Future Cities Advisory Outlook 2025

AI and Cities

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Future Cities Advisory Outlook 2025

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Future Cities Advisory Outlook 2025: AI and Cities

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Future Cities Advisory Outlook 2025: AI and Cities

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Preface

Dr. Jian Wang
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Cities represent humanity's greatest invention and a hallmark of human civilization. Today, we are standing at an unprecedented crossroads, confronting the dual challenges of urbanization and technological transformation. According to United Nations projections, by 2050, an additional 2.3 billion people will reside in cities — a number equivalent to the world's total population in 1950. This exceptionally rapid and large-scale urban expansion will place unimaginable pressure on cities in terms of housing, transportation, environment, and energy. Most of this pressure stems from the excessive and inefficient use of urban resources during urbanization, presenting a challenge of unprecedented scale. The sustainable development of cities worldwide urgently compels us to seek new models of growth — a pursuit that will bring a revolutionary opportunity for every city.

In response to the challenges and opportunities facing future cities, I, with the strong support of Hangzhou Municipal Government, had the privilege of co-launching the non-profit "City Brain" initiative in 2016, bringing together nearly twenty institutions and enterprises and introducing the concept of the "City Brain" for the first time. We believe that in this era of transformation driven by technologies such as the internet, cloud computing, big data, and artificial intelligence (AI), we have the opportunity to re-explore and redefine how cities develop and function. By applying "City Intelligence," we can tackle the challenges of excessive and inefficient use of urban resources, thereby fostering a resource-efficient society and advancing another leap forward in human urban civilization. This was the original intent behind the "City Brain" initiative and remains the guiding principle of this report on "Artificial Intelligence and Cities (AI + City)."

Looking back, urban development, both in China and around the globe, has long relied heavily on the massive expansion and consumption of natural resources such as land, water, and energy. However, in the future, cities can no longer — and indeed must not — continue along the old model of "trading resources for growth." The global sustainable development goals and the planetary ecological boundaries compel us to pursue high-quality economic growth and social progress with finite resources. In this context, the path forward for cities lies in achieving more with less: higher-quality development with reduced resource consumption, thereby creating a better living environment for all residents.

The technological foundation enabling this paradigm shift is the internet and cloud computing, while the decisive variable lies in data and AI. Data is emerging as a "new resource" on par with land and energy — a natural resource of the digital era and a core driver of resource-efficient cities. With data as the key element, City Intelligence — powered by computing — can transform "data value" into "resource value," significantly enhancing the efficiency of current urban resources. This transformation achieves an effect comparable to increasing the availability of natural resources, enabling cities to optimize and conserve energy, transportation, water, and construction resources in ways once unimaginable with traditional information technologies. Thus, cities are gradually evolving from the "Era of Electricity" brought by electrification into the "Era of Computing Power" shaped by digitalization and intelligence.

Nearly a decade has passed since the City Brain concept was first introduced — a journey that has far exceeded my professional expertise. Yet through these hands-on experiences, I have become firmly convinced that future City Intelligence will help us bring the City Brain vision to life: enabling a city to function using only ten percent of the resources required today. The remaining ninety percent can then support future development and innovation, benefiting more residents — without demanding additional resources from our planet. In the future, City Intelligence has the potential to boost urban resource efficiency — in energy, water, electricity, and land — by severalfold. We will ultimately embrace a people-centred, resource-efficient and sustainable urban civilization. This reflects not only the value of City Brain for urban development, but also the conviction of a new generation of urban planners, designers, and builders: less resource consumption can create a better life.

Less is more for better life.

1 October 2025

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Key Findings

The UN-Habitat China Future Cities Council was established in 2019 under the initiative of UN-Habitat. By bringing together technology companies, municipal governments, research institutions, and social organizations, the Council is dedicated to empowering sustainable urban development with advanced technologies and realizing a better urban future that is people-centred. ***Future Cities Advisory Outlook 2025: AI and Cities*** is the fifth annual flagship report issued by the UN-Habitat China Future Cities Council. The report is structured as follows: Chapter 1 outlines the formidable challenges cities face in the context of the Sustainable Development Goals (SDGs) and elucidates how City Intelligence, grounded in "City Brain," is becoming a pivotal force driving a paradigm shift in urban development; Chapter 2 systematically examines how Chinese cities, through extensive practices of City Intelligence, are exploring breakthrough solutions for high-quality and sustainable development by adopting resource-efficient approaches; Chapter 3 proposes a roadmap and development guidance for translating the concept of City Intelligence into action, delineating a systematic progression through the stages of value reshaping, data foundation building, scenario-driven implementing, and intelligence emerging; Chapter 4 provides detailed cases of cities and specific scenarios, offering replicable Chinese samples for "Artificial Intelligence + Cities;" Chapter 5 summarizes the key Chinese experiences in leveraging City Intelligence to advance sustainable urban development and puts forward a call to action for City Contributors, as well as a global collaboration initiative for "AI + City."

Chapter 1 Global Urban Transformation in the Era of Artificial Intelligence

Amid a critical window period for achieving global sustainable development, cities are becoming the epicenter where pressures converge most intensely. On the one hand, overall progress toward the global SDGs has lagged, while resource and environmental constraints are accelerating; on the other hand, technological revolution presents unprecedented opportunities for innovative governance. This chapter systematically analyzes the challenges cities face and the logic of their transformation in three dimensions: global progress, shifts in resource structures, and technological impetus.

1. Global Sustainable Development Goals Face Severe Challenges

According to the 17 Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 under the 2030 Agenda for Sustainable Development, by 2025, of the 139 assessable specific targets, only 35 percent are on track or in moderate progress, while 18 percent are even regressing. Cities stand at the focal point of global pressure — occupying less than 3 percent of the world's land, consuming 60 to 80 percent of the energy and generating approximately 75 percent of carbon emissions — the burden on cities continues to intensify, while their operational efficiency remains relatively low.

(1) Lagging Progress and Intensifying Challenges: The growing frequency of extreme climate events, the degradation of ecosystems, and the mounting pressure on infrastructure have led to stagnation or even regression on several key SDG indicators in cities worldwide.

(2) Finite Resources and Systemic Inefficiencies: Land, energy, water, and other critical resources are not only finite in absolute terms, but are also utilized within urban systems that are often inherently inefficient. This dual reality sharpens the fundamental tensions in urban development.

(3) Cities are Decisive Drivers in Global Sustainable Development: The way cities function almost dictates the pace of the global energy transition and emissions reduction. As such, they stand as indispensable and pivotal drivers for achieving global sustainable development.

2. Cities: From Resource Expansion to Resource Efficiency

As cities edge closer to the limits of their resource capacity, a profound transformation is reshaping their developmental logic — a shift away from the historic reliance on land expansion, energy-intensive inputs, and large-scale infrastructure, toward a paradigm centered on efficiency, synergy, and sustainability. Cities are undergoing comprehensive transitions in foundational philosophies of urban growth, patterns of resource utilization, and even people's daily lifestyles, which are reflected across several dimensions:

(1) The Transformation in Development Philosophy: As cities advance from the electrification-centric "Era of Electricity" to the AI-defined "Era of Computing Power," their development philosophy is shifting — from supporting growth through increased resource consumption to driving sustainable urban development through data-optimized resource efficiency.

(2) Data-Driven Optimization of Urban Resource Efficiency: The core of resource-efficient cities lies in transforming data into a calculable, fluid strategic resource through "data bitization" and "data tokenization." This transformation allows for the precise identification and elimination of systemic inefficiencies, moving urban governance from experiential estimation to accurate, data-guided resource optimization.

(3) Urban Development Pathways and the Rise of a New Urban Civilization: By using data-driven breakthroughs in governance, service delivery, and development models as the key lever, cities are achieving systemic gains in resource efficiency to realize high-quality sustainable development, thus paving the way for a new, tangible urban civilization.

3. City Brain and Sustainable Urban Development

"AI + City" presents an opportunity for AI to evolve beyond a structural revolution in technology itself into a driving mechanism for fundamental shifts in urban development logic. The practice of City Brain provides an excellent practical foundation for realizing this transformation, holding significant importance for the modernization of urban governance systems and capacities. Serving as the technical backbone of City Brain, City Intelligence is a primary means of implementing AI in cities. By leveraging integrated AI models, computing power, and data systems, cities can gain a comprehensive understanding of their operations, enabling predictive insights, scenario simulation, and dynamic resource allocation — allowing them to achieve greater efficiency with fewer resources. This leap in capability is rapidly giving rise to a new paradigm for urban development:

(1) From Electrification to Digitalization: Today's digital transformation mirrors the electrification wave of a century ago. "AI + City" is positioned within a historic technological shift of a magnitude unseen in a hundred years. For cities, this represents a structural change comparable to the electrification of the 20th century.

(2) The City Brain Question: As a new paradigm for urban development, "City Brain" is fundamentally built upon answering the core question: "Can 10 percent of a city's current resources support its sustainable high-quality development?" In doing so, it establishes a core philosophy of people-centred, holistic view, resource efficiency, and sustainable development.

(3) City Intelligence Drives a Paradigm Shift for Sustainable Urban Development: the practice of "City Intelligence," based on City Brain, drives a systematic transformation of urban develop-

ment models. The primary power shifts from simple reliance on physical resources to leveraging data and computing power; governance evolves from fragmented departmental silos to integrated coordination; and the core value shifts from scale expansion to resource optimization and human well-being.

Chapter 2 City Brain: "City Intelligence" and "AI + City"

China has been confronted with the dual challenges of resource constraints and systemic inefficiency more directly in the process of rapid urbanization. Exploring a new paradigm for urban development has thus become the key to breaking the impasse. In 2016, Hangzhou pioneered the practical exploration of this new paradigm with its "City Brain" initiative. By 2020, Nanchang had achieved a breakthrough in governance by successfully implementing the "No-Traffic-Restriction" policy. This served as tangible proof that data value can be translated into resource value, systematically enhancing urban operational efficiency without increasing the consumption of physical resources — a clear early success for City Intelligence. Since then, City Intelligence has seen widespread adoption across China. This chapter systematically examines the resource bottlenecks confronting Chinese cities and elucidates the technological architecture and practical pathways of City Intelligence. It reveals that City Brain represents not merely a technological upgrade, but a profound transformation in the model of urban governance.

1. Challenges to Sustainable Urban Development in China

(1) Resource Bottlenecks Amid Accelerated Urbanization: The rapid growth of urban populations has made the goals of per capita resource consumption in cities of developed nations unattainable and undesirable for China. Compounding this pressure is the widespread issue of systemic inefficiency of urban resources.

(2) Urban Transformation Under Resource Constraints: Guided by the strategic vision that "building a resource-efficient society is a social revolution," the development philosophy has shifted from "resource expansion" to "resource conservation." At the national level, the goal of establishing a "resource-efficient and environmentally friendly society" has been integrated into the highest tier of planning and policy design.

(3) The Evolution of City Brain: "City Brain" views the city as an integrated, organic system. By optimizing the use of data resources, it advances significant conservation of natural resources. The application of City Intelligence technologies in fields such as ecological monitoring and energy management enables precise oversight and allocation, paving a new path for urban transformation.

2. Pioneering Exploration in City Intelligence: No-Traffic-Restriction Cities

(1) Traffic Congestion As a Common Challenge Faced by Chinese Cities: While private car parc in China has surged and road infrastructure has expanded, cities continue to grapple with deep-seated structural issues such as "high vehicle vacancy rates" and job-housing imbalances. In response, a common approach has been made by cities to implement aggregate control measures — most notably, traffic restriction policies related to the last digit of license plate numbers and limits on new vehicle registrations (often referred to as "traffic and plate restrictions").

(2) City Intelligence Solutions of No-Traffic-Restriction: Hangzhou has explored the adoption of the City Brain-based intelligent solution to address the fundamental problem of disconnection between data and action, thereby tackling traffic congestion. Following this, Nanchang City Brain achieved a breakthrough in traffic governance. In 2020, after the eleven-year-old traffic restriction policy based on license plate tail

numbers was lifted in Nanchang, the congestion index dropped and vehicle speeds increased.

3. City Intelligence Technology Architecture

(1) The Trinity of Computing Power, Data, and AI Models: The realization of City Intelligence relies on a systematic technological architecture, with its core being the integrated trinity of computing power, data, and AI models. Data serves as the foundational resource, AI models as the intelligence engine, and computing power as the essential infrastructure.

(2) The City Intelligence Engine: This engine constitutes the core technical embodiment for City Intelligence, with AI models being a primary means of its implementation. An City Intelligence engine deployed for urban governance integrates various models — such as physical sensing model, social perception model, dynamic simulation model, and knowledge model — into a foundational urban model. This integration endows the system with cross-scenario capabilities for general cognition and reasoning.

(3) Open Source Mechanisms for City Intelligence: The concept of open-source has evolved from merely sharing code and source to opening up innovative resources. Opening access to data, AI models, and computing power equates to opening up the very resources for urban development and innovation. This serves as an important innovative mechanism for fostering collaborative development across cities.

4. Broad Practices of "AI + City" in China

(1) Comprehensive City-Scale Practices: Through widespread implementation in Chinese cities, City Intelligence has demonstrated its governance capabilities across multiple fields, including the environment, public administration, and social services. It represents the endogenous outcome and systemic emergence of "AI + City."

(2) From Basic Scenario to City Intelligence Progressive Practices: Beginning with single-point technological applications, the practice evolved by breaking departmental silos through specific scenarios into comprehensive City Intelligence. Scenario-based applications such as Shanghai's "Unified Governance through One Network," Hangzhou's "One City, One Parking Platform," "Qinqing Online" platform, "One More Hour for Tourism" initiative, and "Campus Brain" showcase the immense potential for the coordinated optimization of urban resources from a holistic, citywide perspective.

(3) Insights from China's City Brain Practice: City Brain originated from a fundamental rethinking of the nature of resource efficiency. The philosophy of "the city as an integrated whole" demands not only breaking down barriers among government sectors to foster internal synergy but also integrating all urban components — government, businesses, and civil society — into a cohesive entity. This shifts the governance from "technology-centric" to "service-oriented", prioritizing people experience. Ultimately, this contributes to rebuilding social trust system, fostering a virtuous cycle of "trustworthy government, ethical citizens, civilized cities," thereby unifying technological value with social value.

Chapter 3 City Intelligence Evolution Roadmap

Building a resource-efficient city requires a systematic transformation of the urban paradigm. This transformation must begin by establishing new values—deeply recognizing that a city is an integrated whole, that data is a decisive resource, and that the goal of City Intelligence is to ensure a high-quality life and advance sustainable urban development through optimized resource utilization. Subsequently, it is essential to gather the foundational data to precisely map the flow and utilization efficiency of resources. Following this, value shall be validated through scenario-driven approaches, gradually achieving a leap forward in City Intelligence. The ultimate goal is to foster an urban civilization founded on trust. The architecture of City Intelligence not only requires integrated support of the trinity of data, AI models, and computing power, but also demands security systems and the rule of law to ensure sustainable development. Its ultimate value can be validated by the City Brain Question: Can 10 percent of a city's current resources support its sustainable high-quality development and achieve an organic integration of technological progress and social value.

1. Building Resource-Efficient Cities Based on City Intelligence

City Intelligence represents far more than a mere technological upgrade; it constitutes a strategic revolution in the paradigm of urban development. This revolution manifests in three distinct forms: foundational applications serve as the base form, addressing specific technical challenges; scenario-based solutions as the higher form, tackling particular governance issues through the integration of diverse data sources; and City Intelligence as the highest form, enabling holistic and collaborative governance across fields, sectors, and administrative hierarchies.

2. Mapping the Baseline: A Critical Prerequisite

Mapping the baseline must proceed across three dimensions. First, resource inventories, such as "on-road vehicles" in the traffic, water distribution network leakage rates, and parking space turnover rates. Second, the city's overall operational status, enabling real-time grasp of the city's "vital signs." Third, an inventory of operational data and its quality, transforming routine work into high-quality data resources.

3. Guidelines for City Intelligence Implementation

(1) Four Phases of City Intelligence Development: The successful evolution of City Intelligence follows four distinct phases: "Value Transformation → Data Foundation → Scenario Validation → Civilization Shaping."

(2) Architecture and Key Technologies of City Intelligence: The integrated architecture of "Computing Infrastructure — Data Networks — Intelligence Engines" and "Scenarios" establishes the critical foundation for translating technological capability into tangible governance capacity.

(3) Key Actions Guidelines: Action 1: Establish an overall strategic plan and a phased action framework. Action 2: Prioritize the construction of intelligent infrastructure as a key lever. Action 3: Use scenario-based applications to drive the refinement of both intelligent infrastructure and governance systems. Action 4: Build a robust system for security and legal safeguards based on City Intelligence.

4. Future City Intelligence Outlook

City Intelligence is going to catalyze a revolutionary shift in the paradigm of urban development focusing on resource efficiency. This shift will be pivotal in addressing the global challenge of carbon neutrality and will help forge a new model of civilization. In future cities endowed with sophisticated City Intelligence, success will be measured not merely by economic prosperity, but also by the maximization of public well-being, environmental quality, and urban resilience, all achieved through the minimization of resource consumption per unit of output. This marks a profound transition: from an industrial urban civilization predicated on "scale expansion" to a digital urban civilization that will be defined by resource conservation, measured by human welfare, and designed to be inclusive for all.

Chapter 4 Case Studies

This chapter presents six city cases and six scenario cases, comprehensively showcasing the diverse practices and outcomes of "AI +

City," ranging from fundamental applications to specific scenarios, and culminating in multifaceted City Intelligence. The city cases contain both systematic explorations of holistic intelligent governance in megacities and innovative practices in specific domains such as education, precise governance, transportation, and urban planning. The scenario cases cover multiple dimensions of urban operations, including public infrastructure, domestic waste management, green finance, biological resources, traffic management, and featured towns. Collectively, they demonstrate replicable Chinese solutions for global cities.

City-specific examples range from Hangzhou's exploration of sustainable development based on the "City Brain" concept to Shanghai's transformation in megacity governance from digitalization to intelligenization, from Shenzhen's smart allocation of educational resources to Guangzhou's AI-powered precise management, from Chengdu's intelligent traffic control around hospitals to Wuhan's intelligent urban planning solutions. Scenario-based cases include efficient integration of public infrastructure, intelligent urban waste management, smart delivery of inclusive green finance, circular regeneration of urban biomass, urban events and traffic governance empowered by "5G + AI", and optimized innovation resource integration in featured towns.

Chapter 5 Conclusion and Initiatives

This chapter systematically summarizes the conceptual and practical insights of "City Intelligence driving sustainable urban development." Based on this, this report puts forward initiatives for city contributors and global initiative and actions for "AI + City."

