxi's proximity to ASEAN to establish China's first cross-border credit query platform, breaking new ground in providing comprehensive access to credit reports for ASEAN enterprises. This initiative offers a practical model for the construction of border-area credit systems and cross-border data flow, setting a precedent for future development. Guangxi has been intensifying its efforts to build a "frontier" for cross-border credit cooperation with ASEAN, gradually improving the China-ASEAN cross-border credit

1   Sixth Batch of Systemic Innovation Achievements | Credit Bridge Connecting ASEAN: Cross-Border Platform Drives Cooperation, China (Guangxi) Pilot Free Trade Zone WeChat Official Account, May 15, 2025. Available at https://mp.weixin.qq.com/s/ZUH-c6M7gwXVKZBSglcN9_w.

2   Yang Xisun, Peng Xinyun: Guangxi: Injecting Financial Power into High-Quality Co-development of the "Belt and Road" Initiative published by Financial Times, Page 002, February 12, 2025.

3   Liao Xin: Creating a New Digital Economic Cooperation Landscape: A Win-Win Future for the "Digital Silk Road" published by NANZNINGZ YIZBAU, Page 007, December 13, 2024.

service platform and other cross-border information infrastructure. By establishing a diversified credit product system that "focuses on Guangxi, radiates nationwide, and targets ASEAN", it encourages local credit institutions to deeply engage in international exchanges, export credit expertise overseas, promote cross-border information sharing and enhance regional cooperation. These efforts aim to empower Guangxi's socioeconomic high-quality development, providing valuable experiences that can be replicated.[1]

**4. Recognize the Importance of Digital Financial Inclusion to Advance Sustainable Urban Development and the SDGs**

The construction and operation of the China-ASEAN cross-border credit service platform not only effectively addresses the issue of cross-border information asymmetry but also injects new momentum into regional sustainable development, strongly aligning with the SDGs. The platform serves as a key cross-border digital financial information infrastructure. By integrating global data resources and applying big data and AI technologies, it significantly enhances the efficiency and accessibility of cross-border digital financial services. The platform, based on digital financial information infrastructure, incorporates enterprises from developing countries into the financial services value chain and market, enabling them to access affordable credit on fair terms. This contributes positively to supporting economic development and enhancing human well-being

in alignment with the achievement of sustainable development goals.[2] The platform also focuses on cross-border data sharing and innovative international cooperation mechanisms. It has formed alliances with local credit institutions in all 10 ASEAN countries and actively introduced authoritative resources from leading global credit institutions. It has exported the "China Solution" for credit services, strengthening China-ASEAN partnerships in the areas of credit data standards, credit system development and credit risk management. The platform is committed to global partnerships and cooperation, providing international support to developing countries. This ensures that no one is left behind on the path to development,[3] exemplifying the strengthening of global partnerships to achieve sustainable development goals.

# Policy Recommendations

**1. Leverage Digital Platforms to Promote Citizen-responsive Urban Cooperation**

Through the integration of governments, international organizations, private enterprises, community groups and resident representatives, regional smart city cooperation alliances have the capacity

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1　Tan Zhuowen: Data-Driven, Enabling Micro and Small Enterprises to Sprint Quickly by Guangxi Daily, Page 010, May 22, 2025.

2　The Sustainable Development Goals (Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation), United Nations. Available at https://www.un.org/sustainabledevelopment/zh/infrastructure-industrialization/.

3　The Sustainable Development Goals (Goal 17: Revitalize the global partnership for sustainable development), United Nations. Available at https://www.un.org/sustainabledevelopment/global-partnerships/.

to support and enhance urban policy development and project implementation. Community participation modules in cross-border projects and digital platforms can help to identify citizen priorities related to elements such as transportation, healthcare and environmental sustainability, allowing localized needs to inform international cooperation agendas. Cities can leverage participatory urban digital platforms designed to collect public concerns via means such as surveys and town hall meetings, linking them with technological solutions via international collaboration networks to generate co-created, citizen informed city solutions.

### 2. Foster Youth-led Innovation and Inter-generational Urban Collaboration

Youth participation mechanisms, such as participatory budgeting and innovation competitions, can introduce new perspectives into smart city planning and contribute ideas for sustainable urban solutions. Programmes including the World Youth Smart City Innovation Competition in Chengdu demonstrate how young people can influence urban renewal initiatives. It is evident that collaboration among government, industry, universities and research institutions can help cultivate multidisciplinary talents combining technical expertise with social awareness. Cross-border youth innovation labs and vocational education initiatives, drawing on experiences such as the Huawei ASEAN Academy in Bangkok or Microsoft TH AI Academy, also offer platforms for multinational collaboration on issues such as smart healthcare and low-carbon transportation.

### 3. Strengthen South-South City Networks and Encourage the Development of Associated Knowledge Sharing Platforms

Knowledge-sharing platforms facilitate the dissemination of practical, low-cost solutions suitable for small and medium-sized cities through workshops, policy briefs and peer exchanges. South-South knowledge flows, promoted by networks such as WeGO, enable cities such as Chengdu and Bangkok to share experiences with emerging cities in Africa and Southeast Asia along with other regions. Transnational city data-sharing frameworks allow for anonymized data across multiple urban elements to support evidence-based urban solutions and provide opportunities for third-party applications. Global databases of smart city solutions also provide resources tailored to diverse contexts including tropical climates, high-density settlements and other specific urban scenarios in the Global South.

### 4. Promote the Mutual Recognition of Technical Standards and Local Adaptation in Regard to Digital Urban Systems

Transnational coordination mechanisms hold significant potential in aiding the development of compatibility standards for smart city technologies, including digital twins and IoT, while also unlocking avenues for local enterprises to contribute to standard-setting processes. As highlighted in Nanning, cross-border cooperation laboratories can test and optimize sensor network deployment in different climatic and urban conditions. These approaches support the adaptation of technical solutions to local environments and facilitate the efficient transfer of technology across regions.
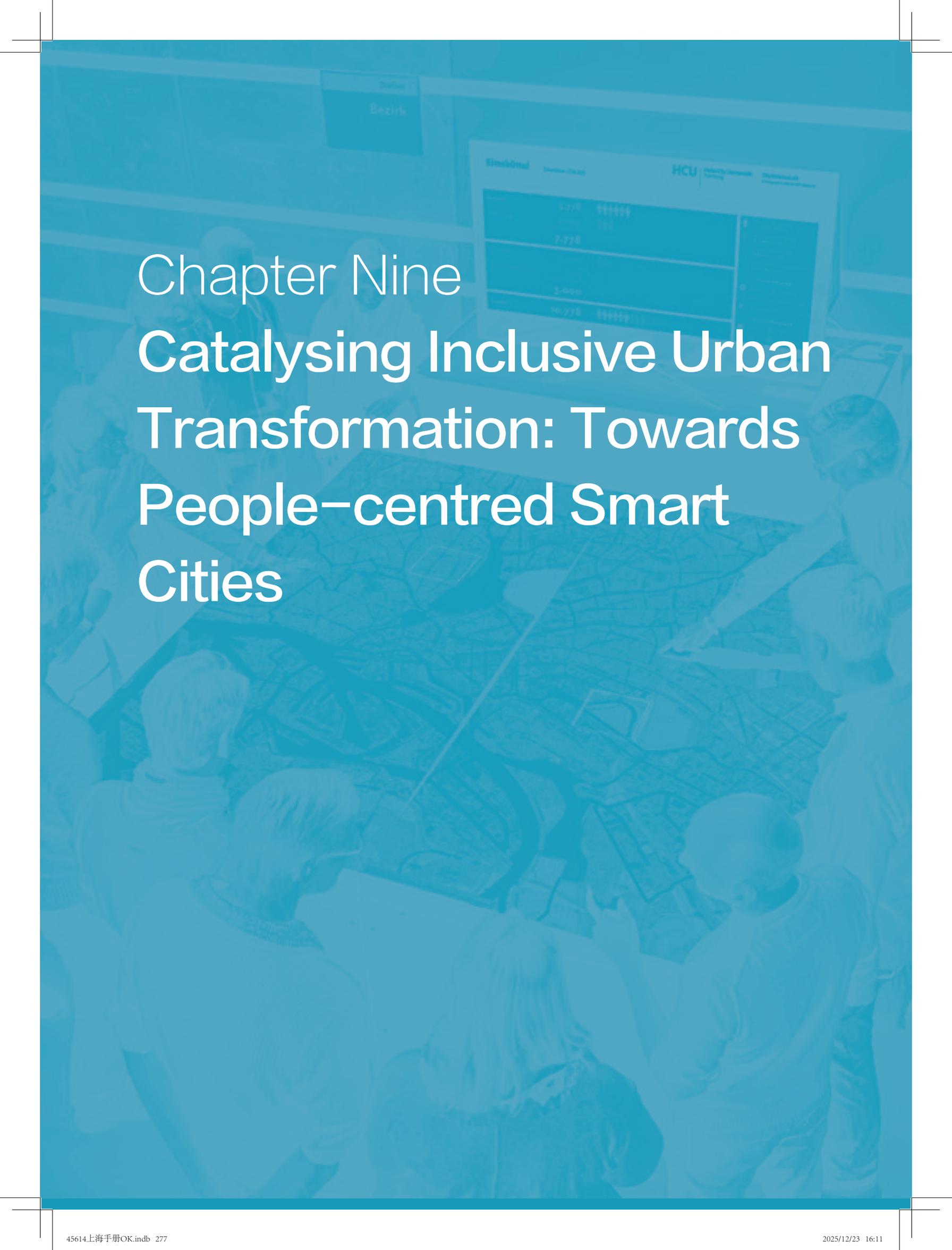
Chapter Nine

# Catalysing Inclusive Urban Transformation: Towards People-centred Smart Cities

# Introduction[1]

As cities undergo rapid urbanization and digital transformation, the challenge no longer remains the adoption of new technologies alone but ensuring that these innovations enhance urban inclusivity, equity and sustainability. Without a people–centred approach, smart city development risks deepening digital divides, undermining public governance and compromising human rights. As of 2024, approximately 68 per cent of the global population had access to the internet, indicating that a significant digital divide remains.[2] This is found to be particularly pertinent in low–income urban areas, limiting equitable access to smart city benefits and pushing the most marginalized further behind. With the growing privatization of public infrastructure, gaps in public oversight as well as national and local regulations persist in regard to the adoption of new smart city technologies. Here, data on individuals and communities is extensively recorded, and the integration of human rights and sustainable development aspects is marked as weak across smart city programmes. Operating as testbeds for new and sometimes unregulated technologies, cities are pressed to respond to these disruptive trends while also addressing emerging risks concerning surveillance and cybersecurity.

As smart technologies advance, cities are presented with opportunities to improve quality of urban life through increased governmental efficiency, uprated urban service delivery, job creation, citizen participation and the implementation of novel, sustainable city solutions. There is thus a growing need to ensure that smart city initiatives embed sustainability principles to ensure that actions successfully translate benefits to all urban citizens. It is imperative that cities prioritize people at the core of transformation and ensure that urban digital approaches prioritize human needs ahead of technology–led approaches alone.

Recognizing this and in line with the overall report theme, this chapter will unpack development regarding people–centred smart cities to highlight leading global actions and frameworks that are facilitating integrated, people–centred approaches in urban development policy and practice.

The chapter explores the current landscape in global local and national policy, and regulatory

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1   This chapter was written by UN-Habitat.
2   International Telecommunication Union (ITU), (2024). Internet Use. Available at https://www.itu.int/itu-d/reports/statistics/2024/11/10/ff24-internet-use/ (Accessed: 11/8/2025).

development in directing people-centred smart city development. It assesses current policy, including regional variations, as well as challenges and opportunities across areas such as digital infrastructure, data governance, digital human rights and environmental sustainability. It sets the foundation for understanding the complex regulatory environment that enables cities to accelerate the implementation of people-centred smart city initiatives, helping key stakeholders better understand hurdles in urban policymaking and practice. In addition, it showcases successful practices and presents policy-oriented recommendations to help cities fast track people-centred smart city development. It also introduces UN-Habitat's people-centred smart cities flagship programme including the draft International Guidelines on people-centred smart cities. The chapter aims to: ① define the core principles and frameworks of people-centred smart cities; ② assess the current policy landscape regarding people-centred smart cities; ③ highlight urban initiatives that demonstrate outstanding impact in the implementation of people-centred smart city development; and ④ introduce the UN-Habitat's people-centred smart cities flagship programme, and enhance global outreach and knowledge dissemination on the draft international guidelines on people-centred smart cities.

# Core Principles and Frameworks of People–centred Smart Cities

At the forefront of people-centred smart cities is the prioritization of urban citizens in smart city innovation and urban digital transformation processes. Central to this vision is the notion of digital inclusion and the provision of digital tools including internet connectivity extended to all, specifically those who are seen to be systematically excluded. This includes women and girls, children and youth, older people, the urban poor, people with disabilities, minorities and marginalized groups, as well as indigenous communities. In this regard, technology and digital tools can be seen as essential instruments to enhance the prosperity and quality of life for urban citizens. Bridging the digital divide is not limited to infrastructure expansion, but requires that access, services and opportunities are equitably distributed to enable all urban citizens to participate fully in social, economic and civic life. In tandem, the safeguarding of human rights and privacy in the digital sphere emerges as a critical concern. As data becomes increasingly integral to the functioning of cities, embedding principles of privacy, protection and non-discrimination across governance systems is key to ensure that new technologies enhance the quality of life for urban citizens without compromising their dignity or freedoms. In this regard, ethical approaches to digitalization can position technology as an instrument for empowerment and inclusion.