1. AI-Driven Sustainable Urban Development

The prevailing development model, which traded high resource consumption for convenience and relied on high emissions to drive growth, had led to stagnation or even regression in achieving the global Sustainable Development Goals across multiple domains. Much of the traditional "smart city" discourse remains at the level of technological accretion, failing to address the fragmentation of urban capabilities caused by rigid departmental silos. In contrast, China's practice of adopting "City Brain" as a new urban development paradigm reconstructs the very philosophy of urban growth from a holistic and people-centred perspective. It offers a proven pathway — leveraging City Intelligence to advance sustainable development through resource efficiency. The moment for global implementation has arrived: Open data systems for cities are gradually maturing, while open-source AI foundational models and urban open research ecosystems are lowering entry barriers. Guided by the vision of a shared destiny for all mankind, City Intelligence carries the promise of steering global cities toward a common future characterized by low consumption, high well-being, and strong resilience. **Less is more for better life.**

2. Recommendations for City Contributors

(1) For Individuals and Organizations: Co-Create People-Centred City Intelligence.

(2) For Industry and Academia: Collaborate on City Intelligence as a Public Good.

(3) For City Operators and Builders: Advance Scenario-Based Solutions for Good Governance.

(4) For National and Local Governments: Establish Infrastructure and Institutional Frameworks.

3. "AI + City" Global Collaboration Initiatives

(1) Build Resource-Efficient Cities: **Less is More for Better Life.**

(2) Leverage AI to Support Resource-Efficient City Transformation.

(3) Advance "AI+City" Evolution Through a

Holistic Approach.

(4) Co-Design People-Centred Good Governance Scenarios.

(5) Foster an Intelligent City Network for Collaborative Learning.

(6) Open City Intelligence Resources to Share AI Innovations.

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Global Urban Transformation in the Era of Artificial Intelligence

Chapter 1 Global Urban Transformation in the Era of Artificial Intelligence

01

Global sustainable development is confronting formidable challenges. The United Nations' 2030 Agenda for Sustainable Development outlines 17 Sustainable Development Goals (SDGs), comprising 139 assessable targets. According to the UN's Sustainable Development Goals Report 2025, only 35 percent of these targets were on track or in moderate progress, while 18 percent have even regressed. Cities, as concentrated hubs of population, economic activity, and resource consumption, are focal points where these sustainability challenges manifest most acutely, yet they also represent critical arenas for solutions. On the one hand, despite occupying only 2 to 3 percent of the Earth's land surface, cities consume 60 to 80 percent of global energy and generate approximately 75 percent of carbon emissions. On the other hand, they stand at the forefront of technological innovation and institutional change, possessing unique potential to lead the global transformation.

The dual constraints of absolutely finite resources and systemic urban inefficiency collectively bind urban development. Land resources are diminishing, global water crises are intensifying, and the carrying capacities of energy systems and the environment are nearing their limits. Even more pronounced is the pervasive issue of extensive management within urban operations, which leads to systemic inefficiency and results in significant waste of resources during distribution and utilization.

AI is increasingly becoming a pivotal force in overcoming this dilemma. Just as electrification shaped the 20th century, digitalization and intelligentization (hereafter referred to as intelligence-driven transformation) are set to redefine the logic of 21st-century urban operation. As cities transition from the "Era of Electricity" to the "Era of Computing Power," the process of digitizing, tokenizing, and intelligently applying data resources is propelling a shift from "resource expansion" to "resource efficiency" paradigm. While "AI" technologies have achieved scaled application in specific scenarios, the integrated form of "AI + City" is evolving into the higher-level of "City Intelligence." The City Brain represents the modernization of governance infrastructure within the urban governance system, embodying enhanced governance capacity, while City Intelligence serves as its technical vehicle. By optimizing the value of natural resources, data resources enable cities to unleash multiplied value within their finite physical space. This advances the City Brain vision — "sustaining a city's high-quality, sustainable development using only 10 percent of its current resources" — from a concept toward reality. This paradigm shift involves not merely the innovation of technological applications but signifies a comprehensive leap of urban civilization toward a more people-centred, innovative, and resource-efficient future.

1.1 Global Sustainable Development Goals Face Severe Challenges

1.1.1 Lagging Progress and Intensifying Challenges

Figure 1–1: The 17 Sustainable Development Goals (SDGs) of the United Nations

Source: United Nations, The Sustainable Development Goals Report 2025

Overall Progress Across Targets Based on 2015-2024 Global Aggregate data

Progress Assessment for the 17 Goals Based on Assessed Targets, by Goal (Percentage)

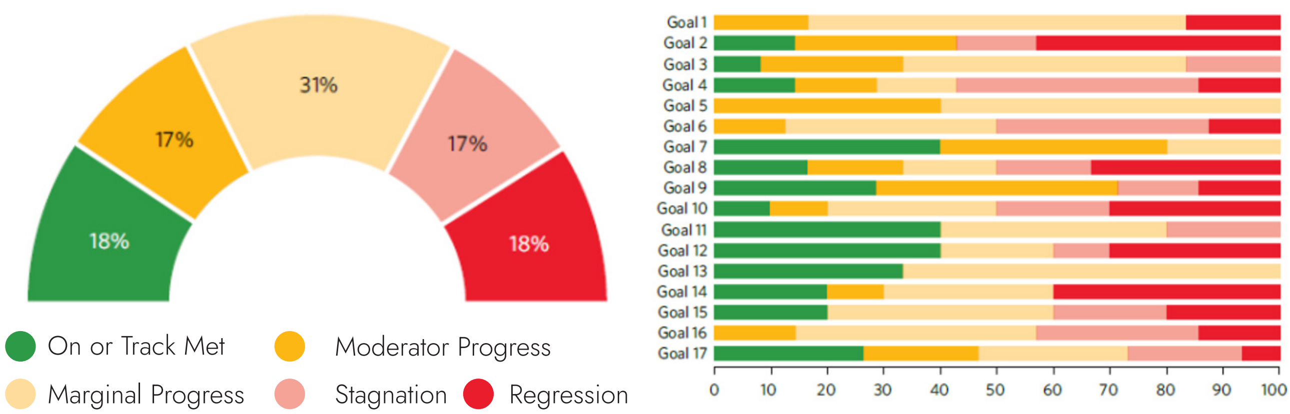


Figure 1–2: Assessment of progress on the Sustainable Development Goals

Source: United Nations, The Sustainable Development Goals Report 2025

In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development, launching 17 Sustainable Development Goals (SDGs)[1] designed to improve human well-being, drive economic prosperity, and protect the environment (Figure 1-1)[2]. However, the 2025 progress assessment reveals that the world remains far off track from achieving the 2030 Agenda. Of the 139 assessable targets (out of 169 SDG targets), only 35 percent are in adequate progress – 18 percent are on track and 17 percent are making moderate progress. In contrast, 48 percent of targets are in insufficient progress, including 31 percent in marginal progress and 17 percent in stagnation (Figure 1-2). Most concerning, 18 percent of targets have regressed below 2015 baseline levels. For instance, reports indicate that progress on SDG 11 ("Sustainable Cities and Communities") has been slow, with almost no significant improvement since 2015[3], highlighting the growing challenges of global city development.

Cities occupy only 2 to 3 percent of the world's land area, yet they are home to over half of the global population, consume 60 to 80 percent of the world's energy, and generate about 75 percent of its carbon emissions[4]. The extreme concentration of people, economic activity, and infrastructure makes cities a focal point for sustainable development challenges and a strategic lever for achieving all 17 SDGs. Urban issues are deeply connected to most of the SDGs, meaning the quality of city development directly impacts the entire global agenda: 1) On No Poverty and Settlements (SDG 1, SDG11): Informal settlements and housing shortages in cities directly block poverty reduction and inclusive development. 2) On Good Health and Air Quality (SDG 3): $PM_{2.5}$ emissions from urban industry and traffic are closely linked to public health burdens. 3) On Energy and Climate (SDG 7, SDG 13): Cities' energy systems and transport emissions largely determine greenhouse gas output. 4) On Infrastructure and Economic Opportunity (SDG 8, SDG9): Lagging urban infrastructure and resource supply limit productivity and fair opportunities. 5) On Land Ecosystems (SDG 15): Urban sprawl encroaches on farmland and natural habitats, reducing overall resource efficiency. The International Energy Agency (IEA)'s World Energy Outlook 2024 notes in its chapter on "Key Clean Energy Technologies" that deploying seven major technologies — including EVs, wind, solar, and carbon capture — will account for about 75 percent of energy-related CO_2 reductions between 2023 and 2035. These are key to cutting fossil fuel demand this decade and staying on a 1.5°C path. Cities, which are home to over half of the global population, play a critical role in overall emissions reduction through improvements in their energy efficiency and transportation systems[5].

1.1.2 Finite Resources and Systemically Inefficient Cities

Nearly all challenges under the UN's 2030 Agenda are, at their core, all linked to saving resources and using them more efficiently. The UN Environment Programme (UNEP)'s Emissions Gap Report 2024 finds that current policies and national pledges put the world on a path that falls short of the 1.5°C target and make the 2°C goal much harder to reach[6]. Meanwhile, UN-Habitat's World Cities Report 2024 points out widespread gaps in housing, public transport, and resources for climate-resilient infrastructure in cities globally. Climate shocks are making these weaknesses worse, especially in low- and middle-income cities with many informal settlements and limited governance capacity and funding[7]. The Intergovernmental Panel on Climate Change (IPCC)'s AR6 Synthesis Report: Climate Change 2023 states that incremental tech fixes or economic growth alone won't cut global emissions fast enough. It calls for more efficient resource use and a full transformation across key systems like energy, transport, buildings, and land use to keep warming below 1.5°C or 2°C[8].

(1) Finite Resources

From the earliest days of civilization, access to key resources like water and fertile soil decided whether a city or settlement would thrive or fail. For example, prehistoric settlements at Tell es-Sultan (ancient Jericho) grew around a permanent spring, with early drainage and flood control works showing water's decisive role on the survival and expansion of early communities[9]. In the Mesopotamia and the Tigris-Euphrates basin, large-scale irrigation boosted farm yields but caused long-term salt buildup and soil degradation. Historical and archaeological studies such as the classic discussions by Thorkild Jacobsen and Robert McC. Adams on salinization in Mesopotamia point out that such land degradation and imbalances in water resource management are significant participants contributing to social reconfigurations, population migrations, and even the decline of city-states[10].

Resource scarcity has always been a fundamental constraint. Back in the 1970s, The Limits to Growth (1972) warned about the constraints of a finite planet. Today, global cities are hitting that "ceilings" of resources[11].

First is the limit of land. Studies predict global city land could grow by about 1.2 million square kilometers from 2000 to 2030, doubling or tripling the scale in the year of 2000[12]. But imagine the next 30 years, for instance in China: we simply cannot develop cities by multiplying land area like that again. This kind of sprawl pushes cities toward an ecological red line, often at the cost of forests, wetlands, and farmland. Scientists estimate that by 2030, land-cover changes from urban expansion could release about 1.38 billion tons of carbon and seriously threaten biodiversity[13]. Many urban regions are nearing their land capacity, forcing a tough choice between new development districts, precious cropland, and sensitive ecosystems. This absolute limit means cities must optimize what they have, not expand endlessly.

Water and energy constraints are also tightening. Cities' demand for fresh water is rising fast, but supply is tightly limited by nature, and climate change is worsening water crises. Analysis shows about 10 percent of global water withdrawals go to municipal supply[14]. According to the UN World Water Development Report from the World Bank and UNESCO, the number of urban dwellers facing water scarcity could rise from 933 million in 2016 (one-third of the global urban population) to between 1.7 and 2.4 billion by 2050 (one-to nearly two-thirds)[15][16]. Rapid urbanization fuels this demand, with cities like Bengaluru, India and Cape Town, South Africa facing "Day Zero" crises. Climate models warn that by 2050, climate change alone could reduce available fresh water for at least 685 million city residents by over 10 percent. In cities heavily reliant on external water sources, rainfall has dropped sharply by 30 to 50 percent (places like Amman, Jordan; Melbourne, Australia; and Cape Town, South Africa have faced severe water crises in recent years)[17]. The combination of global warming and rising urban demand for water is making city water supplies extremely fragile. UNESCO predicts that by 2050, the number of urban residents facing water scarcity will double from 930 million in 2016 to between 1.7 billion and 2.4 billion people[18]. According to the World Resources Institute (WRI), 25 countries are currently exposed to extremely high water stress annually (Figure 1-3).

In terms of energy and environmental capacity, cities rely on importing fuels, food, and building materials from elsewhere. This concentrated consumption puts great pressure on the climate and ecosystems. The buildup of greenhouse gases has already raised the global average temperature by about 1.1°C compared to pre-industrial times, with record-breaking heatwaves becoming more frequent[20]. According to the

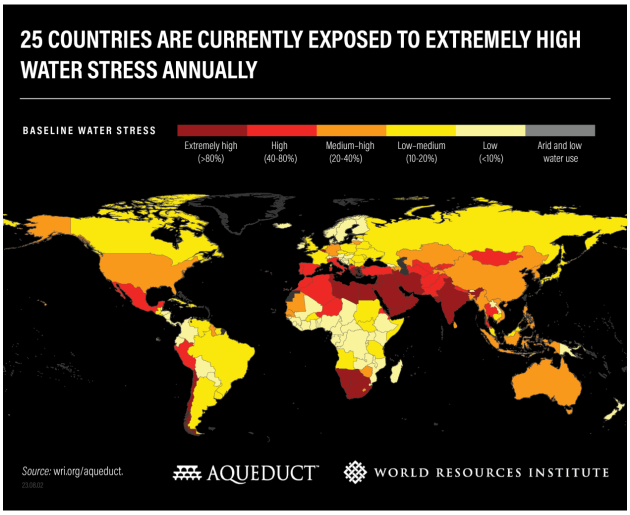


Figure 1–3: Water scarcity in countries (and major cities) worldwide[19]

Source: World Resources Institute

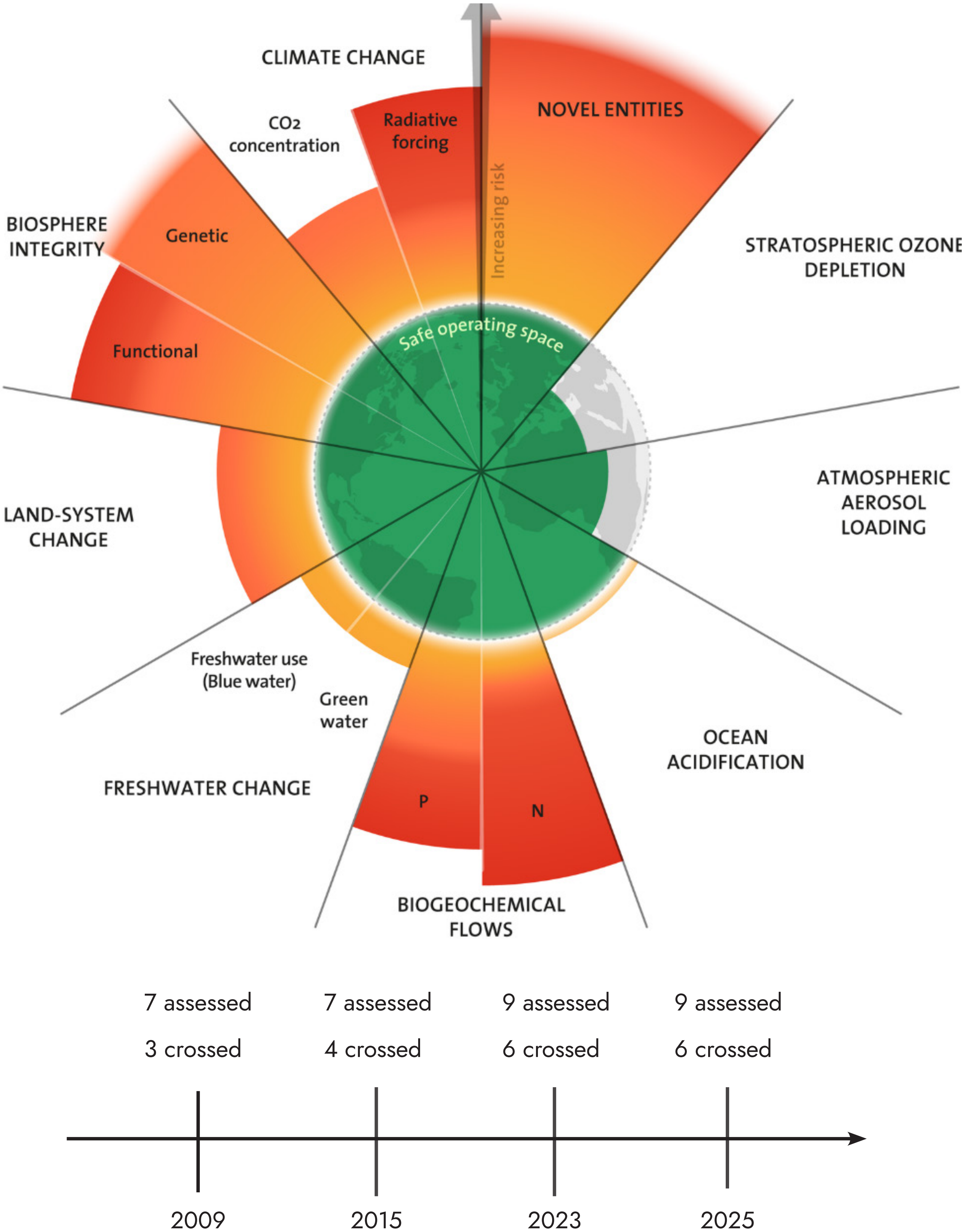


Figure 1–4: The "Planetary Boundaries" framework indicates seven crossed boundaries by 2025[21]
Source: Stockholm Resilience Centre[22]

Planetary Boundaries Framework from the Stockholm Resilience Centre, by 2025, seven out of nine planetary boundaries have already been crossed (Figure 1-4).

(2) Systemic Resource Inefficiency

Finite resources alone cannot fully explain why the UN's 2030 Sustainable Development Goals are lagging. A bigger issue is the widespread, systemic inefficiency and waste in how we use resources at every step, which makes the problem of scarcity much worse. Cities, with their high concentration of activity, are a major source of this inefficiency and a critical area for change.

First is inefficient land use. Many cities expand in a sprawling, "pancake-like" manner. Land use is separated by function and managed inefficiently, wasting space and leaving infrastructure underused. From 2000 to 2014, the world's urban land area grew 1.28 times faster than its urban population, and per capita urban construction land continued to rise[23]. The International Energy Agency (IEA) notes in Energy Efficiency 2023 that since 2000, the energy demand per unit area in residential buildings and per passenger-kilometer for light vehicles has decreased. However, the efficiency improvements in heavy vehicles and industrial sectors have been very slow[24]. The Organization for Economic Co-operation and Development (OECD) also points out in its report Rethinking Urban Sprawl that urban expansion in most developed countries exhibits trends of land use fragmentation and non-compact functionality, leading to reduced efficiency in public services and infrastructure[25].