Transparency and accountability further underpin a people-centred approach to smart city development. Accessible data, open communication and robust mechanisms for public oversight are fundamental to build trust among urban citizens, authorities and private actors. Within this framework, citizen participation assumes a central role and unlocks opportunities for them to shape urban development processes in accordance with their own unique needs. Integrated frameworks that align governance, technology and service delivery are essential to realize these aspirations providing coherent policy direction, regulatory clarity and strengthened institutional arrangements that promote accountability in the deployment of smart city initiatives. When coupled with a well-governed data ecosystem, secure and interoperable digital infrastructure helps to build trust among urban citizens, promotes more efficient service delivery, and increases transparency in governance and data use. Service design that is accessible and responsive to local needs can ensure inclusivity remains central to smart city development.

As digitization processes require substantial energy and resource demands, urban digital transformations have environmental implications via emissions production, resource extraction and waste production, thus situating sustainability and resilience as equally critical principles. Cities are increasingly exposed to the impacts of climate change, more frequent and severe natural disasters, and related socioeconomic disruptions. They are pressed to address these environmental impacts while simultaneously enhancing their capacity to adapt to and recover from the related

impacts. By aligning technological transformation with environmental sustainability, cities can enhance urban efficiencies while preparing more effectively for future uncertainties.

When applied as integrated and connected concepts, these principles demonstrate that people-centred smart cities represent a holistic model of urbanization. Under such a framework, technology is harnessed as a means to advance inclusivity, protect human rights and strengthen the resilience of urban ecosystems. Such a model highlights the interdependence between social equity, environmental sustainability and digital governance, recognizing that the success of smart city transformation depends on their integration. In doing so, people-centred approaches reframe urban digitalization as a pathway towards inclusive prosperity and sustainable development, positioning cities not only as hubs of technological innovation but also as spaces that build trust and facilitate shared urban futures.

## Kigali, Rwanda
## Bridging the Digital Divide

Kigali has pioneered urban digital transformation and smart city development processes within Africa. Post 2010, the city relied primarily on 2G and 3G mobile networks with household broadband penetration at less than 10 per cent. With limited public internet coverage, the majority of citizens relied on a small number of hotels and business centres, severely limiting internet access.[1] In 2013, the city launched the Smart Kigali initiative in line with the national Smart Rwanda Master Plan (2015–2020). To reduce the digital divide, Kigali has channelled significant investment into digital infrastructure including Wi-Fi roll out across major bus stations, public squares, commercial hubs and university campuses. In addition, PPPs have supported the development of a nationwide high-speed broadband foundation, ensuring residents are provided with access to reliable, high-capacity internet. By 2023, 480 buses in Kigali's urban fleet had been equipped with free 4G LTE Wi-Fi, delivering affordable internet connectivity for the low and middle-income groups most reliant on public transport.[2] Free Wi-Fi is now widely available within public spaces, laying the foundation for the city to expand smart mobility services and digital public platforms that improve both urban mobility and administrative efficiency.

1　Ministry of ICT and Innovation Rwanda. Smart Kigali Initiative Launch Report, 2013. Kigali: Government of Rwanda.

2　MINICT Rwanda. Rwanda tops again Sub Saharan Africa in internet affordability. Available at https://minict.prod.risa.rw/news-detail/rwanda-tops-again-sub-saharan-africa-in-internet-affordability (Accessed 5 September 2025).

# Guiding People–centred Smart City Development– the Global Policy Landscape

The role of policy and regulation is increasingly critical to shape how emerging technologies and digital tools effectively serve urban citizens. In this light, urban digital transformation processes can be seen to be shaped by policies as much as the technologies themselves. This section analyses the current landscape in global policy and regulatory development on people-centred smart city development among local and national governments. Reviewing existing trends and variations, it explores current policy challenges and opportunities across areas such as digital infrastructure, data standards and governance, human rights in relation to the digitalization process as well as the environmental consideration of smart city transitions. It hence provides an overview to better understand the complex regulatory environment that guides people-centred smart city development, helping key stakeholders to better understand hurdles in urban policymaking.

## Urban Policies and Regulations

Working in harmony, national and local policies serve as the primary reference points for the implementation of digital technologies in urban contexts, particularly those governing broadband and sensor networks. As of 2020, 66 per cent of countries had ad-

opted national broadband plans to expand infrastructure and encourage the adoption of digital services. In addition, 70 per cent of countries had introduced national ICT strategies to foster digital transformation across sectors and promote the growth of the digital economy.[1] At the local level, municipal governments have promoted digital infrastructure developments through cost-effective regulations, including the reuse of existing physical infrastructure such as co-ordination of works across utilities and broadband providers. Several cities have also deployed publicly funded broadband networks via local utilities which have expanded affordable access but, in some cases, discouraged private investment due to concerns over long-term financial sustainability.

This re-emergence of public control over digital infrastructure has become a central policy debate, reflecting the need to balance accessibility, competition and technological sovereignty. In 2022, 82 per cent of countries had set up independent regulatory authorities to oversee ICT markets to promote competition, consumer rights and transparency.[2] More recently, calls for the re-nationalization of digital infrastructures, particularly within Europe, reflect efforts to safeguard technological sovereignty and democratic oversights of strategic facilities such as broadband network and data centres. These developments highlight the evolving tension between public control, market competition and citizen participation in shap-

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1   Based on the latest information from the ITU Data Hub.

2   ITU Data Hub. (2023). Regulatory Authority – Institutional structure. Available at https://datahub. itu.int/data/?i=100089&s=3144 (Accessed: 10/8/2025).

ing urban digital ecosystems. Concerns regarding freedom of expression and democratic oversight have incentivized calls for community-owned digital infrastructures, which are increasingly recognized by international institutions as tools for inclusion. Cybersecurity regulation has advanced rapidly alongside these developments. As of 2022, 71 per cent of countries had adopted national cybersecurity laws across areas of cybercrime (62 per cent), child protection (50 per cent), network security (49 per cent), critical infrastructure protection (48 per cent) and online fraud (45 per cent).[1]

Technical data standards also play a critical role in the deployment of urban digital infrastructures and services by ensuring interoperability, reducing vendor lock-in and operational costs. As of August 2024, the European Union Observatory for ICT Standardization listed 22 international standards specifically for smart city technologies, including ISO/IEC 30146:2019 which provides indicators to assess ICT adoption in cities and ITU-T Y.4905, a framework for the evaluation of socioeconomic and environmental impacts of digital innovation. Alongside global bodies such the International Organization for Standardization, International Electrotechnical Commission and the International Telecommunication Union, regional and local initiatives are advancing interoperability standards. Since 2015, municipalities across Asia and the Pacific, Europe and Latin America have joined the Open and Agile Smart Cities network to promote minimal interoperability mechanisms. Standardization organizations from China, the European Union, India, Japan, the Republic of Korea and the United States, have collaborated to establish a global standard for machine-to-machine communication across multiple domains including smart cities. Despite these efforts, however, significant barriers persist. In a Global Review on Smart City Practices, 30 per cent of participating cities stated that no data standards were in use within their smart city initiatives.[2] Policies promoting open-source and interoperable technologies remain limited. In 2022, 51 countries were enforcing laws on open-source technology use, and 38 were promoting the compulsory prioritization of open-source technologies over proprietary solutions in public procurement according to the Centre for Strategic and International Studies.[3]

As smart city services rely on both personal and non-personal data from both citizens and public spheres, this reiterates the importance of developing robust data protection and governance frameworks. The global regulatory landscape remains uneven. As of 2023, 58 countries lacked any data protection laws – predominantly small island developing states in the Caribbean and Oceania, alongside low-income

1   ITU Data Hub. (2024). Cybersecurity framework and mandates. Available at https://datahub.itu.int/data/?i=100103&d=Areas+covered (Accessed: 10/8/2025).

2   Beckers, D., Gerli, P., Mora, L., Thabit, S., & Tonnarelli, F. (2022). Global Review of Smart City Governance Practices. Available at https://unhabitat.org/global-review-ofsmart-city-governance-practices (Accessed: 11/8/2025).

3   UN-Habitat. (2024). World Smart Cities Outlook 2024. Available at https://unhabitat.org/sites/default/files/2024/12/un_smart_city_outlook.pdf (Accessed: 13/8/2025).

countries in Africa and Asia.[1] Similarly at the municipal level, findings from the Global Review indicated that 35 per cent of participant cities reported no significant challenges in the application of data protection rules, however, this share decreased to just 14 per cent among those in Africa which are subject to limited administrative resources and expertise. Across regions, smaller cities are disproportionately impacted by the bureaucratic requirements of data protection legislation, often lacking the capacity to recruit professionals with specialized skills. As of 2024, only 5.6 per cent of countries globally had adopted a dedicated framework according to the International Telecommunication Union, indicating a lag in the development of policy for data governance. In the absence of broader national frameworks, however, municipalities have started to bridge the gap. The United Nations Department for Social and Economic Affairs 2024 e-government survey found that 33 per cent of sampled municipalities had adopted open data policies.[2] Whilst this highlights some traction at the local level, it is evident that cities face barriers in ensuring compliance, particularly in regard to a lack of clear guidelines for issues such as the handling of non-personal data and datasets used within AI systems. Consequently, a more consistent approach to data governance is required to ensure fairness and accountability in data use among municipalities of different contexts.

The assurance of human rights within digital spaces is equally critical to the technical regulations and standards associated with digital infrastructure and data. Emerging technological developments, such as AI and facial recognition, have raised concerns regarding ethics, privacy and unintended societal challenges, yet regulation remains underdeveloped to address adverse consequences. Ethics frameworks are increasingly viewed as interim tools to highlight risks and guide responsible innovation in the absence of comprehensive laws. While municipalities find compliance with digital rights obligation challenging, a proliferation of initiatives across local, national and international levels have been observed in recent years. Efforts to strengthen algorithmic transparency and online rights protections have also gained momentum. For instance, the European Union AI Act (2022) and the Office of the High Commissioner for Human Rights toolkit on the protection of human rights in the context of peaceful protests restrict high-risk applications such as biometric surveillance. The Atlas of Urban AI (2024) recorded 216 initiatives across 74 cities, predominantly in Europe, North America and South-East Asia, in which privacy protection was a primary element to 107 initiatives, and fairness and non-discrimination principles were central to 40.[3] Despite this progress, however, inclusivity and accessibility of online services remains limited. The United Nations Department for Social and Eco-

1   Commission Nationale de l'Informatique et des Libertés (CNIL). (n.d.). Data protection around the world. Available at https://www.cnil.fr/en/data-protection-around-the-world (Accessed: 10/8/2025).

2   United Nations Department of Economic and Social Affairs. (2024). UN E-Government survey 2024. Available at https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2024 (Accessed 10/8/2025).

3   Atlas of Urban AI. Available at https://gouai.cidob.org/atlas/ (Accessed: 15/8/2025).

nomic Affairs 2024 e-government survey found that only 5 per cent of city portals meet World Wide Web Consortium accessibility standards.[1]

Smart city agendas are increasingly shaped by environmental policies across both national and local levels. These reflect two parallel trends – mitigating climate change and reducing the ecological footprint of urban activities – whilst also addressing the environment costs of digital transformation. New regulatory frameworks are emerging to curb the environmental costs of digital transformation processes including e-waste generation, rising water and electricity consumption, and the pressures of mining and resource extraction. Yet alignment between digital and green agendas remains limited. Of 1,159 initiatives catalogued in the international Science, Technology and Innovation policies for net zero portal, only 8 per cent exhibited linkages to digital transformation and only 1 per cent specifically addressed smart cities.[2] These initiatives are predominantly concentrated in Europe and ASEAN countries, in which the interconnections between digital and green agendas have been at the forefront of key policy dialogues.[3] E-waste also remains a key issue, and while a number of laws are in place in Europe including those focused on circular economy promotion, there is a slowdown in new policy adoption with no globally coordinated system for the regulation of environmental footprints of digitalization. A lack of robust monitoring in regard to the environmental tracking of smart city projects is also evident at the local level, obscuring their impact on climate goals and undermining the "people-centred" vision of such initiatives.

## Amsterdam, the Kingdom of the Netherlands
## Deploying Smart Technologies to Catalyse Circular, Energy Positive Communities

Reducing carbon emissions is emphasized within the Dutch Climate Agreement (2019) and the European Union Green Deal (2020). In line with both national and European climate strategy, Amsterdam Smart City functions as a citywide open innovation platform and collaborative urban strategy network. In conjunction with the city government's Roadmap Amsterdam Climate Neutral 2050, it supports a low-carbon urban transition, aiming to cut carbon emissions by 60 per cent by 2030 and 100 per cent by 2050 in comparison to 1990 levels. The roadmap outlines measures needed to achieve $CO_2$ reduction targets, including maximizing generation of solar power on

1   W3C (n.d.) Introduction to Web Accessibility. Available at https://www.w3.org/WAI/fundamentals/accessibility-intro/ (Accessed 4/8/2025).

2   STIP Compass (2024). STI policies for net zero. Available at https://stip.oecd.org/stip/net-zero-portal (Accessed 12/8/2025).

3   UN-Habitat. (2024). World Smart Cities Outlook 2024. Available at https://unhabitat.org/sites/default/files/2024/12/un_smart_city_outlook.pdf (Accessed: 13/8/2025).

rooftops, developing electricity infrastructure and designing dedicated energy-neutral construction.[1] Within the Amsterdam Smart City Platform, Buiksloterham is striving to become a circular, energy-positive neighbourhood. Pilot sites integrate distributed solar energy, local energy communities, energy efficient buildings, the use of circular building materials, and an integrated microgrid and energy storage system (Buiksloterham Integrated Energy System). Building on this, the subsequent ATELIER project, a European Union funded smart city initiative, has connected smart microgrids in the district to create a regional network for energy production, storage and trading, see Figure 9-1. This system helps to maintain grid stability while maximizing local renewable energy use.[2] It also reduces reliance on long-distance transmission, strengthens resilience against power outages or peak loads through local storage and enables flexible load management. Overall, it demonstrates how smart technologies can enhance both resilience and energy efficiency at the local level.