In water use, systemic waste comes from two sides: not knowing the real demand, and an inefficient supply system. On the demand side, a clear picture of actual water resource needs is lacking. For example, a household in the UK uses about 340 liters of water per day, while one in Ethiopia uses only about 40 liters (Figure 1-5). There is no universally agreed-upon benchmark for reasonable daily household water consumption. If the truth lies somewhere in between, it shows both clear shortages in some places and massive waste in others and also reflects issues of inequality and unsustainability, represented by disparities in per capita water resources.

On the supply side, leaks cause major waste. Globally, about 126 billion cubic meters of water are lost through leaks each year — astonishingly, enough for nearly 90 million people. In some areas, up to 30 percent of water is lost before it reaches users. Reducing these losses is a key task[26]. According to data on water loss through leakages in the distribution network of countries provided by Roland Berger, reducing leakage is a key measure (Figure 1-6). Ireland, for example, reduced its national water leakage rate through persistent

"The London question for City Brain: How many buckets of water does each household really need?"

In the United Kingdom: 340 litres In Northern Ethiopia: 40 litres

Figure 1–5: Comparison of average daily household water consumption: in the UK and Ethiopia

Source: Photographed by the principle author in London, 2018 effort from 46 percent in 2018 to 40 percent in 2020, aiming for 25 percent by 2030. While halving the rate from 46 percent to 25 percent is progress, a quarter of water still being lost is a huge waste[27].

Energy use is also highly inefficient. The IEA's World Energy Outlook 2023 shows that global primary energy conversion efficiency has long hovered around 30 to 40 percent, with massive losses in generation, transmission, and end-use. Without the shutdown of facilities taking into account, the average annual capacity participant (the ratio of actual generation to theoretical maximum generation) of coal-fired power plants is expected to decrease from over 50 percent currently to about 30 percent by 2030[29]. This infrastructure inefficiency means we use far more limited energy than necessary. At the usage end, urban buildings and industry has great potential to improve energy efficiency. Conventional building designs frequently overlook energy efficiency, leading to high heating and cooling loads. Meanwhile, aging industrial and commercial equipment further compounds energy waste.

Transportation is another area of major inefficiency. According to the 2023 INRIX Global Traffic Scorecard published by the traffic data and analytics company INRIX, urban residents

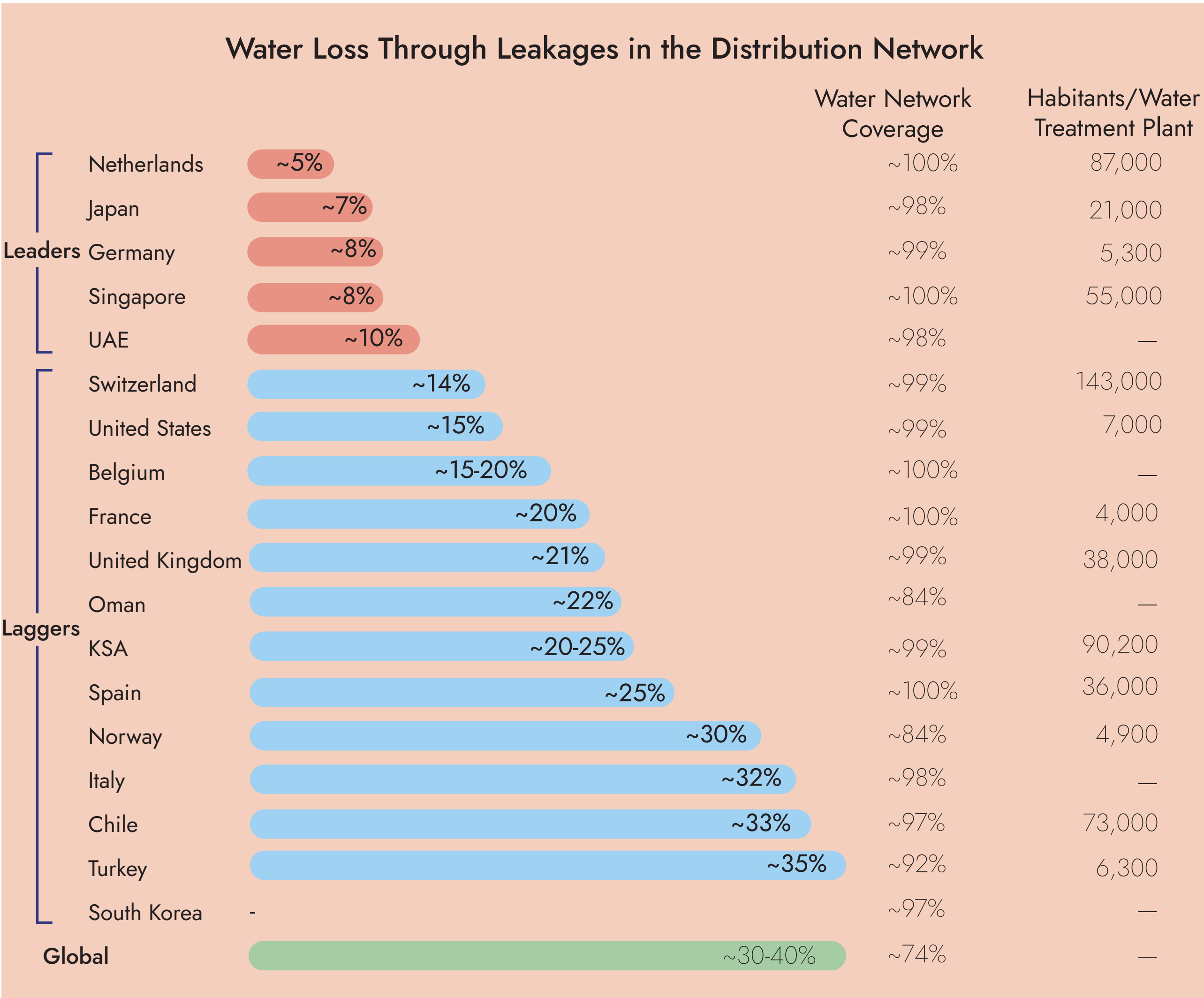


Figure 1–6: Water loss through leakages in the distribution network: reducing leakage is the key solution[28]

Source: Roland Berger

across the United States lose an average of approximately 42 hours per year due to traffic congestion (an increase of 4 hours compared to 2022). This is equivalent to a $70 billion waste of time resources nationwide. (The data on travel delays and economic losses for the top 10 cities in the U.S. are shown in Table 1-1). Globally, city residents lose 50-150 hours annually, wasting hundreds of billions in productivity[30]. A deeper structural inefficiency is the "one person, one car" model, which occupies tens of square meters of road space and parking space that remain idle most of the time, operating at full capacity only briefly during peak hours. Meanwhile, insufficient public transport pushes more people into cars, creating a vicious cycle. UN Statistics Division (UNSD)'s data from 2023 shows that in a sample of 1,507 cities across 126 countries, only about 51.6 percent of the urban population had convenient access to public transport (within a 500-meter walking distance to a bus stop or within a 1,000-meter walking distance to a rail station)[31]. Low accessibility to public transportation directly forces more people to rely on private cars, which in turn worsens road efficiency and increases energy consumption.

1.1.3 The Decisive Role of Cities in Global Sustainable Development

Cities are humanity's greatest invention[32]. Their dense, organized form concentrates people, the economy, culture, and technology, driving civilization forward. Cities play a dual role: they are the main hotspots of resource consumption and inefficiency, putting huge pressure on the global environment. Yet cities are also at the forefront of change, assembling the technologies, talent, and institutions needed for a transition to resource-efficient development — one that AI can significantly accelerate.

(1) Cities As the Epicenter of Consumption and Inefficiency

Since 1960, the global urban population has surged from about 1 billion to about 4.5 billion, showing a trend of continuous and accelerated expansion. In contrast, the rural population, after reaching a plateau, has begun to decline slowly over the past decade or so. In 2008, the urban population first exceeded the rural population, setting a major milestone for urbanization. Since

Table 1-1: Top 10 U.S. Cities Ranked by Traffic Delay and Economic Loss (2023)

U.S. Rank	City	Per Capita Traffic Delay (hours)	Per Capita Delay Cost (USD)	Total Delay Loss (billion USD)
1	New York	101	1,762	9.1
2	Chicago	96	1,672	6.1
3	Los Angeles	89	1,545	8.3
4	Boston	88	1,543	2.9
5	Miami	70	1,219	3.1
6	Philadelphia	69	1,209	2.9
7	Washington D. C.	63	1,095	2.7
8	Houston	62	1,082	3.2
9	Atlanta	61	1,066	2.6
10	Seattle	58	1,010	1.6

2010, the urban population has continued to rise rapidly, and the gap between urban and rural populations has kept widening. Today, more than half of the world's population lives in urban areas, a proportion expected to rise to about two-thirds by 2050. Overall, the world has entered an era dominated by urban populations. Urbanization is profoundly reshaping the patterns of population distribution, making cities the key spatial arena for addressing global development challenges.

In terms of water resources, the dense concentration of people and industry in cities pushes demand in many areas beyond local supply limits. To meet urban needs, cities are forced to transfer water from other river basins and overpump groundwater. Some megacities have even become regional "water funnels," draining resources from surrounding areas. For instance, megacities like Mexico City and Delhi are experiencing land subsidence and other geological issues due to excessive groundwater extraction, a clear sign of the immense pressure urban water use places on the natural environment. Meanwhile, inadequate water supply networks and poor management lead to high rates of water loss, compounding the strain on resources. High water demand coupled with inefficient use make cities an "amplifier" of the global water crisis.

Similarly, traffic and air pollution also highlight the profound impact cities have on the environment. Most vehicles and traffic are in cities, making them hotspots for air pollution due to exhaust emissions from fuel-powered vehicles. Air quality monitoring data covering over 6,000 cities across 117 countries reveals that in 2022, 99 percent of the world's urban population lived in areas where air quality exceeded safe limits — specifically, where the annual average concentration of $PM_{2.5}$ was higher than the new guideline set by the World Health Organization in 2021 (which is below 5 micrograms per cubic meter)[34]. Urban air pollution not only harms the health of residents but also affects regional and even global environmental quality through atmospheric circulation.

More significantly, the current model of urban

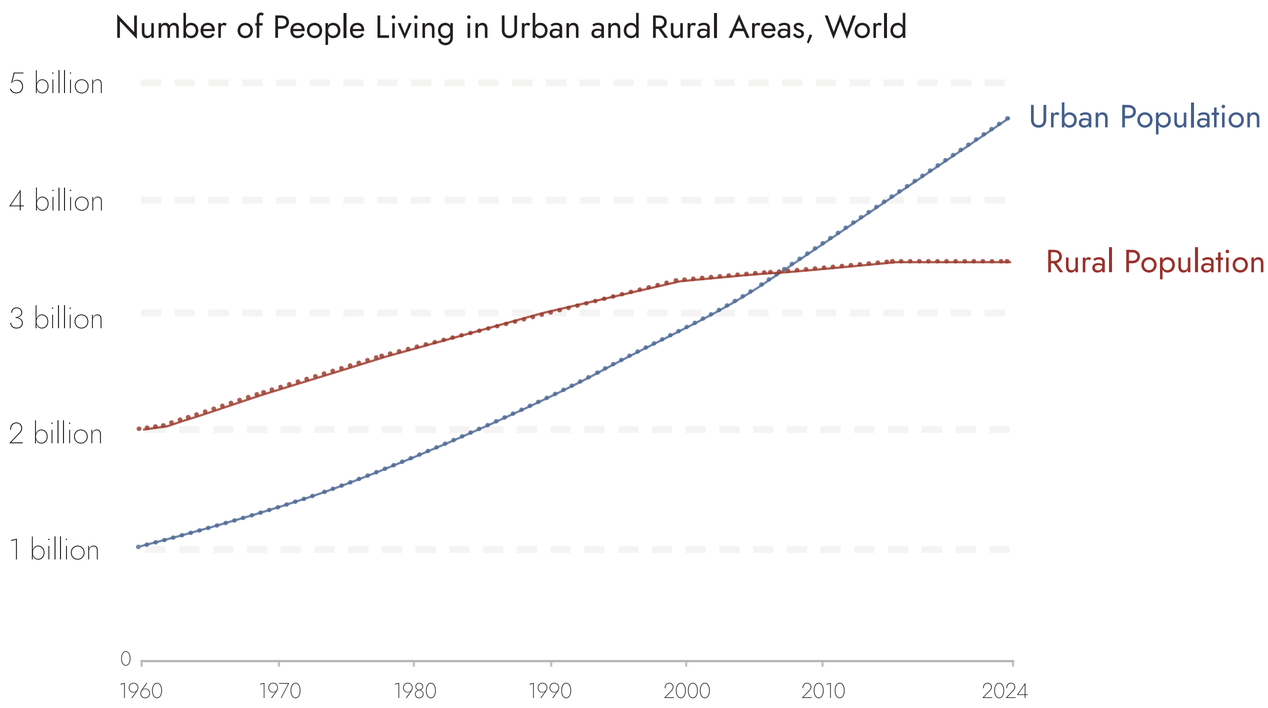


Figure 1–7: Global urbanization trends[33]

Source: "Our World in Data" website

development amplifies the inefficiency of resource use. Inefficiencies like energy waste, traffic jams, and building waste are magnified in dense cities. This highlights the urgent need for new urban development models, positioning cities to lead the sustainability transition[35].

(2) Cities As the Frontline of Driving Changes and Innovation

Cities have been the birthplace of humanity's greatest innovations. Throughout history, cities have been the stage for every major productivity leap. "The Era of Horsepower" was epitomized by ancient Rome, whose roads, water systems, and public architecture demonstrated the concentrated advantages early cities held in transportation, energy, and organizational capacity. The first Industrial Revolution emerged from Manchester, UK[36], where steam engines and textile factories marked the dawn of the Industrial Revolution, catalyzing the birth of modern industrial society. The wave of electrification was led by New York[37], its illuminated night sky heralding the "Era of Electricity" and fundamentally transforming how people work and live. Nighttime lights serve as the most intuitive and consistent global-scale indicator for mapping the intensity of human activity, spatial structure, and economic vitality in cities. As shown in the night-time light distribution maps, both the Yangtze River Delta urban agglomeration and the city of Bogotá display vibrant activity (Figure 1-8). Now, AI and digital infrastructure are reshaping cities' operation logic in the "Era of Computing Power" at an unprecedented pace (Figure 1-9). From horsepower to electricity to computing power, cities have always been the frontline for technological advancement and social transformation.

Cities are pivotal arenas for achieving the global Sustainable Development Goals (Figure 1-10). Cities produce over 80 percent of global economic output and house nearly 60 percent of the population, making themselves the most concentrated spatial units for human innovation and governance capacity[39]. Their flexibility and capacity often lets them act faster than national governments on implementing sustainability policies. Many cities proactively commit to emission reduction targets that exceed their national counterparts' pledges. For example, the C40 Cities Climate Leadership Group brings together over one hundred major cities worldwide, jointly committed to achieving net-zero emissions by mid-century and sharing best practices[40]. As of 2024, more than 500 cities have joined the United Nations' "Race to Zero" campaign, using local action to advance global climate goals.

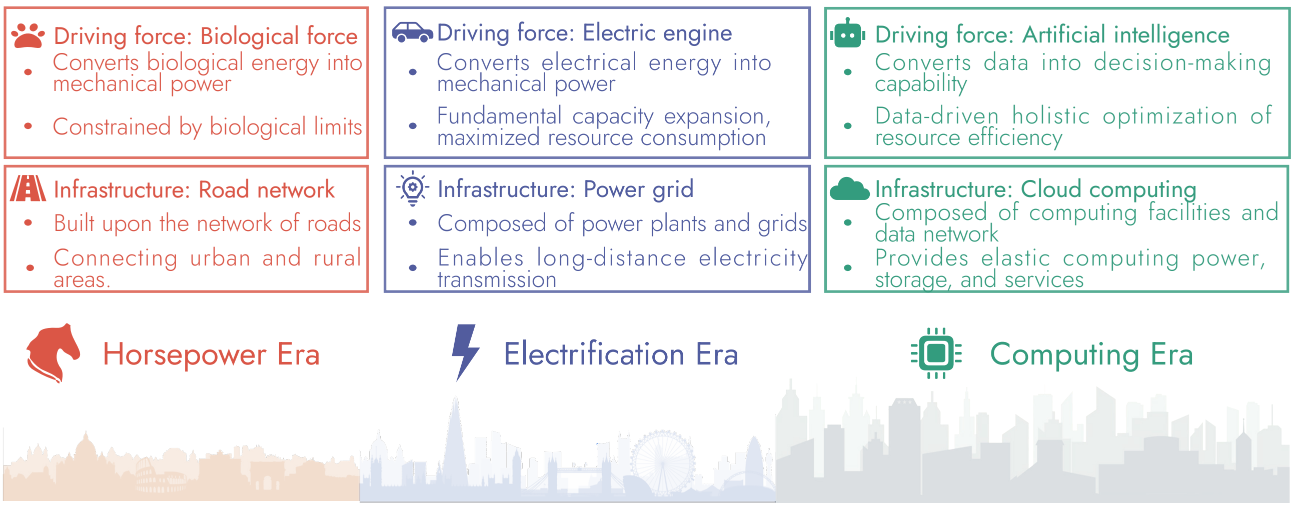


Figure 1–8: Infrastructure and driving forces in the eras of horsepower, electrification and computing

Source: Created by authors

Cities are also labs for new ideas and actual transformation. Concepts such as the "15-Minute City," "Shared Mobility," and "Green Commuting" all started in cities and spread globally. Copenhagen and Amsterdam, by restricting private car use and expanding bicycle commuting, have significantly reduced transportation energy consumption and carbon emissions, providing a replicable model for sustainable mobility[41].

On a social and cultural level, lifestyles and public awareness are just as crucial. Cities, with their dense populations, rapid information flow, and active civil society, are ideal places for public engagement in sustainability. Global environmental campaigns like "Earth Hour" and "Car-Free Day" are often spontaneously initiated by city residents and spread worldwide through city networks. This growing citizen involvement and awareness are forming a social foundation that drives market change and policy innovation.