Source: Metabolic. Circular Buiksloterham. (Metabolic.nl). Available at https://www.metabolic.nl/projects/circular−buiksloterham/ (Accessed 5 September 2025).

Figure 9−1   Integrated smart microgrid connections under the ATELIER project

1   Municipality of Amsterdam. Policy: Climate Neutrality. (Amsterdam.nl). Available at https://www.amsterdam.nl/en/policy/sustainability/policy-climate-neutrality/ (Accessed 5 September 2025).

2   Metabolic. Circular Buiksloterham. (Metabolic.nl). Available at https://www.metabolic.nl/projects/circular-buiksloterham/ (Accessed 5 September 2025).

## Regional Policy Trends

While increasing urbanization and technological progression has driven the global adoption of smart city initiatives, it is important to note that policy-making and implementation for urban digital infrastructures and smart city initiatives remains highly heterogenous due to socioeconomic disparities, contrasting governance capacities and varying levels of technological infrastructure. While convergence is visible in areas such as broadband and cybersecurity, the application of a one-size-fits-all approach is not feasible. Consequently, the overarching guidance for local policymakers and administrators is key to harmonizing regulations and enable the effective implementation of people-centred smart cities. A clear global North-South divide is exhibited along with subregional differentiations such as a North-South divide in the Americas and an East-West divide in Asia, with concepts of smart mobility and smart living demonstrating the highest levels of association.[1] Evidence highlights that smart city development is not uniform but is shaped by regional socioeconomic and technological conditions, indicating the importance for context-dependent regional policies.

In practice, cities in the Global North predominantly focus on enhancing the rights of urban citizen through digital solutions, promoting participatory governance, climate resilience and urban sustainability. Accordingly, their urban infrastructure is typically highly digitized, characterized by universal broadband penetration, widespread 5G rollout, advanced digital platforms and regulatory mechanisms supported by both public and private actors. Such cities also benefit from increased institutional capacity and stronger regulatory oversight, enabling more effective implementation of people-centred smart city initiatives, with common challenges including cybersecurity and legislation issues as well as inefficient data use.[2] In contrast, cities in the Global South face distinct socioeconomic and infrastructural challenges that constrain the deployment of such initiatives, whilst emerging forms of governance means that implementation relies on weaker accountability mechanisms. In regard to digital inclusion, the Global North focuses predominantly on digital literacy in contrast to the fundamental concern of basic internet access in the Global South.[3]

Challenges such as rapid informal growth, limited access to adequate housing and mobility, and deficiencies in urban basic services often makes people-centred smart city development a secondary priority. One-size-fits-all policies have derived several risks in the Global South, with smart city solutions often ignoring the socioeconomic realities, reiterating the importance of contextualizing smart city development. Consequently, where the notion of smart city operations is deeply rooted within the context of the

1　Tijjani, K.S., Sarıkaya Levent, Y., and Levent, T. (2025). Smart Cities in the Global Context: Geographical Analyses of Regional Differentiations. Systems, 13(4), p.296.

2　The Hague Academy for local governance. (n.d.). Building Smart Cities in the Global South. Available at https://thehagueacademy.com/news/building-smart-cities-in-the-global-south/?utm_source=chatgpt.com (Accessed: 20/8/2025).

3　Subedi. S. (2020) The digital divide in education: Policy lessons from the pandemic. London School of Economics, 2020.

Global North, it is critical that its application reaches the Global South in which the majority of the world's cities are situated.

The cases featured in this section illustrate smart city initiatives across developed, emerging and developing economies, highlighting the varying realities of their implementation in accordance with different governance frameworks and resource availabilities. Hamburg in Germany's Digital Participation System (DIPAS), embedded within broader, highly digitized infrastructure, demonstrates a typical approach to people-centred smart city development in the context of the Global North whereby participatory governance, transparency and technological sophistication are prioritized. Riyadh's urban digital transformation focuses on legal and regulatory frameworks for digital city transformation and highlights a top-down, policy driven approach to smart city development. In contrast, both Dar es Salaam, Tanzania's smart payments mechanism for gas for clean cooking and India's Smart Cities Mission (SCM) highlight the implementation of smart city approaches within Global South contexts. In regard to the former, technology serves as a means to address basic urban challenges rather than enable digital governance or participation, whilst the latter combines participatory principles amidst practical constraints, reflecting a hybrid approach that scales citizen engagement at both local and national levels.

## Hamburg, Germany
## Digital Participation System

Hamburg first presented its Digital City Strategy in 2015, which was subsequently revised in 2018, setting out the city's vision to improve quality of life and economic attractiveness. The strategy addressed areas of digital transportation and administration as well as resident participation mechanisms.[1] Within this policy framework, DIPAS, an open-source digital engagement system, was officially launched in January 2016 by the Hamburg Ministry of Housing and Urban Development, the Geographic Information Agency and the City Science Lab at Hafen City University. In 2017, it was integrated into Hamburg's broader Digital First digitalization initiative. It aims to integrate online and on-site tools to create a unified platform for information dissemination and public feedback, enabling citizens to more directly and conveniently participate in urban

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1    Intelligent Cities. (n.d.). Hamburg. Available at https://www.intelligentcitieschallenge.eu/cities/hamburg (Accessed: 12/8/2025).

Source: Walter Schießwohl. (n.d.). About DIPAS. Available at https://www.dipas.org/en/about (Accessed: 25/8/2025).

Figure 9–2　Interactive touch–tables facilitate more effective collaboration between actors

planning processes. Online, DIPAS provides daily updates on ongoing and completed projects, detailing their location, theme and construction status. Citizens can explore digital maps, aerial imagery, 3D city models and other geospatial data to quickly grasp the context of projects, and contribute feedback including suggestions and approvals. In offline settings such as citizen events, DIPAS uses a touch-table interface, enabling intuitive on-site interactions which support real-time communication between designers and the public, see Figure 9-2. DIPAS, therefore, facilitates communication between urban planners, city officials and local communities by enhancing accessibility, transparency and efficiency in participation while complementing conventional public consultation processes.

## Riyadh, Saudi Arabia
## Digital Transformation Strategy

Since 2024, the Riyadh Municipal Government has accelerated its citywide digital transformation in alignment with Saudi Arabia's Vision 2030 and the national Digital Government Authority's strategic agenda for consolidating and professionalizing e-government services. The programme centres on a unified identity, platform rationalization and a whole-of-government approach to increase the maturity and accessibility of digital services. At the national level, Saudi Arabia has strengthened digital government regulations and has become a global leader in open government data accessibility as reflected in international rankings, situated fourth in the United Nations E-Government Development Index 2024.[1] A central element to this transformation has been the streamlining of platforms and services, reflected in the Digital Government Authority's integration and closure of 267 government digital platforms to improve efficiency and user experience.[2] A cornerstone of this transformation is the Personal Data Protection Law.[3] Overseen by the Saudi Data and AI Authority, the Personal Data Protection Law establishes the rights of data subjects, the obligations of data controllers, and requirements for cross-border data transfers and breach notifications, thereby creating a legal baseline for municipal services involving IoT, video analytics and mobility platforms. At the operational level, the Unified National Access system has become the backbone of digital identity in Saudi Arabia. Nafath functions as a single sign-on platform and is integrated with public and private services, enabling secure authentication for millions of citizens and residents. The Saudi Data and AI Authority has developed a national data infrastructure, including the National Data Bank and an Open Data Platform which hosts thousands of datasets from hundreds of entities to support data-driven services and improve interoperability.