As UN Secretary-General António Guterres stated, "Cities are where the battle for climate will be won or lost[42]." This is true for all climate action as well as broader sustainable development agenda. Cities concentrate both global risks and the potential for hope and transfor-

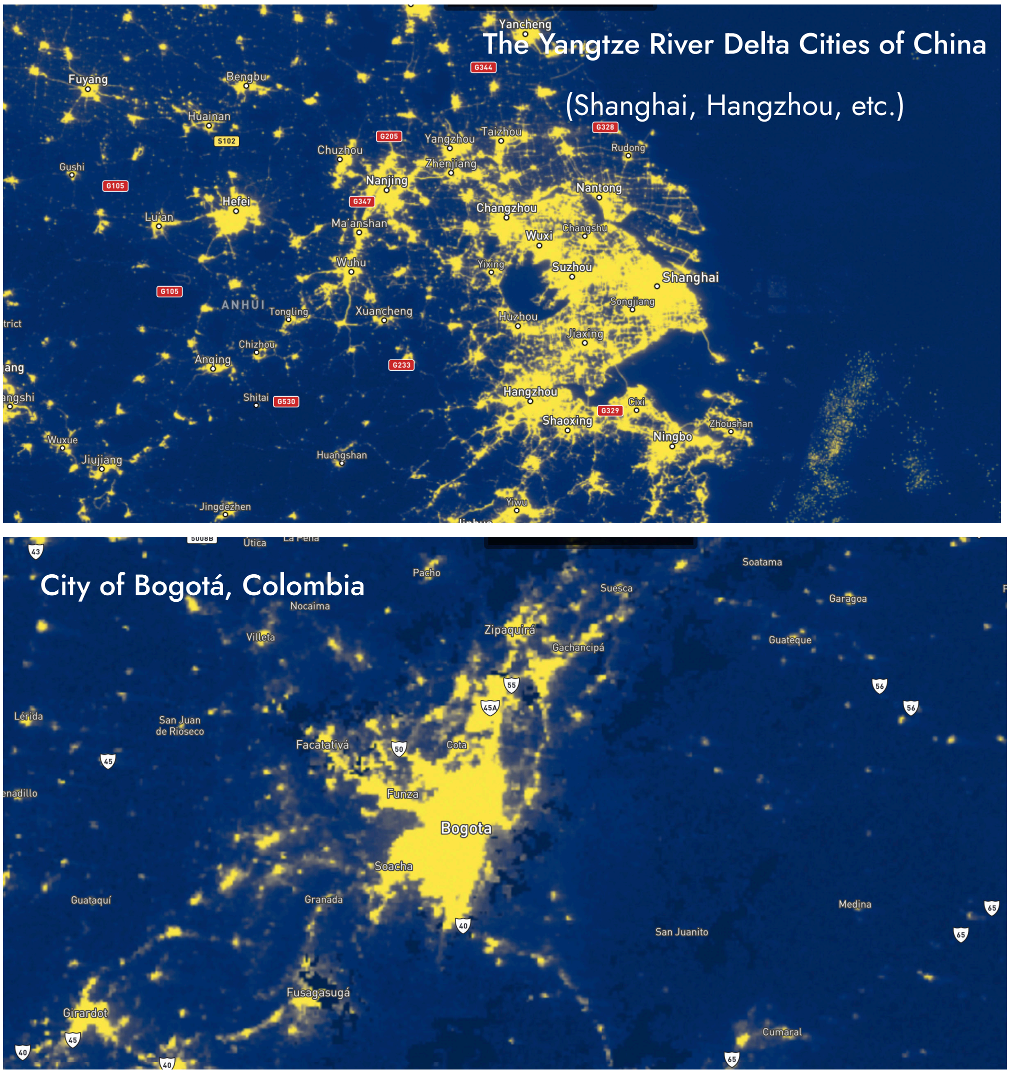


Figure 1–9: Nighttime lights distribution in the Yangtze River Delta urban agglomeration, China and the City of Bogotá, Colombia

Source: Created by authors based on Suomi NPP satellite VIIRS DNB (Day/Night Band) monthly composite nighttime lights average radiance data from August 2025[38].

mation. The future of global sustainable development depends on whether cities can lead the way in technological innovation and resource efficiency.

1.2 Cities: From Resource Expansion to Resource Efficiency

1.2.1 The Transformation in Development Philosophy

The history of urban civilization is marked by three great leaps, each driven by a revolution in key infrastructure. Over 2,000 years ago, Rome's construction of road networks ushered humanity into the "Era of Horsepower." For the first time, a city's scale and development level could be measured by the number of horses it supported. Then, around 130 years ago, the introduction of the electrical grid by Edison in New York marked the dawn of the "Era of Electricity." Electrification not only transformed the urban landscape but also sparked a wave of innovation in appliances — from light bulbs to air conditioners, televisions, and refrigerators — linking a city's economic level directly to its electricity consumption[43]. Today, with the maturation of the internet, cloud computing, and AI, cities are making the third leap — moving from the "Era of Electricity" to the "Era of Computing Power." Just as cities needed roads in the "Era of Horsepower" and grids in the "Era of Electricity," they now require a new kind of infrastructure to harness computing power.

Figure 1–10: Cities are key arenas for achieving global Sustainable Development Goals

Source: Created by authors

From ancient Rome in the "Era of Horsepower" to New York in the "Era of Electricity," cities have long fueled their growth by consuming more resources to meet the demands of a rising population and economy. The widespread adoption of electricity, in particular, dramatically increased energy use in industry and homes, placing immense pressure on the planet's natural resources. For decades, many cities expanded in a sprawling, "pancake-like" pattern. They supported growth by constantly adding more land, energy, water, and other resources. While this model of expansion drove rapid urbanization, it has become unsustainable as resource constraints and environmental pressures intensify.

Currently, entering the "Era of Computing Power," we are recognizing for the first time that data is, in essence, a form of "natural resource." Emerging technologies, exemplified by AI and big data, empower cities to optimize the operation of their energy, water, and transportation systems. By leveraging data resources with high efficiency, cities achieve greater efficiency in the use of all other urban resources. This marks a strategic pivot for cities — from a reliance on the expansion of natural resources toward a pursuit of optimal resource efficiency. It drives a fundamental shift from "incremental expansion" to "optimization of existing stock," enabling cities to meet their development goals without increasing, or even while reducing, resource inputs. In the "Era of

Computing Power," the advent of new infrastructure is catalyzing a profound transformation in urban development philosophy: cities are no longer dependent on the boundless expansion of natural resources. Instead, they are harnessing data to optimize the utilization efficiency of existing natural assets, thereby transitioning onto a sustainable development path defined by "resource conservation" rather than "resource expansion."

1.2.2 Data Resources Driving Efficient Use of Urban Resources

The goal of Resource Efficient Cities is not just to use less, but to maximize the efficiency of the resources we do use through systemic and holistic optimization. This paradigm shift is rooted in the deep understanding of urban metabolism. Ireland's water management case illustrates the point: even in a developed economy, up to 25 percent of water is lost through pipeline leakage — far outpacing savings from household conservation. Real sustainability comes from fixing system inefficiencies, not just asking people to cut back. Using data resources to optimize resource efficiency is key to this.

(1) Data Bitization: The Foundation of a New Resource

In the "Era of Computing Power," data becomes a strategic resource from conventional information through "bitization." According to the "Every Bit Being Online[44]" principle, this transformation establishes three foundational conditions for creating value from data resources: First, every bit is on the internet. Second, every bit can flow freely across the internet. Third, every object represented by a bit is computable online. The rule of Being Online defines the true efficiency of data as a resource. Bits hold no economic value when disconnected from the internet and trapped on local hard drives. If bits cannot flow freely, their latent value remains fragmented. When bits cannot be computed, data resources cannot be turned into real-world productivity. This "bitization" process represents more than a technological leap — it's a fundamental shift in our perception of resources. By transforming data into a strategic asset, it provides the essential groundwork for powering sustainable city development.

Cities are the most concentrated hubs of data resources. In modern cities, sensors such as cameras generate vast amounts of data every day. This data is meant to optimize traffic, safety, and public services, yet during the "bitization" stage, most of it remains "dormant" — offline and inactive. This situation shows that while data exists in the form of bits, it has not yet been truly transformed into a computable, flowing resource. As a result, efforts to optimize city resources are limited by human cognitive capacity, making it difficult to achieve citywide optimization.

(2) Data Tokenization: A Qualitative Leap in Resource Value

The scaling effect unleashed by combining data, AI models, and computing power is key to achieving a qualitative leap in AI. The AI era, ushered in by the rise of deep learning in 2012, truly achieved the synergistic integration of massive data, complex models, and large-scale computing power only after the introduction of the transformer architecture and tokenization technology in 2017. Within AI models, the token serves as the fundamental unit of data. Tokenization is the process of converting data into tokens, which can also be termed "token-ization." It is through this transformative process that data achieves a qualitative leap — becoming structured, computable, and aggregable — and thus becomes directly usable by AI models, enabling truly scalable AI applications. Tokenization is more than just a technical method; it is a paradigm for organizing resources. It allows data to enter the computational pipeline in a unified and efficient form, thereby unlocking exponential value. In the urban context, tokenization means transforming scattered, heterogeneous data into transferable, computable, and shareable resource units. Open sharing of resources is fundamental to systemic innovation. Tokenization facilitates the efficient, secure, and controlled flow and collaborative computation of urban data across different departments and systems. This helps dismantle "data silos" and advances urban governance from localized optimization toward comprehensive intelligence[45].

(3) Data Resources Leading City Resource Efficiency Optimization

Data resources help to optimize city resource efficiency by providing measurement to eliminate cognitive blind spots and restructuring systems through open sharing mechanisms.

First of all, data resources eliminate "blind spots" in urban governance through precise measurement. For a long time, cities have had a vague understanding of resource use, lacking a scientific baseline to define reasonable demand. For example: How much water does a household actually need? There is no scientific benchmark. By comprehensively bitizing and tokenizing all types of city resource data, a city can establish an end-to-end monitoring system from source to consumption. For example, Hangzhou City Brain found through real-time data that in a city of 3 million vehicles, only about 300,000 were causing peak-hour congestion[46]. This revolutionary finding — from focusing on the car parc to analyzing the dynamic on-road vehicles — totally reshapes our understanding of how cities operate and provides a precise target for resource optimization.

Deeper optimization comes from open sharing and system restructuring driven by data resources. "Opening up model weights today is, in essence, opening up data resources and computing resources[45]." This mechanism enables the secure flow of tokenized data across municipal departments, allowing them to share computing power and AI models based on unified standards. This avoids redundant resource investment, leading to a leap in the overall efficiency of the city's resource systems.

1.2.3 Shift of City Development Pathways and New Urban Civilization

This data-driven optimization of urban resource efficiency is moving urban civilization from the "Era of Electricity" to the "Era of Computing Power." When "Every Bit Being Online" becomes the reality through digital infrastructure in cities, every parcel of land, every kilowatt-hour of electricity, and every drop of water will be sensed, measured, and optimally utilized through data. This transformation manifests concretely as a triple breakthrough in governance models, service delivery, and development paradigms[43].

First, a breakthrough in urban governance: From decision-making based on experience to decision-making driven by data. Urban governance is undergoing a profound shift toward "seeking human and service capacity from data." It is moving from reactive responses to proactive predictions, and from broad-brush management to precise policy implementation.

Second, a breakthrough in services: From one-size-fits-all provision to precise matching. Data is now delivering more direct value to society by tackling urban development challenges that are beyond the scope of human cognition alone. When public services become as reliable and fundamental as electricity, achieving the greatest social benefit with the minimal resource consumption, then resource conservation and the improvement of people's livelihoods are no longer a zero-sum game but a new paradigm of synergistic progress.

Third, a breakthrough in the urban development model: From reliance on consuming resources to being driven by computing power. Open urban data is like the "new oil" or "new semiconductors," which is a core element for upgrading industry and fostering innovation. The digital economy exhibits a distinct characteristic: a city's economic development level is increasingly decoupling from its electricity consumption while becoming more tightly linked to its computing power consumption. This signals a shift from the old oil-based economy to a new computing-based economy, opening a new path for sustainable urban development.

For this to happen, cities must plan for their data resources as strategically as they plan for land, manage their data processing with the seriousness afforded to waste treatment, and provision their computing power supply as meticulously as they do their electricity supply. When these shifts are realized, cities will truly complete the leap of civilization from the "Era of Electricity" to the "Era of Computing Power," where economic growth does not require high resource consumption[43]. This vision has gained global consensus. The UN Environment Programme's "Resource Efficient Cities" initiative[47] systematically advocates for cities to grow their economies while using far fewer resources and to minimize resource consumption and pollution emissions per unit of GDP.

Certainly, the shift toward resource-efficient cities is not merely a technical challenge; it involves changes in social behavior and lifestyles. Cities, with their dense populations and rapid information flow, serve as the leading test beds for sustainable living practices. Initiatives like green commuting, sharing economy, low-carbon communities, and energy-saving households are often piloted in cities, where public education and community engagement build social consensus. Increased citizen participation not only drives market "greening" but also provides feedback for policy implementation, achieving dual optimization in both resource conservation and social culture. However, none of these transformations can occur without the support of urban infrastructure. In the "Era of Computing Power," as data resources become a new form of urban capital, their ability to dramatically enhance the efficiency of existing urban assets — achieving an effect equivalent to increasing natural resources — will propel human urban civilization toward a truly sustainable future defined by resource conservation, environmental harmony, and economic prosperity. In this sense, new digital infrastructure — much like the roads in the Roman era or the power grids in the "Era of Electricity" — will lay the foundation for sustainable development of urban civilization driven by data resources[48].

1.3 City Brain and Sustainable Urban Development

1.3.1 From Electrification to Digitalization

The profound and comprehensive structural changes that reshaped the world in the early 20th century stemmed from a foundational technology announced by the U.S. National Academy of Engineering (NAE) as the most primary one of the "Greatest Engineering Achievements of the 20th Century": electrification.

Electrification was not merely a key engineering feat; it served as the foundational technology for modern civilization itself. Almost all modern technological systems and industrial forms — communications, computing, transportation, manufacturing, healthcare — were built upon the completion of electrification (Figure 1-11). Consequently, electrification largely shaped the direction and pace of national development in the 20th century, restructuring modes of production, organization, and governance.

From this perspective, today's digitalization and intelligentization bear a resemblance to the electrification of a century ago. Cities in the 20th century were reshaped by electrification, and the 21st century is being reshaped by digitalization and intelligentization. "AI + City" is positioned within the historical coordinates of "profound technological revolution unseen in a century," representing a structural transformation comparable to electrification. This shift signifies not just technological evolution at the industry level, but a fundamental reconfiguration of the operating logic of city systems from the ground up — a new foundational change.

1.3.2 The City Brain Question

Global urban challenges like traffic congestion and water scarcity have yet to find ideal solutions. The smart city initiative was once seen as the answer, but it quickly fell into the traps of being too tech-focused, lacking a holistic view, and struggling with sustainability. Against this background, the "City Brain" initiative emerged from practice in Hangzhou, China. It represents a decisive turn from resource expansion to resource efficiency, using data as the primary driver to optimize all urban resources. This marks the exploration of an entirely new paradigm for urban development.

In 2016, before the opening of the G20 Summit, Hangzhou resolved to tackle its chronic traffic congestion as a starting point for systematically addressing broader urban challenges. It was during this period that Dr. Wang Jian, the member of the Chinese Academy of Engineering, first introduced the concept of "City Brain" for Hangzhou. He posed the crucial City Brain Question: "Can 10 percent of a city's current resources support its sustainable high-quality development?" He argued that genuine urban transformation must be built upon a holistic view of the city as a "complete living organism." Just as such an organism requires a brain to coordinate its functions, a city needs its own "brain" to achieve efficient governance — the core of which is coordination, ensuring that actions are taken by an integrated whole, which is inherently the most resource-efficient approach. Therefore, "City Brain" is conceived not merely as a tool for solving isolated, departmental issues, but as a digital infrastructure designed to synergize various departmental systems, enabling them to operate collectively with high efficiency. Appointed as the "Chief Architect of Hangzhou City Brain," Dr. Wang Jian, with the support of the Hangzhou government, led a group of over a dozen companies from different regions who volunteered to explore and implement "City Brain." This itself was an innovative mechanism. A joint task force of government, businesses, and social organizations focused on building City Brain scenarios. They performed real-time, citywide calculations on all urban data, dynamically allocated public resources, and ultimately

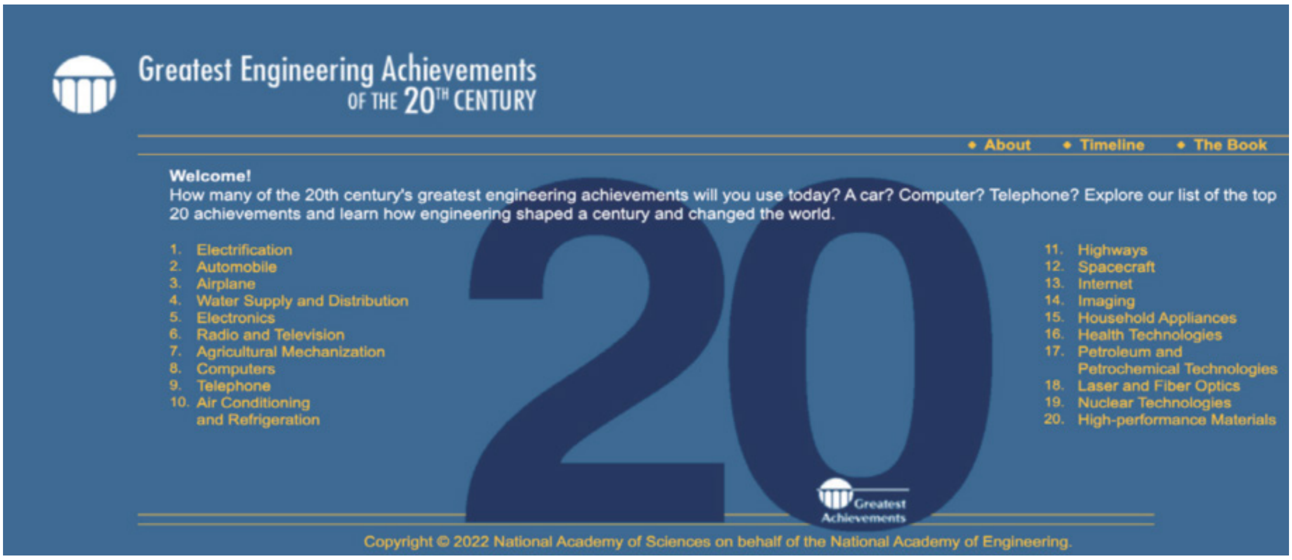


Figure 1–11: The U.S. National Academy of Engineering's selection of the 20 Greatest Engineering Achievements of the 20th Century

Source: U.S. National Academy of Engineering transformed data into the most crucial resource for urban governance and development[49].

The emergence of the "City Brain" concept is largely a response to the problems of traditional smart city projects, aiming to solve the old issue of treating symptoms instead of the root cause. The Smart City concept emerged in the early 21st century alongside advances in information and communication technology (ICT)[50]. The early version of "Smart City 1.0" was mainly technology-driven. Led by major vendors, it focused on deploying sensors and networks at the infrastructure level for data collection and basic information management. However, it often overlooked citizens' needs and the coordination among various urban entities[51]. In the early 21st century, some countries planned and built "digital cities" (e.g., Songdo City, South Korea; Masdar City, Abu Dhabi), using central control systems to optimize things such as traffic signals and energy distribution. Around 2010, the Smart City 2.0 placed greater emphasis on citizen participation and open data. Many established cities launched intelligent transformation projects. However, traditional smart city models revealed multiple limitations in practice[52].

(1) Tech-Driven, but Not People-centred. Projects of this period, often led by tech companies, became overly fixated on sensor networks and data collection. They merely prioritized quantifying and algorithmizing city life rather than addressing citizens' core needs and experiences. The result was impractical applications that failed to enhance quality of life.

(2) Not Holistic or Inclusive Enough. Most smart projects merely serve specific groups or a single area, exacerbating the digital divide for already vulnerable urban populations. Meanwhile, implementation is concentrated in affluent cities or new developments, with scant presence in less developed regions or older urban cores, thereby failing to achieve broad societal inclusion.

(3) High Cost, Hard to Sustain. Early smart city models were predominantly technology-centric. They relied on extensive sensor networks, complex IT systems, and centralized control mechanisms in pursuit of isolated efficiencies. This approach proved prohibitively costly, fostered duplication of efforts, and resulted in sub-optimal resource utilization, contributing little to long-term, sustainable urban development[53][54].

The root of these issues lies in two main flaws in the traditional smart city approach. First, it often views the "city" merely as a physical machine for technology, missing a true understanding of it as a place for life and growth. Second, it fails to see the city as a single, connected system, which stops us from thinking about saving resources and building efficiently for the future. For a long time, people thought solving congestion was only about the total number of cars registered in a city (the "car parc"). But what really matters is how many cars are actually on the road at any given time (the "on-road vehicles"). "Car parc" refers to the total number of vehicles officially registered in a city. It is a static concept of total volume. "On-road vehicles" refers to the number of vehicles that are actually driving on the roads at a specific point in time. It is a dynamic concept of real-time flow. In their core nature, the former is based on a static total (how many cars there are), while the latter focuses on dynamic, real-time data (how many cars are running). In terms of data source, the former comes from registration information at the vehicle management authorities, while the latter comes from real-time data from the urban sensing system (such as cameras, magnetic sensors, GPS, etc.). The former is concerned with the scale of vehicle assets a city owns, while the latter focuses on the immediate status and efficiency of vehicle operation. Hangzhou City Brain was the first to accurately count its "on-road vehicles." When Hangzhou's car parc reached about 3 million, the data revealed a critical insight: even at peak times, only around 300,000 cars (just 10 percent) were actually on the road. The urban resources needed to manage 300,000 moving cars are completely different from those needed for 3 million parking cars[49]. This 10 percent ratio has since been found in many other cities using City Brain (Figure 1-12). This huge gap challenges the waste of old, inefficient ways of using resources and proves the value of asking the fundamental "City Brain Question."

Beginning with Hangzhou in 2016, the practice of City Brain expanded with unexpected speed to cities across China, redefining the logic of urban development and operation. It addresses the critical challenge of excessive resource consumption by optimizing the allocation of citywide resources, systematically advancing sustainable development[55][56]. This embodies four core principles:

(1) People-Centred: City Brain scenarios are tightly focused on residents' needs, with the core goal of improving public welfare and convenience. For example, Hangzhou City Brain improved emergency medical response by giving ambulances traffic priority and created a convenient "Pay-after-Departure" parking system with China's first citywide barrier-free parking[57].

(2) Holistic Perspective: The City Brain inherits and deepens the concept of holistic view, emphasizing a shift from local optimization to system-level optimization. This equips the city, for the first time, with the capability to optimize resource allocation as an organic whole.

(3) Resource Efficiency: The City Brain Question is, at its core, a resource question. Building a resource-efficient society first requires a precise mapping of how resources flow[58]. "City Brain" tackles this by using minimal resources to boost efficiency — saving through computation. For example, it cuts waste in water networks to conserve water[59], or reduces traffic jams without needing driving restrictions, as seen in Nanchang's "No Traffic Restriction" approach that significantly improved the commuting experience for citizens without building new roads[60].

(4) Sustainable Development: City Brain enhances resource-use efficiency by leveraging data reuse and smart regulation. Most importantly, cities can improve functional efficiency without increasing physical resource inputs. The unsustainability of resources leads to the unsustainability of cities. To achieve the "dual carbon" goals and ensure sustainable urban development through resource efficiency, "City Brain" may represent one of the essential pathways forward.

	Vehicle Ownership (Million)	On-road Vehicles (Million)	Road Network Length (km)	Intersections (Signalized)	Road Segments
City A	3	0.3	3057	3819(2864)	5462
City B	1.18	0.12	1289	2067(1004)	3041

Figure 1–12: Peak–hour on–road vehicles accounted for only 10 percent of vehicle ownership in two typical Chinese cities (2020)

Source: Created by authors

1.3.3 City Intelligence: a New Paradigm for Sustainable Development

The progression from digitalization to city intelligence is fundamentally reshaping our world through AI. Digitalization forms the foundation by accumulating data as a key factor of production, while city intelligence represents an advanced stage that unlocks the value of this data through computation and AI technologies. AI signifies not merely a revolution in tools, but a tool for scientific revolution itself[61]. With the key mechanism of "AI +," the entire logic of development undergoes a profound transformation. The city serves as an exemplary case. Following its own developmental patterns, the evolution of AI technology has given rise to City Intelligence. This concept recognizes that a city operates as an integrated entity with its own intrinsic mechanisms, rather than merely serving as a vessel for imposed human ideas[62]. In essence, City Intelligence is not a technological projection of human cognition onto urban space, but an organic system endowed with its own form of wisdom. This represents a fundamental shift in the very logic of urban development.

City Brain constitutes the modern digital infrastructure that enables advanced urban governance. City Intelligence is the tech that powers it. With the deep integration of data, AI models, and computing power, City Intelligence can sense the entire city, perform real-time analysis, and make holistic decisions. This is reshaping resource utilization, governance, and development patterns in cities, fundamentally steering urban growth toward greater resource efficiency. This transformation is manifested in three fundamental shifts. First, the primary driver of development has moved from reliance on land and energy to dependence on data and computing power, making urban operations measurable and optimizable. Second, the methodology of governance has evolved from fragmented, department-specific "technology application" toward the coordinated intelligence of the "city as a whole," enabling the systemic allocation of resources. Third, the core value objective has shifted from pursuing scale expansion to optimizing resources and enhancing human well-being. Operating within the hard constraints of urban resource limits, this approach charts a course toward a digital civilization founded on trust and efficiency — ultimately giving rise to an entirely new form of city.

This shift from a focus on resource "expansion" to a "resource efficiency revolution" is operationalized by City Intelligence, which "substitutes the consumption of additional natural resources with data-enabled efficiency gains"[63]. Shanghai's "Unified Governance through One Network" and Hangzhou City Brain both contribute to public service efficiency by integrating data and working across departments. Cities globally are leveraging data and AI to enhance urban operations. Examples include Paris with open traffic data[64], New York with open data platform, and Seattle with Project Green Light[65]. In Seattle, AI analysis of traffic data indicates the potential to reduce vehicle stops by approximately 30 percent and CO_2 emissions by about 10 percent. This translates data insights into tangible reductions in fuel consumption and travel time delays[65]. A study in Nature Communications (Figure 1-13) found that smart, data-driven traffic lights in China's 100 most congested cities cut peak-hour travel times by 11 percent. This could lead to social benefits equal to cutting carbon emissions by up to 31.73 million tons each year[66].

The strategic directions of major global organizations also corroborate this trend. For instance, the Group on Earth Observations (GEO) has shifted its strategic focus from Earth Observation to Earth Intelligence[67], dedicated to transforming high-precision global environmental data into actionable intelligence to support urban climate adaptation and sustainable investment decisions. Notably, GEO's Global Heat Resilience Service (GHRS) specifically focuses on providing executable intelligent solutions to low- and middle-in-

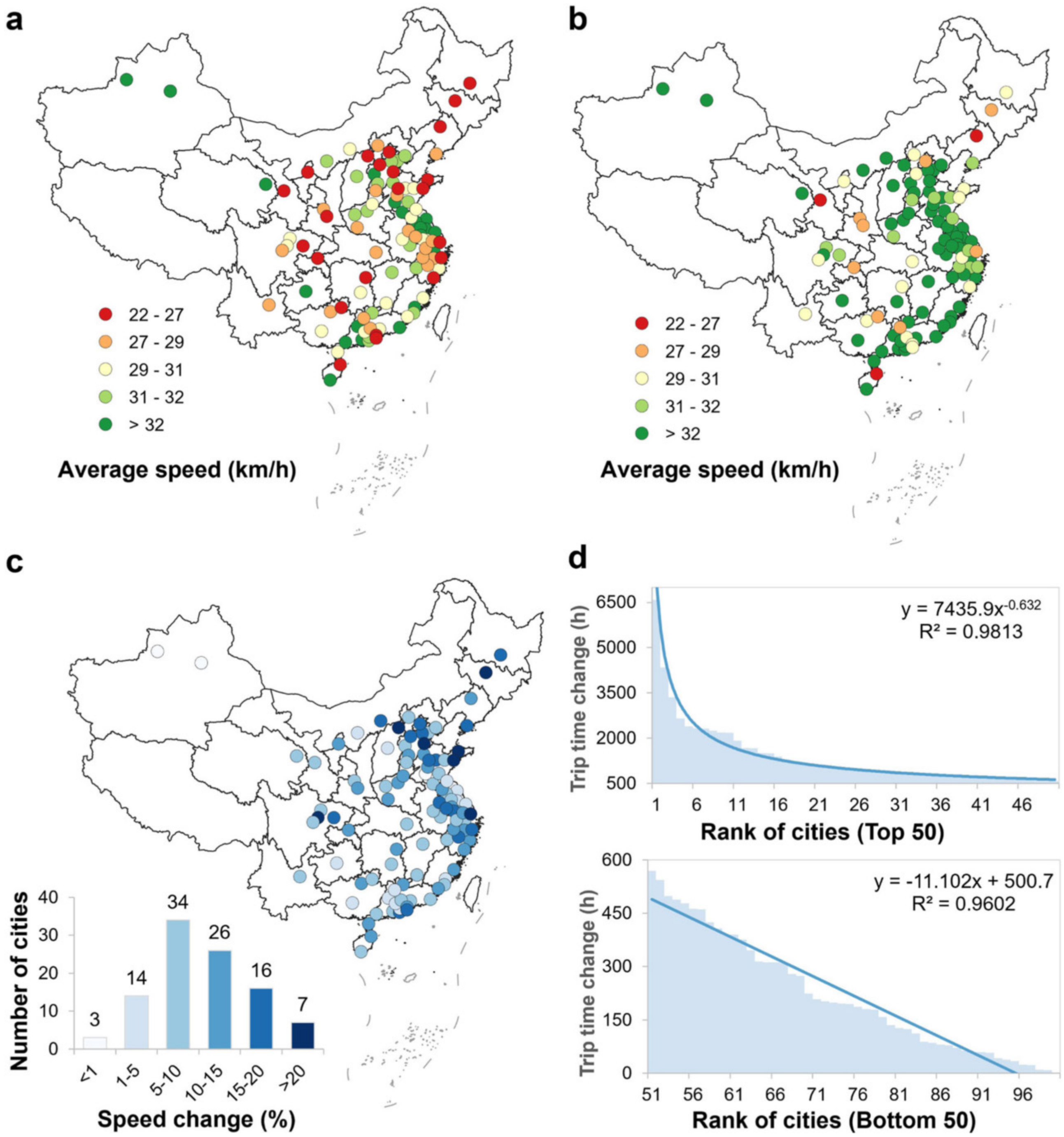


Figure 1–13: Optimizing city intelligent traffic signal control can significantly alleviate congestion and reduce transportation carbon emissions

Source: Created by authors

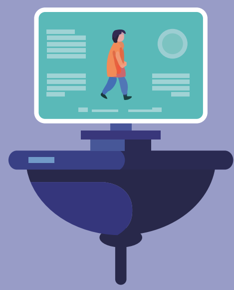
come cities that lack reliable localized data[68]. Similarly, the C40 Cities Climate Leadership Group leverages real-time data to guide cities in emission reduction and disaster resilience practices[69]. These strategic shifts align closely with the City Intelligence vision of City Brain.

The insight from the "City Brain Questions" symbolizes a paradigm reshaping in urban governance — from relying on vague experience and aggregate estimates toward reconstruction based on precise data. Its ultimate goal aligns with humanity's fundamental pursuit. "People-centred and digitally empowered — this is the code for City Brain to unlock a city of well-being[70]." This means technology must serve to enhance human welfare and social equity. This concept extends to the vision of common prosperity — building a sustainable, rational social structure centered on lifelong capacity development for the people. The City Brain's vision of "cities meeting needs with just 10 percent of their original resources" is the technical embodiment of this goal. It envisions a sustainable future where "City Intelligence" enables a sharp drop in material consumption alongside sustained growth in well-being and civilizational prosperity.

City Brain: "City Intelligence" and "AI + City"

Chapter 2 City Brain: "City Intelligence" and "AI + City"

02



Amidst its remarkable growth, China's urbanization now faces serious challenges of resource overconsumption and systemic inefficiency. Guided by the strategy that "building a resource-conserving society is a social revolution," the "AI + City" initiative — driven by a holistic urban perspective — is advancing China toward "City Intelligence." City Intelligence initiatives, guided by the philosophy and framework of the "City Brain," have become a key driver for advancing sustainable urban development.

The realization of City Intelligence depends on a synergistic technical architecture, centered on the integrated "trinity" of data, AI models, and computing power. Data is the core resource, models are the intelligence engines, and computing power provides the foundational infrastructure. The City Intelligence engine, deployed for governance, integrates various AI models — such as those for physical sensing, social perception, dynamic simulation, and knowledge — into a unified city foundation model (a general-purpose urban AI model). This integration endows the system with general cognitive and reasoning capabilities across diverse scenarios. By 2025, Hangzhou has emerged as a foremost thought leader and practitioner in open-sourcing AI foundation models. In shaping City Intelligence, opening access to data, AI models, and computing power is tantamount to opening up the very resources for urban innovation. This represents a vital collaborative mechanism for synergistic development among cities.

The practices of "AI + City," represented by City Brain, have steadily expanded from its origins in transportation to encompass a comprehensive range of city-scale applications, including ecological monitoring, energy management, healthcare, and education. Signature scenarios such as "One City, One Parking System," "Qinqing Online," "One More Hour for Tourism," and "Campus Brain" vividly illustrate this deepening integration — evolving from respective applications to interconnected scenarios and ultimately toward a holistic panorama. This progression has catalyzed a profound transformation in governance paradigms: cognitively, shifting from vague intuition to scientific decision-making grounded in data; methodologically, breaking down departmental silos to embrace a holistic view of the "city as an organic living system;" and axiologically, moving away from a technology-control mindset to return to "people-centred." Its ultimate significance lies in the reconstruction of social trust, paving the way through intelligent transformation toward a new form of urban civilization.