1    United Nations Department of Economic and Social Affairs. (2024). UN E-Government survey 2024. Available at https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2024 (Accessed: 10/8/2025).

2    Saudi Gazette. (2025). Saudi Arabia shuts 267 digital platforms to boost unified government services. Available at https://saudigazette.com.sa/article/653583/SAUDI-ARABIA/Saudi-Arabia-merges-267-digital-platforms-to-streamline-government-services (Accessed: 11/7/2025).

3    Saudi Data and AI Authority. (2023). Personal Data Protection Law. Available at https://sdaia.gov.sa/en/SDAIA/about/Documents/Personal%20Data%20English%20V2-23April2023-%20Reviewed-.pdf (Accessed: 11/7/2025).

## Dar es Salaam, the United Republic of Tanzania
## A Mobile Payment Smart Meter Solution to Increase Access to Clean Cooking

While the United Republic of Tanzania does not yet accommodate a defined national smart city development strategy, many smart city practices and strategies have emerged across cities. Nationwide, more than 90 per cent of households are unable to afford the initial investment in equipment to use clean Liquid Petroleum Gas (LPG) due to poverty and are therefore unable to use clean energy for cooking. Since 2015, KopaGas has designed an LPG system with a smart flow meter in Dar es Salaam, using a pay-as-you-go business model that allows users to purchase gas on demand through mobile payments, making clean cooking more affordable, see Figure 9-3. The service utilizes machine-to-machine connectivity to monitor and control gas usage in which customers use mobile money to purchase gas in affordable quantities for clean cooking. It connects with the M-Pesa payment service as well as short message service text messaging to link to cloud servers, sending payment information, LPG usage and smart meter usage information to KopaGas headquarters to more conveniently provide LPG distribution, use and maintenance. In tandem, the Pay-as-you-Cook service adopts gender-specific marketing and distribution to women. Digital technology, therefore, not only enables access to affordable clean energy but also empowers women and enhances social inclusiveness.



Source: KopaGas. (2018) KopaGas Mobile-enabled Pay-as-you-Cook™ service in Tanzania. Available at https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/wp-content/uploads/2018/02/KopaGas-Mobile-enabled-Pay-as-you-Cook%E2%84%A2-service-in-Tanzania.pdf (Accessed: 04/08/2025).

Figure 9-3　The KopaGas smart meter installation

## Pan–India
## Smart Cities Mission

India launched its SCM in June 2015 to facilitate integrated, people-centred sustainable urban development across 100 cities. A key feature of this initiative was the emphasis on citizen engagement and participatory planning, recognizing the need to ensure transparency and responsive solutions that meet the requirements of local residents. The Ministry of Urban Development created the MyGov platform as a tool for official citizen engagement, facilitating extensive public consultation and enabling citizens to participate in discussions, polls, blogs and tasks related to urban development. The platform allows municipalities to gather feedback on smart city proposals, ensuring that urban planning is not just top-down but also co-created with the community. By 2023, it had over 30 million registered users with 11.75 million citizens engaging during the preliminary phase. In response to the COVID-19 pandemic, SCM also launched the Cycles4Change Challenge in June 2020. This initiative aimed to promote cycling as a sustainable mode of transport and to reimagine urban spaces for better pedestrian and cyclist infrastructure. Cities including Ahmedabad, Coimbatore and Ranchi participated by implementing pop-up cycle lanes, measures to calm traffic on streets and promoting safe intersections. As of 2021, over 95 cities had registered covering approximately 400 km of arterial roads and more than 3,500 km of neighbourhood streets.[1]

SCM's emphasis on citizen participation marked a significant shift in India's urban planning and governance paradigm. Traditional top-down approaches were replaced with bottom-up strategies in which citizens actively contributed to planning and project implementation processes. This transformation was evident in the development of strategic plans where nearly 30 per cent of the evaluation criteria focused on citizen involvement and the feasibility of proposals. While SCM officially concluded in March 2025, its legacy continues to influence urban development in India. The focus on citizen engagement, sustainable infrastructure and neighbourhood-level interventions has set a precedent for future urban policies. Initiatives such as the Cycles4Change Challenge have not only improved mobility but also fostered a sense of community ownership and participation in urban transformation.

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1    Press Information Bureau Government of India Ministry of Housing & Urban Affairs. (2021). "India Cycles4Change" challenge gains momentum. Available at https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1723860&utm_source=chatgpt.com (Accessed: 10/8/2025).

# UN–Habitat–People–centred Smart Cities Flagship Programme

UN-Habitat's flagship programme, people-centred smart cities, provides technical and strategic support on digital transformation to both national, regional and local governments. This section details how the programme supports cities in implementing digital technologies and innovations that promote sustainability, inclusivity and human rights in urban development. It also highlights the core components of the programme including capacity building tools, and introduces the draft international guidelines on people-centred smart cities. It explains how the guidelines assist policymakers, urban planners and stakeholders in adopting best practices for smart city governance, digital infrastructure and citizen engagement.

## United Nations Innovation Technology Accelerator for Cities

The United Nations Technology Accelerator for Cities (UNITAC) is a United Nations entity managed by UN-Habitat in partnership with the United Nations Office for Information and Community Technology and HafenCity University – a technical university focused on the built environment. UNITAC supports national and local governments with digital transitions, applying a multi-level governance strategy and helping them build skills and capabilities to develop,

procure and effectively leverage digital technologies via inclusive and ethical methods to ensure no one is left behind. UNITAC applies an urban technology and acceleration approach to enhance quality of life in cities, with a special emphasis on marginalized communities. It delivers services through digital transformation and readiness assessments; strategic advice on urban digital transformations; urban data visualization, analysis and scenario planning platforms and smart city development; and data and digital transformation strategies, framework and policies. In addition, it harnesses citizen science, crowdsourcing and participatory data collection; digital public participation toolboxes; digitally enhanced service provision; training for city leaders on people-centred smart cities; plus technical advice service on digital platforms, tools and approaches. Critically, the work of UNITAC is embedded in detailed research, a robust understanding of urban challenges and assessment of local community needs.

## People–centred Smart City Playbooks

UN-Habitat provides a series of people-centred smart city playbooks which serve as practical capacity building tools for local, regional and national governments as well as policymakers, civil society and NGOs. These focus on centring people in smart cities; assessing and addressing the digital divide; shaping co-creation and collaboration in smart cities; building and securing digital public infrastructure; and building capacity for people-centred smart cities. These playbooks help governments to collaborate with di-

verse stakeholders to design and deploy smart city infrastructure and services; expand staff capabilities in areas such as digital transformation, policymaking and technology procurement; and also evaluate technology needs while ensuring equity, environmental justice and social inclusion.