2.1 Challenges to Sustainable Urban Development in China

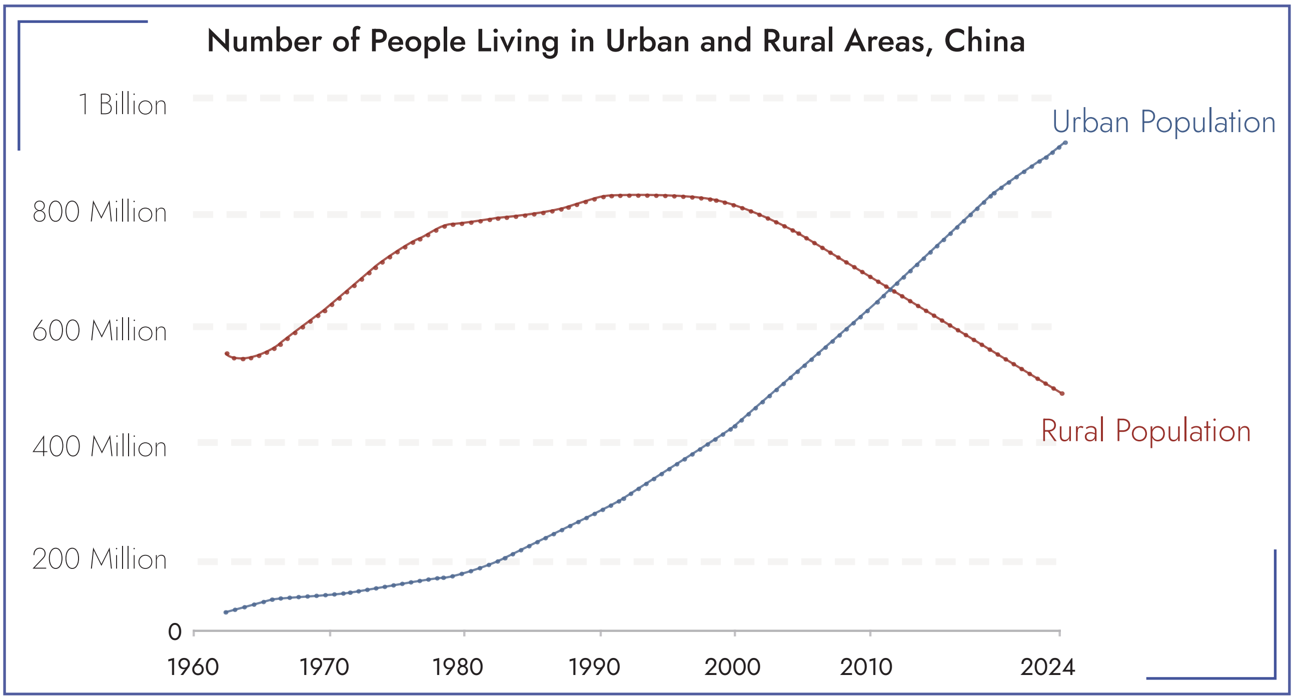


Figure 2–1: Changes in urban and rural population in China

Source: "Our World in Data" website

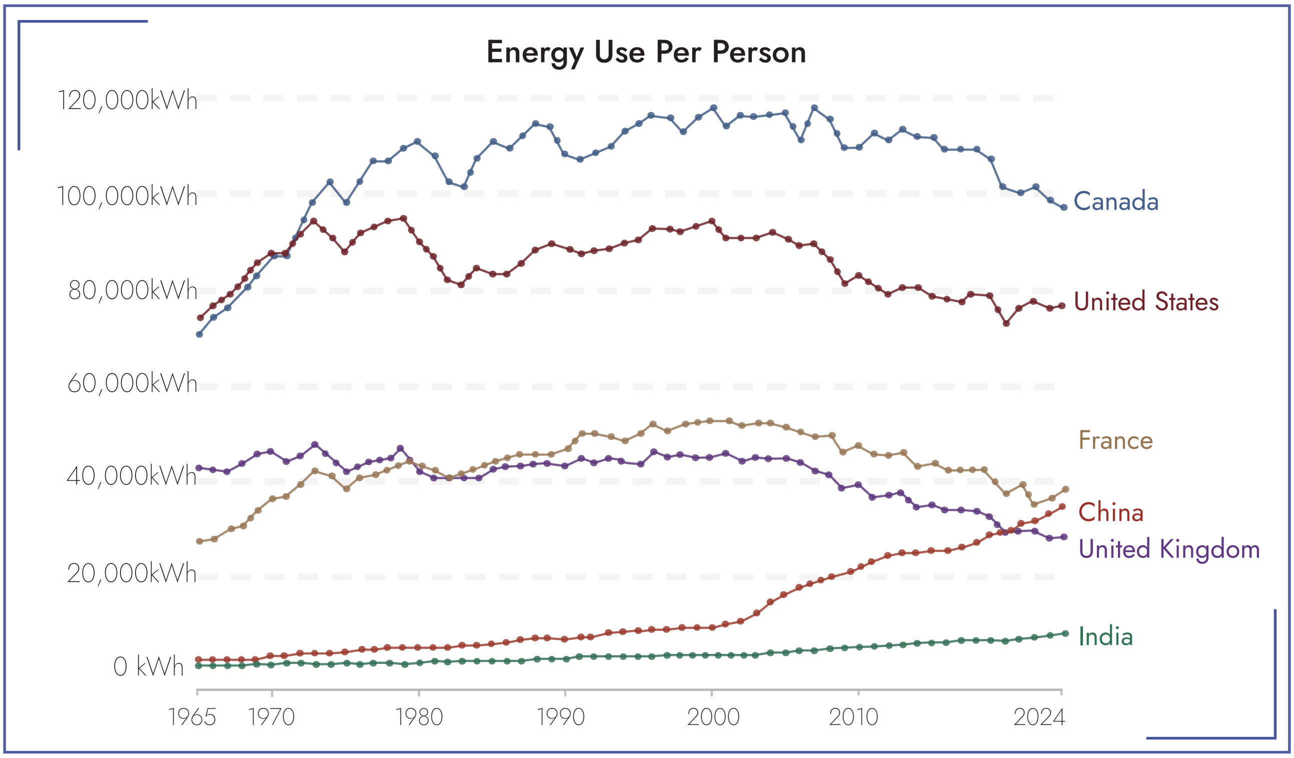


Figure 2–2: Comparison of energy consumption per capita of China, Canada, the United States, and other countries

Source: "Our World in Data" website

2.1.1 Resource Bottlenecks Amid Accelerated Urbanization

China's urbanization has surged over the past few decades, with city populations and physical scales expanding rapidly (Figure 2-1). According to urbanization projections from the UN Department of Economic and Social Affairs, China is estimated to add approximately 255 million new urban residents between 2018 and 2050 (ranking second globally, behind only India)[71], while annual statistics from China's National Bureau of Statistics also indicate that China's urban permanent population reached 944 million by the end of 2024, with the absolute scale of resource demand continuing to grow substantially[72].

Statistics from "Our World in Data" indicate that while China's per capita energy consumption remains below that of major developed countries, the gap is rapidly narrowing (Figure 2-2)[73]. If consumption patterns in China's major cities (private car parc, air conditioning energy use, household appliance penetration, etc.) converge with those typical of developed countries, it will place enormous pressure on infrastructure such as land use, energy, and transportation.

In China, systemic inefficiencies in infrastructure are more pronounced than the global average in several critical areas: Non-Revenue Water (NRW) levels in urban water supply systems serve as a key indicator of management efficiency. World Bank reports indicate that NRW in some Chinese cities ranked at the mid-range among developing nations, with millions of cubic meters of water lost daily due to pipeline leaks or inadequate billing, resulting in significant water waste and management inefficiencies. In contrast, major European cities and Japan showed significantly lower NRW levels than developing countries, demonstrating

Top 20 Chinese Cities by Peak–hour Signalized Intersection Delay (Seconds)

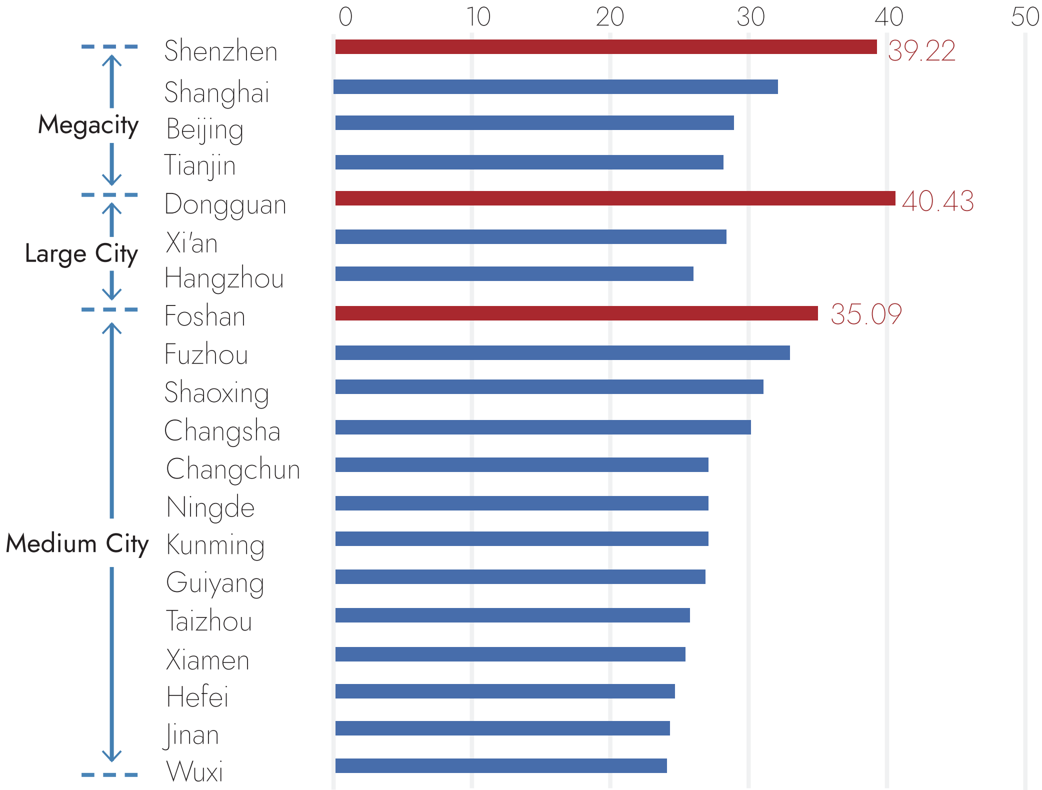


Figure 2–3: Average delay during morning and evening peak hours at major signalized intersections in Chinese cities (2024)

Source: China Urban Road Intersection Efficiency Report superior pipeline management, leakage control, and infrastructure modernization[74].

In transportation, the new century saw private cars entered Chinese households on a massive scale, overwhelming urban roads and making congestion relief a nationwide priority. Despite increased infrastructure investment across regions, sprawling expansion created new challenges: rapid urban growth encroached on farmland, squeezed ecological space, and thinned green belts around cities, further exacerbating resource and environmental conflicts. Many major cities have been compelled to implement measures such as traffic restrictions based on the last digits of license plate numbers and vehicle purchase lotteries to alleviate peak-hour traffic pressure and reduce pollution emissions. By the end of September 2025, the total number of motor vehicles in China reached 465 million. Despite proliferating traffic restriction policies, the car parc continues to climb and congestion persists[75]. The 2024 China Urban Road Intersection Efficiency Report (Figure 2-3) quantifies the economic impact: in high-congestion, high-time-value cities (e.g., Beijing, Shanghai), a single congested intersection incurred an economic loss of approximately 1,277 yuan for every thousand vehicles delayed per peak hour, which means an annual loss exceeding 1.27 million yuan[76].

China's urbanization has amplified resource demands, as rising per capita consumption and lifestyle upgrades have increased resource intensity. On the supply and governance side, systemic inefficiencies — such as water pipeline leakage, traffic congestion, and power transmission/distribution losses — prevent optimal allocation and utilization of finite resources. Under the old model of extensive development, many cities traded intensive resource consumption for growth, resulting in immense ecological and environmental pressures. Multiple Chinese and international reports have highlighted that without altering this resource-inefficient development model, the resource pressures stemming from China's urbanization will evolve into long-term systemic bottlenecks.

2.1.2 Urban Transformation Under Resource Constraints

China's urban development model is undergoing a profound paradigm shift, with its core transitioning from scale expansion reliant on resource consumption to pursuing resource conservation through intensive growth. The article "Building a Resource-Conserving Society is a Social Revolution[77](Figure 2-4)" from the book Zhijiang Xinyu profoundly reveals the eternal contradiction between humanity's developmental needs and the finite supply of Earth's resources. It emphasizes that "building a resource-efficient society is a social revolution concerning the harmonious coexistence between humanity and nature," which represents a forward-looking contemplation of China's modernization path, charting a course for a sustainable route to modern development.

Facing severe resource constraints, the national policy framework has responded (Figure 2-5). A landmark milestone was the 11th Five-Year Plan (2006-2010), which for the first time incorporated the goal of building a "resource-efficient and environment-friendly society" into its preamble and set binding targets such as reducing energy consumption per unit of GDP by 20 percent. Since then, resource conservation has become a fundamental constraint on urban development through legislation and policy[78]. In the "14th Five-Year Plan" and the new urbanization strategy, the goal of building a "two-oriented society" (resource-efficient and environment-friendly society) was clearly articulated. The aim is to achieve green and sustainable development through low input, high output, low consumption, and reduced emissions.

At the urban level, this shift toward connotative, quality-focused development is moving from blueprint to reality. The National Development and Reform Commission's Implementation Plan

Building a Resource-Efficient Society is a Social Revolution

(February 23, 2005)

"Building a resource-efficient society is a social revolution concerning the harmonious coexistence between humanity and nature. The eternal contradiction lies between humanity's pursuit of development and the finite supply of Earth's resources. The ancient saying, 'The nature nurtures things in its time, the earth yields wealth in its limits, yet human desires endlessly,' reflects this contradiction in a certain sense. In a long time back in history, though with low productivity and material deprivation, human society endured for millennia without major ecological disruption. Yet in the mere three centuries since the dawn of industrial civilization, humanity's immense productive forces have enabled Western-style modernization in a handful of developed nations — but now threaten human survival and the continuity of Earth's biodiversity. Western industrial civilization rests on the affluence for the few and poverty for the many; if the majority seek to live like the wealthy few, human civilization will collapse. The Western-style modernization pursued by the world today is unattainable — it is a trap for humanity. Therefore, guided by the Scientific Outlook on Development, we must explore a sustainable path to modernization. For Zhejiang, a province rich in economic potential yet limited in resources, building a resource-efficient society is even more urgent. This is the very essence of our efforts to build an ecological province."

Zhijiang Xinyu

Figure 2–4: Excerpt from the Article "Building a Resource–Efficient Society is a Social Revolution"

Source: Xi Jinping: Zhijiang Xinyu, Zhejiang People's Publishing House, 2007 edition.

for New Urbanization in the 14th Five-Year Plan Period proposes limiting new construction land expansion to 29.5 million mu (about 7,600 square miles) by 2025, shifting cities from sprawling expansion to optimizing existing resources[79]. Cities like Beijing and Shanghai are boosting resource circulation efficiency through projects such as energy-saving retrofits in old neighborhoods, rainwater harvesting, and reclaimed water use. Many localities have also incorporated land-use intensity and energy consumption per unit of GDP into their high-quality development assessments, ensuring that growth remains within environmental limits.

2.1.3 The Evolution of City Brain

Amid city resource constraints and the urgent need to shift toward efficient development, "City Brain" has advanced "City Intelligence" in China, guided by a holistic urban perspective. The City Intelligence solutions developed under the City Brain concept have become a key driver for sustainable urban development.

When Hangzhou initiated its City Brain exploration in 2016, it introduced pivotal concepts such as "data resources are the decisive resource for future urban development" and "City Brain is the Apollo program for smart technology." Through practical application in various scenarios, City Brain has demonstrated that a data-driven approach to efficient, resource-conserving governance is both viable and effective. Its evolution is illustrated by the implementation of specific scenarios — from managing traffic congestion to governing the entire city — such as the "Pay-after-Departure" parking system. In

2004-2006	2007-2010	2011-2015	2016-2020	2020-2025
Conceptualize & Framework	Constrain & Qualify	Integrate & Systemize	Legalize & Standardize	Low-carbon & Resource-efficiency
2004 State Council General Office, Notice on Launching Resource Conservation Activities 2005 State Council, Notice on Key Tasks for Building a Resource-Efficient Society 2006 11th Five-Year Plan — Part VI: Building a Resource-Efficient and Environmentally Friendly Society	2007 State Council, China's National Climate Change Program — "energy saving and efficiency improvement" as top mitigation measure. 2008 the National Development and Reform Commission (NDRC), Implementation of the Energy Conservation Law 2008 China's Policies and Actions for Addressing Climate Change (White Paper Report)	2011 China's 12th Five-Year Plan — Develop Circular Economy: "Reduce, Reuse, Recycle" 2011 State Council, China's 12th Five-Year Energy & Emission Plan: control on energy intensity & total consumption 2015 The CPC Central Committee and State Council, Accelerate Ecological Civilization	2016 China's 13th Five-Year Plan (2016–2020) promotes resource efficiency and circular use, calls for a fundamental shift in resource utilization and management across all stages. 2016, NDRC and 12 other ministries issued the 13th Five-Year Nationwide Energy Conservation Action Plan (NDRC [2016] No. 2705). NDRC, The Measures for Energy Conservation Supervision (NDRC Order No. 33, 2016)	2021 China's 14th Five-Year Plan (2021–2035) calls for advancing resource management, scientific allocation, conservation, and efficiency improvement. The State Council's 2024–2025 Action Plan closely links resource conservation with carbon peaking through major sectoral upgrades. 2024 The CPC Central Committee and State Council stress that green and low-carbon development is key to high-quality growth and urge a comprehensive conservation strategy.

Figure 2–5: Policy evolution pathway for Chinese cities' transformation toward resource efficiency

Source: Created by authors

2017, Hangzhou became the first city in China to establish a Data Resources Administration, the first department explicitly named for "data resources," tasked with managing data resources, advancing City Brain development, and coordinating digital infrastructure. That same year, China's State Council issued the New Generation Artificial Intelligence Development Plan, which elevated AI to a national strategic technology and set industry and application targets for 2030. This synergy of practical innovation and policy guidance accelerated AI's transition from research and experimentation to widespread use in urban governance and public services. In 2018, Hangzhou released the comprehensive version of City Brain, which innovatively employed a "central system" to break through traditional architectural limitations. This enabled cross-departmental collaboration and marked a shift from "technical pilot" to "systematic service," laying the groundwork for the city's holistic intelligence.

Hangzhou's exploratory practice quickly garnered broad attention and strategic guidance. In 2018, Chinese President Xi Jinping inspected the City Brain of Pudong in Shanghai's Pudong New Area Integrated City Management Center, and emphasized: "A first-class city must have first-class governance, focusing on scientific, refined, and intelligent approaches." In 2020, President Xi Jinping inspected the Hangzhou City Brain Operations Command Center and emphasized that leveraging cutting-edge technologies such as big data, cloud computing, blockchain, and AI to drive innovation in city management methods, models, and concepts — transitioning from digitalization to intelligentization, and even smartization — is the essential path to modernizing urban governance systems and capabilities, with vast prospects ahead[80].

Intelligentization is the inevitable outcome of digitalization. Digitalization is reshaping urban governance methods, provides robust support for optimizing resource allocation, enhances service efficiency, and enhances citizens' participation. Digital transformation exerts profound influence on urban governance[81]. In 2021, Shanghai designated comprehensive digital transformation as a major strategy in its 14th Five-Year Plan. At a progress symposium, then-Secretary of the Shanghai Municipal Party Committee Li Qiang emphasized the need to "treat the city as a unified whole," advancing transformation systematically and comprehensively by mapping the baseline and strengthening coordination to overcome bottlenecks (Figure 2-6).

After 2020, the development paradigm, technologies, and methodologies of City Brain have been adopted in more cities of varying scales and economic development levels. This expansion has garnered active participation from a wide range of enterprises across China, including industry leaders and startups. Through the joint efforts of these cities and companies, City Brain is demonstrating tangible results in key areas directly addressing resource and environmental constraints. In transportation, tackling congestion and inefficiency from the surge in vehicles, Hangzhou has integrated multi-source data from cameras and sensors, applying AI algorithms to optimize traffic signal control and flow management. This has improved traffic flow efficiency by approximately 15 percent in pilot zones, alleviating peak-hour congestion[82]. In environmental protection, several regions have established intelligent monitoring systems combining big data, IoT, and AI. These systems enable real-time sensing and early warnings for air quality indicators like $PM_{2.5}$, aiding in formulating response measures and significantly enhancing the precision and efficiency of environmental governance[83]. In the energy sector, smart energy management platforms utilize AI for grid load forecasting and peak-valley regulation, optimizing energy utilization efficiency[84].

Shanghai Symposium on Advancing Urban Digital Transformation

(25 March 2021)

Transforming Shanghai into a digital city is a major strategy during the 14th Five-Year Plan period. To succeed, we must respect, understand, and follow its inherent logic. We need to accurately identify trends, thoroughly assess the evolution of future digital cities, leverage Shanghai's unique strengths based on its actual conditions, plan ahead, and implement scientifically. It is essential to understand the baseline by accurately knowing the current status and foundational conditions of digitalization across all sectors, pinpoint the challenges and bottlenecks in the transformation, and focus efforts on breaking through these difficulties while concentrating on cultivating our strengths and distinctive features. We must reinforce iterative upgrades and drive comprehensive progress by treating the city as a cohesive whole, advancing digital transformation with greater consciousness, systematization, and thoroughness.

(Excerpt from the speech by Li Qiang, then-Secretary of the Shanghai Municipal Party Committee, at the Symposium on Advancing Urban Digital Transformation)

Figure 2–6: Excerpt from the Speech at the Symposium on Advancing Urban Digital Transformation

Source: Xinmin Evening News (25 March, 2021)

2.2 Pioneering Exploration in City Intelligence: No-Traffic-Restriction Cities

2.2.1 Traffic Congestion: a Common Challenge Facing Cities

Traffic congestion is a common ailment in modern urban development, and China has experienced it acutely during its rapid urbanization. Over recent decades, as city residents have enjoyed the convenience of motorized travel, they have also endured its gridlock. Data shows that since the mid-1990s, private-owned car parc in China has exploded — from just over 25 million vehicles nationwide in 1995 to 435 million by 2023, with even higher motorization rates in major cities[85]. This surge has led to saturated roads during peak hours and declining average speeds across most urban areas. By the late 1990s, megacities like Beijing and Shanghai witnessed peak-hour "parking lot" traffic phenomena. In the 21st century, congestion spread to cities across all tiers nationwide, becoming a daily frustration. In reality, severe traffic congestion is a nearly inevitable phase of urban development, a challenge faced by major cities worldwide.

To mitigate the inefficiency and environmental costs of congestion, many municipal governments in China have implemented a range of measures. Common administrative approaches include vehicle restrictions and purchase quotas, such as Beijing's weekday license plate restrictions and car purchase lottery system; Shanghai's license plate auction; and Guangzhou and Shenzhen's total vehicle volume control and restrictions on non-local vehicles. These measures have reduced road pressure to some extent during peak hours. However, such restrictions are not a long-term solution. Congestion tends to recur when policies are relaxed, and they also curb travel freedom and convenience. Consequently, while implementing restrictions, cities are also vigorously developing public transportation and infrastructure. However, these measures have not achieved a sustainable balance between convenience for the public and the investment of social resources.

2.2.2 City Intelligence Solution: No Traffic Restriction

A metaphor reveals the core issue in traffic governance: "The greatest distance in the world is between traffic lights and traffic cameras[86]." This metaphor reveals the attempt to seek a sustainable balance between convenience for the public and the societal resource investment. Traffic lights represent action, while cameras symbolize data resources. For a long time, these two have been disconnected: cameras collect data continuously, yet traffic lights rigidly follow preset programs. Data silos between departments have hindered effective action. This insight became the starting point for the City Brain initiative. It poses a critical question to every administrator: "What is the 'traffic light' in your department? And where is your 'camera' ?" Only when data flows seamlessly through decision-making and action can a city transform from a fragmented machine into a coordinated, living organism. This approach has been successfully validated in Nanchang, where the City Brain was implemented to alleviate congestion.

Before 2020, Nanchang, the capital of Jiangxi Province — a mid-size Chinese city that qualifies as a major metropolis by global standards, with 5+ million residents and 1.4 million vehicles — was trapped in a paradox: "restriction or no restriction, the jam remains." Since 2009, it had relied on license-plate restrictions. For 11 years, these measures provided short-term relief but stifled travel freedom and economic vitality.

Nanchang implemented its "City Brain" in 2020. By integrating multi-source data, enabling real-time sensing, and using intelligent algorithms, it achieved citywide, minute-level traffic monitoring and signal coordination. On 29 December 2020, Nanchang became the first Chinese city to lift long-standing license-plate restrictions — after 11 years. After the lift, traffic flowed more smoothly: the average vehicle speed increased from 31.9 km/h during the restriction period in 2019 to 38.0 km/h in the restriction-free period in 2022. Meanwhile, the traffic congestion index dropped from 1.31 to 1.27, even as the city's car parc grew by 26.5% over the same period[87]. These results demonstrate that smart governance can significantly improve system efficiency — without new roads or extra funding.

Nanchang's experience shows that system intelligence outperforms resource expansion in enhancing city efficiency. It breaks the traditional belief that congestion must be tackled by restrictions or construction. By replacing physical expansion with data, and traffic restriction policies with algorithms, the city has shifted from "congestion-based restrictions" to "intelligence-driven flow." This smart governance model supports sustainable development and offers a replicable example for mid-size cities in China and worldwide. As one Nanchang resident remarked in the news comments, "Finally, we can have fun in Nanchang on weekends." This reflects not only improved travel but also a shift in governance philosophy — from control to empowerment.

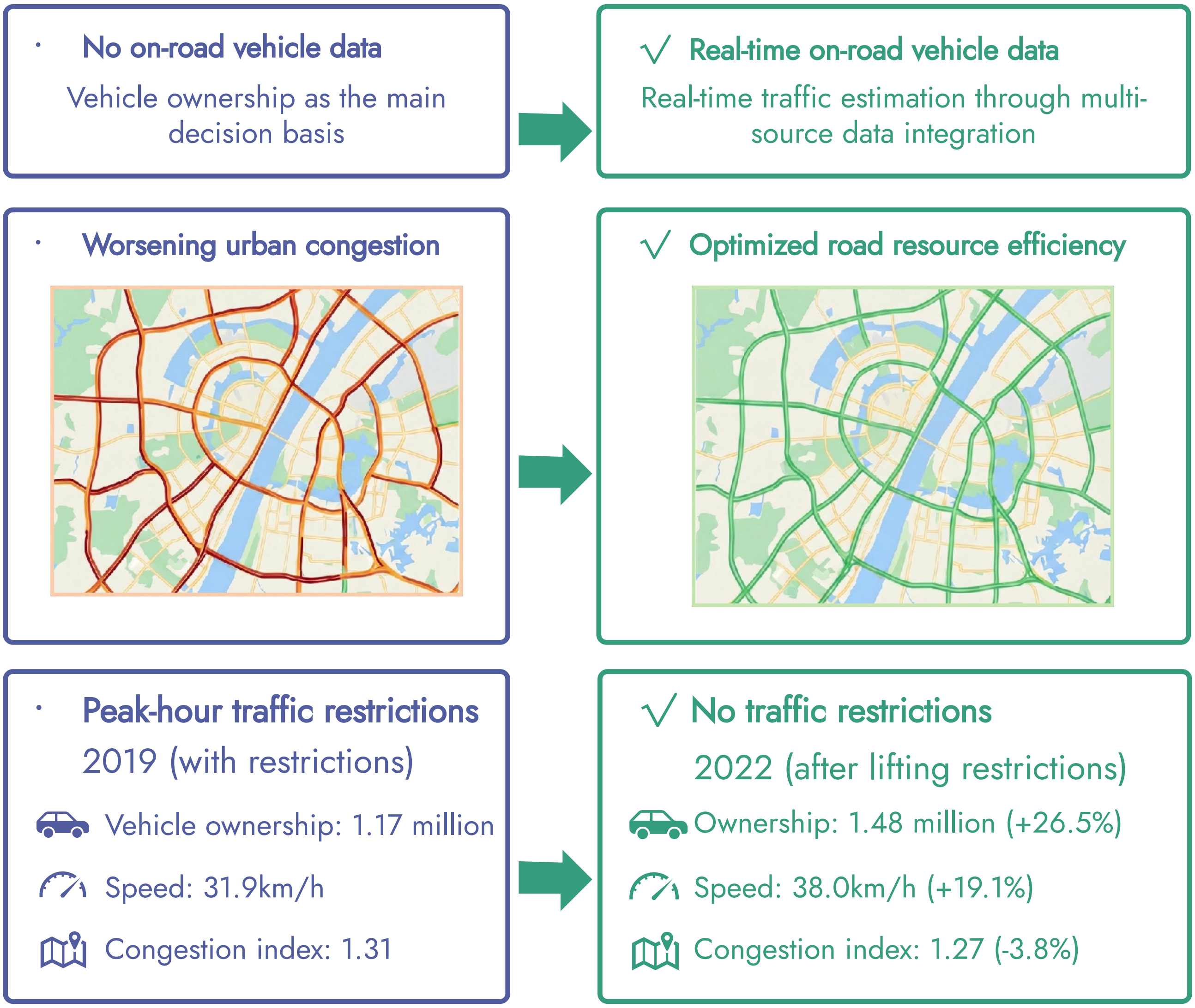


Figure 2–7: Nanchang City Brain's "No Traffic Restrictions" scenario

Source: Created by authors

The significance of Nanchang's "No Traffic Restrictions" case lies in achieving systemic improvement in urban traffic governance with limited fiscal input and infrastructure. In China's urban system, Nanchang, with limited funding and computing power, is not a megacity like Beijing or Shanghai. Yet by international standards, it remains a large city with over 5 million residents and more than 1.4 million vehicles. It is precisely under these constraints that Nanchang, supported by its "City Brain" has realized an innovative governance model through data integration, computing-driven optimization, and intelligent modeling — "using data instead of expansion, intelligence instead of restrictions." This approach transcends the binary dilemma of "restriction or congestion," demonstrating a new pathway for efficient traffic management in large cities (Figure 2-7)[88].

2.3 City Intelligence Technology Architecture

2.3.1 The Trinity of Computing Power, Data, and AI Models

Successful cases like Nanchang's City Brain show that leveraging City Intelligence for congestion management requires both people-centred, resource-efficient, and sustainable principles and the enabling power of a robust technical framework. The implementation of City Intelligence relies on a tightly coupled architecture — the "trinity" of computing power, data, and AI models. Data serves as the core resource, AI models act as the intelligence engines, and computing power provides the essential infrastructure (Figure 2-8).

(1) Data: Integrating Multi-Source Data to Unlock Value

Cities today possess vast multi-source data accumulated over time — from traffic cameras and signals to public transit GPS, IoT sensors, and satellite imagery. Much of this data is now accessible or obtainable with minimal cost. For example, Paris Open Data Platform (opendata.pari.fr)[89] provides municipal data across transport, environment, and infrastructure, supporting both public access and research. London Datastore[90] aggregates cross-sector data

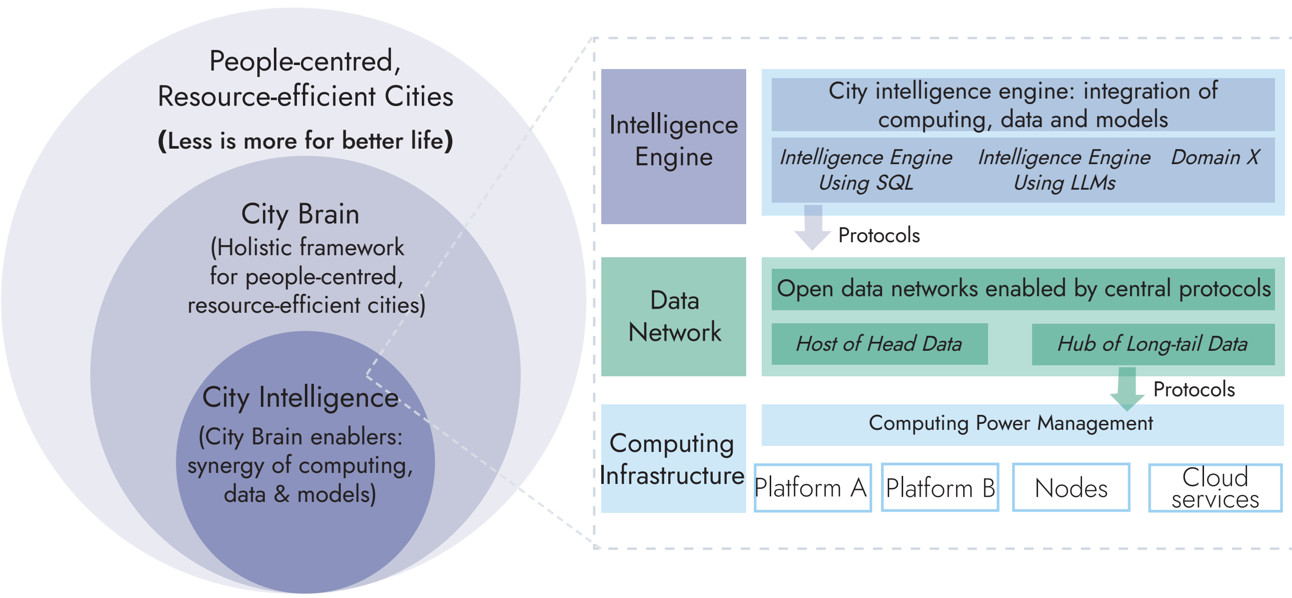


Figure 2–8: Schematic diagram of City Intelligence, City Brain, and resource-efficient urban development

Source: Created by authors

covering demographics, environment, transport, health, and housing, offering a unified interface for data-driven urban management.

International organizations (e.g., the UN, World Bank) emphasize: data is not a fragmented asset, but a key input for urban governance and sustainable decision-making[91][92]. Cities do not need to build data foundations from scratch; rather, they should focus on unlocking the value of existing data through hubs, interoperability standards, and privacy safeguards[93].

At the same time, the integration of satellite remote sensing and AI is reshaping how cities perceive their environment[94]. In October 2021, the United Nations adopted the "Space2030" Agenda ("space as a driver of sustainable development"), which explicitly identifies the combination of Earth observation data and AI as a key driver for achieving the SDGs. With high-resolution and frequent observations, even cities with finite resources can now achieve citywide monitoring and dynamic optimization at low cost. Currently, more than 800 Earth observation satellites are in orbit. Landsat 9, for instance, completes a full global coverage every 16 days[95], and when combined with the

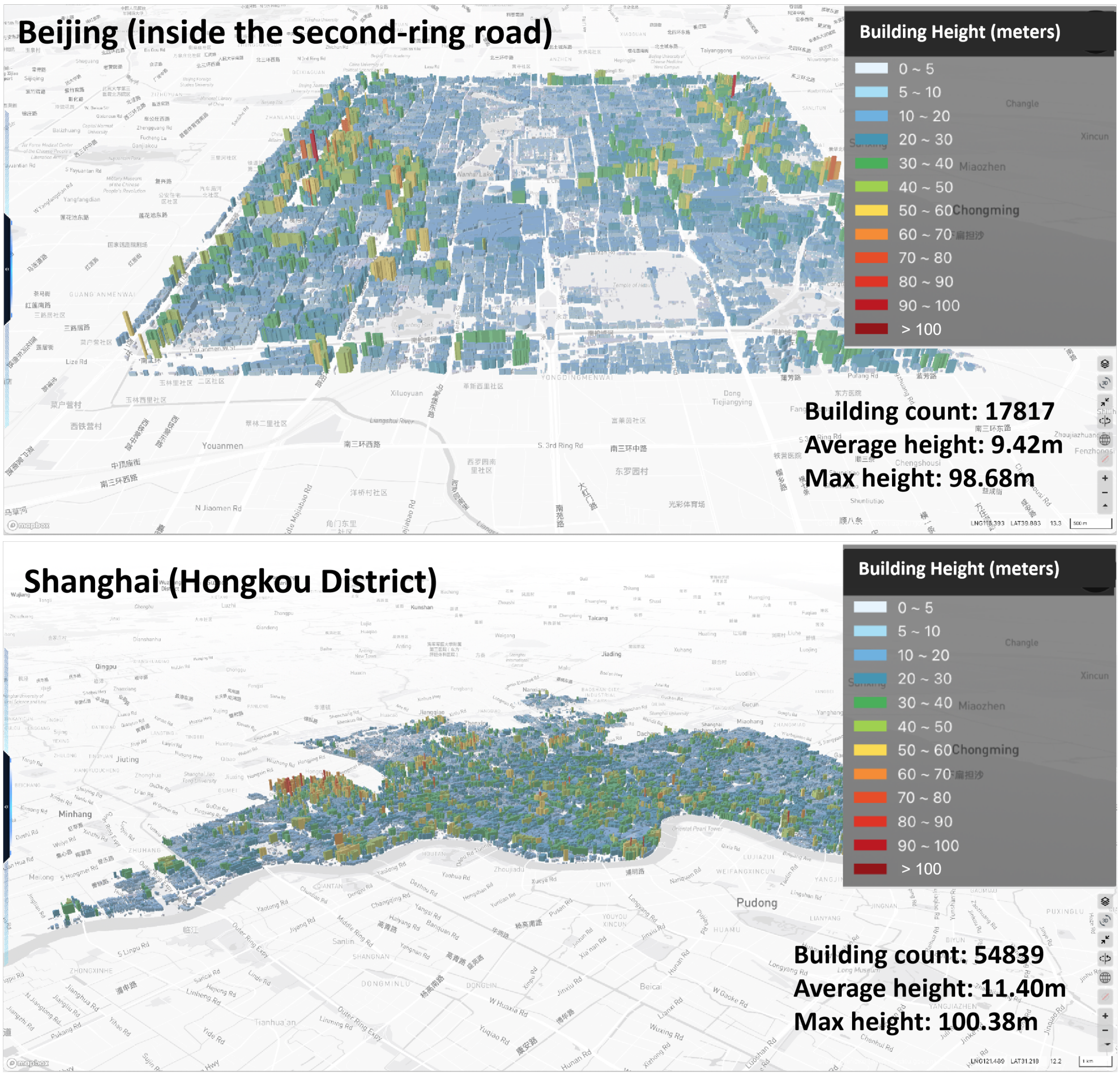


Figure 2–9: Observation of buildings in Beijing and Shanghai using satellite remote sensing data and AI models

Source: Created by authors

5-day revisit cycle of Sentinel-2[96], the number of Earth observation satellites could reach 3,200 by 2032. Urban surface changes can now be monitored in near-real time. This establishes a robust data foundation for developing accessible and inclusive City Intelligence solutions.

Combining satellite remote sensing with AI offers a low-cost method for urban observation. As shown in the figure, multi-source data from satellites and ground-level sensors, processed by AI models, can identify building forms and their distribution. For Beijing City (within the 2nd Ring Road), results show 17,817 buildings, with average and maximum heights of 9.42 meters and 98.68 meters, respectively. For Hongkou District, Shanghai City, there are 54,839 buildings, with heights averaging 11.40 meters and reaching a maximum of 100.38 meters (Figure 2-9).

Applying this integrated approach of multi-source data and AI models, such as satellite remote sensing and ground/near-ground observations globally, provides a holistic view of urban building and space. Namely, New York has 313,521 buildings (avg: 10.50m, max: 113.86m). Paris: 23,159 buildings (avg: 12.91m, max: 76.05m). Dubai: 131,026 buildings (avg: 10.51m, max: 86.26m). Bogotá: 71,227 buildings (avg: 8.39m, max: 87.34m). Nairobi: 114,089 buildings (avg: 5.03m, max: 75.80m) (Figure 2-10).

AI technology now enables cities to acquire previously inaccessible data resources at a lower cost. This observation data can be directly applied to support scenario-based decision-making in urban governance. Moreover, when aggregated into high-quality datasets, it forms the foundational data corpus for generating models that underpin City Intelligence.