## Global Alliance of Mayors for Digital Cooperation

Launched in 2023 by the United Nations Secretary-General's Envoy on Technology and UN-Habitat, the Global Alliance of Mayors for Digital Cooperation connects mayors globally to cooperate on the effective use of digital technologies to accelerate the SDGs and enhance urban governance. Via the platform, mayors are able to share best practices, facilitate collective action and promote policies that support equitable digital access and innovation at the local level. This increases digital innovation for sustainable urban development by raising the voices of cities in global dialogues, providing innovative tools and solutions, while fostering a digitally connected, forward-looking global community that prioritizes urban citizens.

## International Guidelines on People–centred Smart Cities

The development of the International Guidelines on People-Centred Smart Cities was requested at the second session of the UN-Habitat Assembly in June 2023 in Nairobi via the approval of a resolution from 193 countries. The guidelines were issued to formulate both national and local smart city regulations, plans and strategies to ensure that digital urban infrastructure and data contribute to the promotion of inclusive, prosperous and sustainable urban development that is respectful of human rights.

The guidelines are designed to help national, regional and local governments, together with a wide range of stakeholders, to harness digital technologies in ways that genuinely improve quality of life in cities and human settlements, while also anticipating and mitigating the risks that accompany rapid digital transformation. They are grounded in global commitments to sustainable urban development, aligning closely with the New Urban Agenda, the 2030 Agenda for Sustainable Development and other international frameworks that set out a collective vision for a more sustainable and inclusive future. At their core, the guidelines seek to embed a people-centred approach to smart cities that reflect the principles of the United Nations Charter, international law and the Universal Declaration of Human Rights. The intention is not only to encourage the use of innovation and digital tools for more efficient urban systems, but to ensure that these technologies actively contribute to the realization of human rights and to the achievement of the SDGs and the New Urban Agenda. The guidelines also function as a reference for Member States in developing and implementing smart city regulations, plans and strategies. They emphasize equitable access to the opportunities that arise from data, digital infrastructure and digital services, while underscoring the importance of lifelong education

and training to ensure all people can benefit. In doing so, they highlight transparency and accountability as essential conditions for building trust in the governance of digital transformation.

Central to the guidelines is the recognition that local and regional governments play a pivotal role in closing digital divides and localizing global principles, including those outlined in the Global Digital Compact. By focusing on the responsibilities and opportunities at the local level, the guidelines complement existing global principles on digital development, extending them with a specific emphasis on how cities and regions can advance people-centred smart city approaches. While the recommendations are voluntary, they encourage Member States to take concrete steps whether legislative or through other measures, consistent with their constitutional and governance frameworks, and in line with international law. In this way, the guidelines promote a shared global understanding of what it means to adopt a people-centred smart city approach, while offering a universal framework of principles and enabling conditions that can support adequate housing, sustainable urban development and inclusive digital futures. They further aim to accelerate the implementation of the Global Digital Compact at the local level, connecting visions with practical, context-specific action, and fostering cooperation and knowledge sharing across borders.

The guidelines are organized into eight mutually reinforcing pillars, including four thematic pillars which outline the core principles as well as four enabling pillars which highlight the key condition to mainstream the principles of the thematic pillars. The application of the principles requires a holistic and collaborative approach among all stakeholders.

The thematic pillars: ① shared prosperity; ② sustainability, resilience and crisis response; ③ community participation and collaboration; ④ digital human rights, equity and inclusion, should be embedded within the enabling pillars: ① governance and regulations; ② digital public infrastructure, data and smart city services; ③ digital literacy and skills development; and ④ budgeting and financing, see Figure 9-4.

The guidelines recognize that governments at every level remain central to advancing a people-centred smart city approach to urban development, yet they also acknowledge that their responsibilities vary. National, local and regional governments are each called upon to act in ways that reflect their own specific mandates and capacities, while ensuring that their efforts connect within a broader ecosystem of collaboration. The guidelines recognize that a people-centred approach cannot be achieved in isolation but depends on multi-level and multi-stakeholder engagement that converges public authorities, the private sector, academia and civil society in collaboration to co-create urban solutions that embed equity, inclusion and sustainability.

As the pillars that form the guidelines are inherently interconnected, they are not presented in order of priority and neither do they follow a fixed sequence. Many of them overlap, and most require cross-sector collaboration that transcends disciplines and institutional boundaries. It is important to recognize that actions taken in one area may impact other
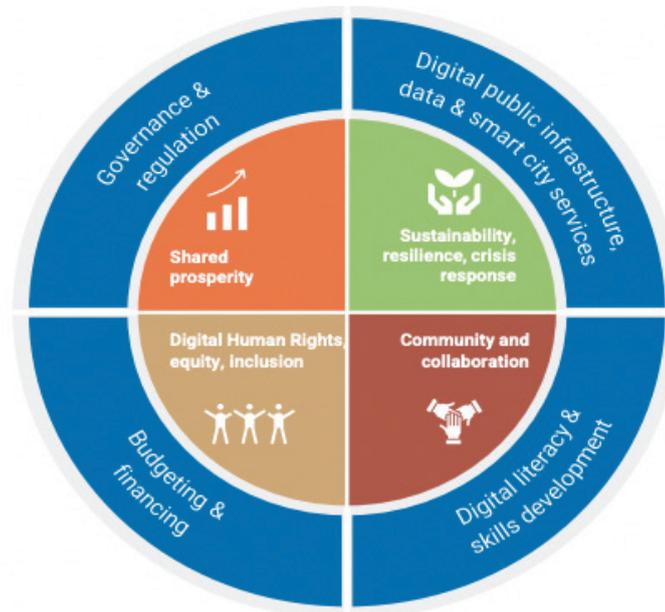
Source: UN–Habitat. (2025). Draft International Guidelines on People–Centred Smart Cities: Smart cities for people: empowering lives, protecting the planet, advancing prosperity.

Figure 9–4    An overview of the thematic and enabling pillars

areas, underscoring the need for holistic strategies rather than siloed interventions, and although they are globally applicable, the principles are not intended to serve as one-size-fits-all solutions. Member States are encouraged to interpret and adapt the principles to their own contexts, taking into account governance structures, local capacities, development priorities and the specific needs of local communities. Such adaptation is critical for both effectiveness and legitimacy, ensuring proportionality and alignment with international obligations while allowing flexibility to address challenges in context-sensitive ways. In practice, this means that state actors, depending on their institutional arrangements and local realities, can develop their own vision and priorities for people-centred smart city development using the thematic areas, principles and recommended actions of the guidelines as a reference point. While governments play a leading role, the responsibility for upholding these principles extends to all actors within the smart city ecosystem. The promotion and implementation of the guidelines is therefore encouraged to be pursued via legislation, regulation, initiatives and investments, among other measures. Their success, however, depends largely on the willingness of stakeholders to work cohesively to embed these principles into the everyday governance and operation of cities.

# Summary and Recommendations

It is clear that inclusive approaches to digital governance are central to ensuring that the deployment of smart city technologies serves the public

interest and enhances equity, transparency and accountability within urban systems. Digital governance operates at the intersection of ICT, policy frameworks and the everyday needs of urban residents. In practice, however, many policies remain fragmented or undocumented, resulting in inconsistent implementation and limited oversight. Evidence from 36 pioneering cities, as reported by the WEF, highlights the persistence of this fragmented approach. The Forum identified five policy benchmarks including: ① ICT accessibility in public procurement (equity, inclusivity and social impact); ② privacy impact assessments ( privacy and transparency); ③ accountability for cybersecurity (security and resilience); ④ "dig once" strategies for digital infrastructure (operational and financial stability); and ⑤ open data (openness and interoperability). Findings indicated that only two of the surveyed cities possessed formal written guidelines covering all five areas and just one city had fully implemented them. This demonstrates a significant governance gap underlining the need for institutional capacity, leadership and coordination to translate digital principles into coherent and actionable frameworks.[1]

Across many urban contexts, governance mechanisms such as procurement standards, municipal codes, ordinances and public right-of-way regulations define how technologies are deployed and how their benefits are distributed among citizens. Within this structure, strategic frameworks and municipal digital plans operate as guiding instruments for the adoption of open standards, shared data ownership models and interoperable digital platforms. The establishment of leadership roles within city administrations has proven particularly effective in aligning digital innovation with urban governance, ensuring that technological development remains people-centred rather than market-driven. In this sense, digital governance becomes a means of embedding accountability, transparency and inclusion into the broader urban policy landscape.

Equally significant are emerging frameworks for digital human rights which reinforce the principles of transparency, participation and oversight in the design and implementation of smart city systems. Standards that safeguard privacy, uphold non-discrimination and facilitate meaningful citizen participation can not only strengthen trust but also ensure that technological innovation supports, rather than undermines, democratic governance. Open standards and transparent procurement processes hold significance in enhancing local innovation and strengthening public confidence, while inadequate protection mechanisms risk deepening social exclusion. It is also critical to recognize that marginalized groups, particularly low-income residents, women, youth, older persons and persons with disabilities, are often most vulnerable to these digital divides, underscoring the need for rights-based governance frameworks that secure privacy, data protection and freedom of expression within digital environments.

The establishment of digital public infrastructure grounded in digital public goods, open-source soft-

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1  World Economic Forum. (2021). Governing Smart Cities: Policy Benchmarks for Ethical and Responsible Smart City Development. Available at https://www3.weforum.org/docs/WEF_Governing_Smart_Cities_2021.pdf (Accessed: 20/8/2025).

ware, interoperable standards and privacy-conscious data systems, offers a pathway to inclusive and sustainable urban digitalization. These approaches reduce dependency on proprietary technologies, lower costs and enable citizen-led innovation through open data and participatory design processes. In aligning with the SDGs, they also promote affordability, accessibility and equitable connectivity, providing a foundation for digital ecosystems that are resilient, collaborative and people-oriented, in which digital inclusion becomes a defining element of equitable urban transformation. Persistent disparities in access to affordable internet, digital devices and skills continue to mirror broader social inequalities and, without targeted action, smart city initiatives risk reinforcing rather than resolving these divides. Local governments play a pivotal role in bridging such gaps by integrating digital inclusion into urban planning, collecting disaggregated data on access and use, and building partnerships with civil society and private actors.

Digital equity frameworks that encompass connectivity, skills development and access to devices also function as essential pillars within inclusive urban digital strategies. Strategic investment in broadband, accessible digital platforms and digital literacy programmes not only broaden civic participation but also align local initiatives with international commitments such as the 2030 Agenda for Sustainable Development, the New Urban Agenda and the Secretary-General's Roadmap for Digital Cooperation. The digitization of public services, spanning digital payments, digital identity systems and data exchange

has fundamentally altered how residents interact with government institutions. While automation and data-driven systems enhance efficiency, they also introduce new ethical and security concerns, including risks associated with surveillance and data misuse. Emerging technologies such as blockchain further illustrate the dual nature of innovation, expanding opportunities for transparency and accountability, yet also posing challenges for privacy and equity. By embedding transparency, user-centred design and interoperability at the heart of these systems, cities can ensure that digital tools serve the collective good.

Data governance represents an additional cornerstone of equitable digital transformation. Policies and standards that promote transparency, accountability and privacy in data collection, storage and use determine how information circulates within cities and who benefits from it. Inadequate data governance can reinforce inequality, entrench bias and undermine public trust. Conversely, robust frameworks encompassing open data policies, privacy protections and digital rights charters can transform public data into a shared civic asset. When supported by open data platforms and multi-stakeholder partnerships, these systems can strengthen coordination across departments, reduce costs and foster innovation, provided that safeguards against misuse and discrimination are firmly in place. Cybersecurity and resilience are likewise central to maintaining trust in digital governance. As technological developments often outpace regulatory processes, new vulnerabilities arise that challenge both ethical norms and institutional capacities. Breaches in digital infrastructure can erode

citizen confidence and destabilize public systems, underscoring the need for comprehensive resilience strategies that combine technical, legal, organizational and educational measures. Institutional capacity remains the decisive factor in determining whether cities can design, regulate and sustain equitable digital systems. In contexts with significant resource constraints, capacity building in areas such as data protection, cybersecurity and digital service delivery becomes essential. The digital economy in Sub-Saharan Africa, for example, is projected to generate up to 230 million jobs by 2030, presenting an estimated USD 130 billion opportunity for investors and educational operators to train the future workforce in digital skills.[1] However, realizing this potential alone will require extensive investment. Strengthened leadership structures, including dedicated digital offices and high-level coordination roles, are thus integral to embedding long-term institutional capacity within governance systems.

Ultimately, inclusive digital governance depends on the ability of cities to evaluate and adapt their digital trajectories in line with people-centred principles. Monitoring and evaluation frameworks that integrate inclusive indicators, representative data and transparent financing mechanisms enable cities to assess both progress and equity impacts. Pilot projects that are iterative and informed by community feedback can serve as learning platforms for scalable, resilient

digital ecosystems. The intersection of physical and digital systems further reinforces the need for safeguards that protect human rights both online and offline. Digital technologies hold immense potential to strengthen public life and empower communities, but they also introduce risks of surveillance, privacy infringement and social exclusion. The Secretary-General's Roadmap for Digital Cooperation underscores that protecting human rights within digital contexts is inseparable from achieving sustainable urban development. In this light, inclusive digital governance is not merely a technical or administrative process but a normative commitment to ensuring that technology remains a means toward a more equitable, transparent and people-centred urban future.

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1   International Finance Corporation. (2020). IFC Report Finds $130 Billion Opportunity in Digital Skills Across Sub-Saharan Africa, IFC Press Room. Available at https://www.ifc.org/en/pressroom/2019/ifc-report-finds-130-billion-opportunity-in-digital-skills-across-sub-saharan-africa (Accessed: 6/9/2025).