(2) Models: City AI Foundation Models As the Intelligence Engine

The core of AI advancement lies in improving model capabilities and fostering an open-source

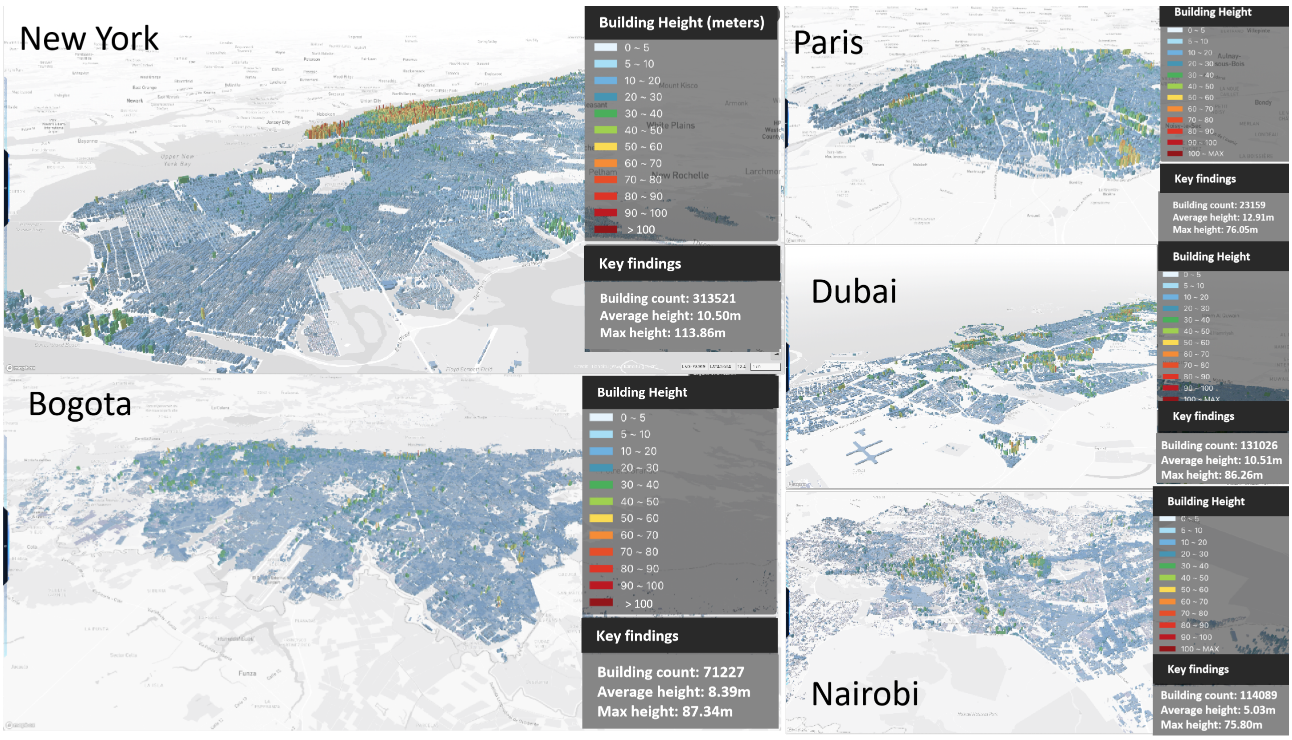


Figure 2–10: Observation of buildings in multiple global cities using satellite remote sensing data and AI models

Source: Created by authors

ecosystem. A wealth of AI foundation models now provide transferable, tunable, and reusable "general-purpose intelligence components" for urban applications (Figure 2-11). "AI + City" is not merely plugging existing tools into city management. It is a profound paradigm shift. At its core is the idea of treating the city as a living, complex organism. By constructing a unified City AI foundation models, we can create a "digital organism" with an intelligence engine capable of continuous sensing, learning, reasoning, and evolution. Its scientific essence lies in leveraging city foundation model to reconfigure the architecture of digital urban infrastructure. This reconfiguration endows the city with holistic capacities for cognition, decision-making, and evolution, leading to a fundamental enhancement in the efficiency of resource allocation, public service delivery, and sustainable development. This signifies that urban development is transitioning from a phase of "digital empowerment" as a tool to a new epoch where "the city itself is intelligent."

Open-source frameworks and AI model libraries have drastically lowered the entry barrier, allowing research institutions, local governments, and small and medium-sized enterprises to customize existing models. In other words, models have shifted from a scarce resource to an "accessible public technical capability." Their ultimate effectiveness, however, still depends on high-quality domain-specific data and appropriate computing power for training or fine-tuning. A Linux Foundation report, The Economic and Workforce Impacts of Open Source AI, shows that deploying open-source models costs over 50 percent less than proprietary ones, 89 percent of organizations use some form of Open Source AI, with 63 percent having deployed open-source models[97]. This enables middle- sized cities and small and micro enterprises to participate in the global value chain.

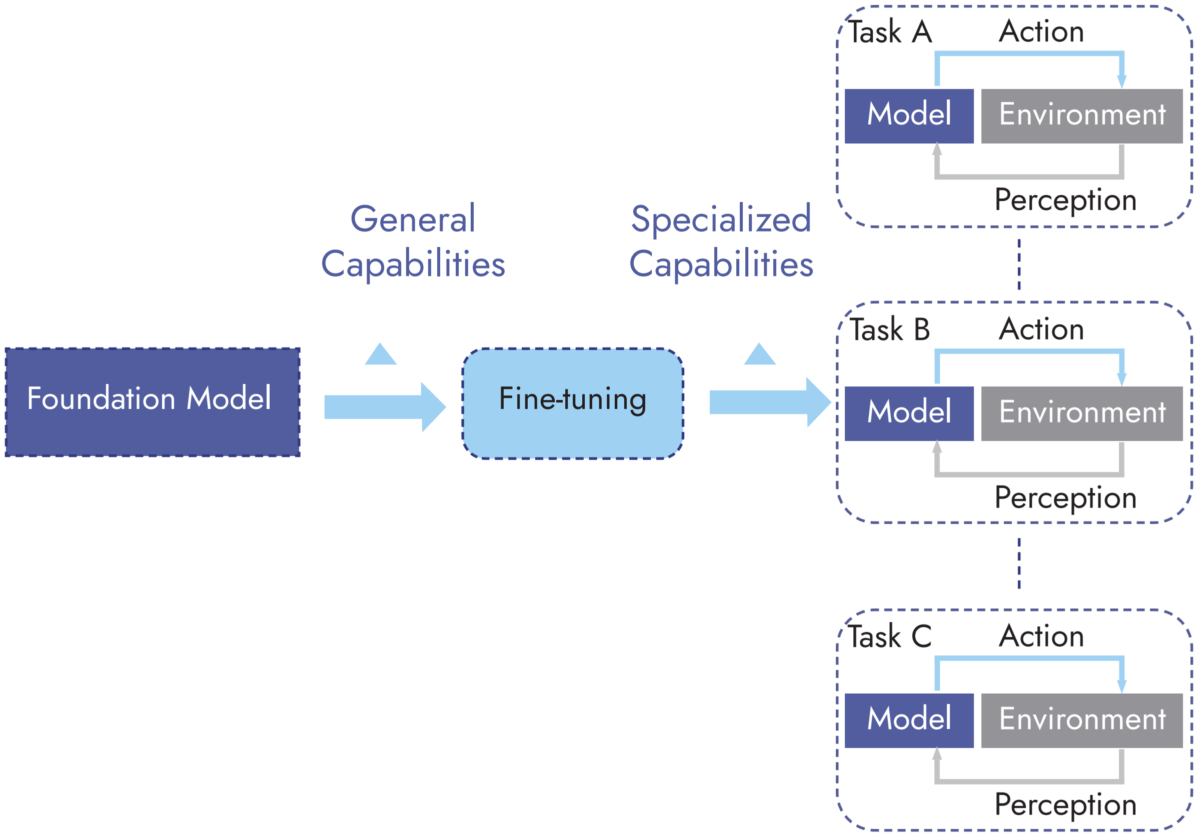


Figure 2–11: The "general capability + scenario–specific fine–tuning" architecture of generative AI supporting City Intelligence

Source: Created by authors

(3) Computing Power: Moderate, Efficient, Inclusive

Computing power is more than just raw processing capacity. It is an integrated technical system encompassing computational capability, storage, network transmission, and energy efficiency management. The real-time processing and analysis of the massive data generated daily by modern cities — from traffic flows and environmental monitoring to public safety footage and energy consumption — depend entirely on computing power. From the perspective of urban decision-making, City Intelligence imposes varying demands on computing power. Tasks such as emergency response and traffic dispatch require low-latency computing; infrastructure planning and public service optimization depend on high-efficiency computing; while urban development simulation and policy impact forecasting necessitate the deep integration of high-performance computing with AI. Temporally, the system must concurrently support real-time processing (with millisecond-level response) and long-term analysis (spanning years of data mining). Spatially, computation across multiple scales — from the micro (buildings, streets) to the macro (urban agglomerations) — presents even greater computational demands.

Certainly, high-quality City Intelligence development requires not just more computing power, but also innovation in computing architecture, optimization of computing efficiency, and improved computing governance. A future city's competitiveness will largely hinge on its ability to build an advanced computing system that aligns with its unique character, humanistic values, and sustainable development goals. The aim is not to create cities with "maximized computing power," but to leverage moderate, efficient, and inclusive computing resources to build computationally efficient cities and more livable, resilient, and dynamic city organisms.

Currently, the computing demands of large models and high-frequency real-time services are growing exponentially[98]. This creates a "capability threshold" in technology and a "computing divide" in resource distribution. Authorities like the United Nations and OECD have identified unequal access to computing power as an institutional challenge affecting global City Intelligence and sustainable development[96], advocating for distributed computing, green energy access, regional computing power sharing, and international cooperation to mitigate these imbalances.

2.3.2 City Intelligence Engine

The City Intelligence engine is the concrete implementation and manifestation of AI models within the City Intelligence system, constituting its core component. Deployed for urban governance, this engine integrates various models — such as those for physical sensing, social perception, dynamic simulation, and urban knowledge — into a unified city foundation model. This integration endows it with general cognitive and reasoning capabilities across diverse scenarios. Through standardized interfaces and fine-tuning mechanisms, the engine can be rapidly deployed for tasks in different domains, including transportation, energy, and environmental protection, thereby achieving a closed loop from perception to decision-making.

Taking city traffic governance as an example: the engine effectively integrates heterogeneous data from multiple sources. It enables real-time monitoring and prediction of traffic conditions, supporting holistic decision-making. For instance, by synthesizing multi-dimensional data, it can dynamically adjust green wave signal coordination parameters, supporting the "on-demand generation" of personalized green waves. It also aids refined demand management by monitoring traffic demand distribution, identifying congestion hotspots and causes, and dynamically adjusting road priority, fees, and bus services to guide rational travel choices. The policy shift to lift driving restrictions in Nanchang relied on the core capabilities provided by such a traffic intelligence engine.

2.3.3 Open-Source Mechanisms for City Intelligence

Advancing "AI + City" requires breakthroughs not only in technology but also in mechanisms. Open source is that key mechanism. With AI foundational models like DeepSeek, Qwen, and the 021 Science Foundation Model being open-sourced[99], Hangzhou has emerged as a leading thinker and practitioner in the open-sourcing of AI infrastructure[67]. Urban development critically needs this new mechanism. Open source has evolved from merely sharing code to opening up innovation resources (Table 2-1). For City Intelligence, this means opening access to data, AI models, and computing power — effectively unlocking the very resources for urban innovation. This creates a powerful new mechanism for collaborative development for cities. It's undeniable that AI R & D consumes vast resources. An open-source mechanism for City Intelligence promotes the sharing and reuse of public intelligent goods, a principle fundamentally aligned with building a resource-efficient society.

2.4 Broad Practices of "AI + City" in China

2.4.1 Comprehensive City–Scale Practices

City Intelligence is an endogenous outcome and systemic expression of "AI + City." Through practical implementation in Chinese cities, City Intelligence has already enhanced governance capabilities across areas such as the environment, public administration, and social services.

In the ecological and environmental field, City Intelligence has moved beyond mere monitoring and early warning toward supporting systematic governance decisions. For example, Guangzhou's environmental intelligence assistant, built on large models, integrates multi-source data and performs knowledge reasoning to aid law enforcement and policy simulation. Cities like Shanghai and Chengdu have deployed intelligent air pollution forecasting systems, shifting governance from passive response to proactive intervention. Such applications not only improve control efficiency but also, through continuous

Table 2-1: Open Source in the Software Era Versus Open Resource in the AI Era

Dimension	Open Source in the Software Era	Open Resource in the AI Era
Core Definition	Open-sourcing software source code	Open data, model weights, computing power, and other core production resources
Core Elements	Code, protocols, and community collaboration	Data resources, computational resources, pre-trained models
Primary objectives	Foster software innovation and avoid redundant development	Lower the barrier to intelligence, preventing society-wide duplication of massive computational resources for training foundational models
Value Realization	Enhance efficiency through code reuse	Conserve resources like electricity through resource reuse and collaboration to build an intelligent ecosystem

data feedback and model optimization, enable urban environmental systems to gradually develop preliminary "anticipatory" and "adaptive" intelligence. Shenzhen has established a municipal big data platform for carbon emissions, integrating cross-sector energy consumption and emission data to dynamically assess emission reduction pathways and asset value through algorithms. This marks a shift in management logic from static statistics to dynamic simulation and optimization, allowing cities to more accurately understand their own "metabolic" processes and provide intelligent decision-making support for systematic low-carbon transition.

In public services, City Intelligence is driving an upgrade of services toward personalization, precision, and proactivity. Smart healthcare, education, culture, and tourism systems are evolving from merely bridging information silos and offering online convenience to providing intelligent service recommendations and dynamic resource allocation based on user behavior and needs. For example, the "Campus Brain" integrates comprehensive education data to create personalized growth support systems for students, while smart tourism platforms can dynamically plan cultural experience routes for residents. These practices show that public service systems are learning to "understand" and "adapt" to citizens' needs, demonstrating initial signs of life-like responsive intelligence.

In urban governance, platforms such as "Unified Governance through One Network" continue to enhance their intelligence. They enable real-time detection, intelligent task assignment, and coordinated handling of urban operational issues. The governance framework is transitioning from "human-machine collaboration" toward an "intelligent agent" with full-scenario perception and closed-loop handling capabilities. In Shanghai's Changning District and elsewhere, intelligent algorithms have effectively addressed urban pain points such as uncollected garbage and haphazardly parked shared bikes. Cities like Beijing and Hangzhou conduct smart inspections of public utilities — for instance, using cameras to detect streetlight failures or missing manhole covers and automatically dispatching repair orders — making urban maintenance more proactive and efficient.

2.4.2 Progressive Practices: from Basic Scenario to City Intelligence

Chinese cities have gradually reached a consensus on city transformation through practical experience: placing people at the center, viewing the city as an organic living system, and building integrated City Intelligence infrastructure as the foundation. This approach supports the evolution from individual applications to connected scenarios, and further to a citywide view, thereby optimizing resources and achieving sustainable development through coordinated governance (Figure 2-12).

(1) Scenarios-Based Exploration: From Application to Scenario

Large models include both foundation models and specialized models adjusted for specific tasks. Model application refers to the process of developing and providing services based on existing models, which may be either general-purpose models or specialized vertical models. In China's urban governance, "AI +" manifests in both "applications" and "scenarios," each with distinct emphases. "Applications" focus on the deployment of specific technologies, such as smart traffic lights, traffic cameras, and disaster-response robots. "Scenarios" focus on governance within specific public service contexts, such as "Pay-after-Departure" parking. A successful scenario must identify the "core problem," break down departmental silos, and enable data sharing and operational synergy within that context. This holistic approach generates comprehensive governance effectiveness to tackle complex systemic issues. Without in-depth scenario exploration, even the most advanced AI foundation model will underperform.

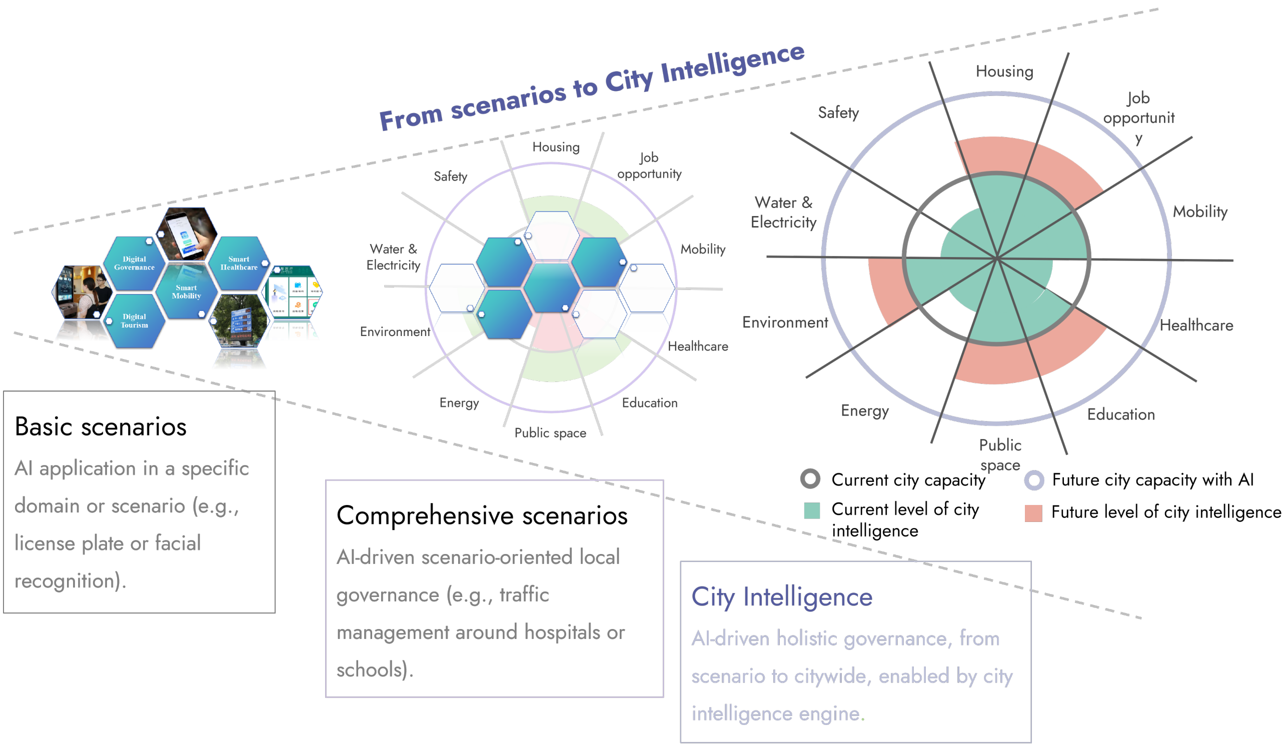


Figure 2–12: From scenario–based to City Intelligence practices in China

Source: Created by authors

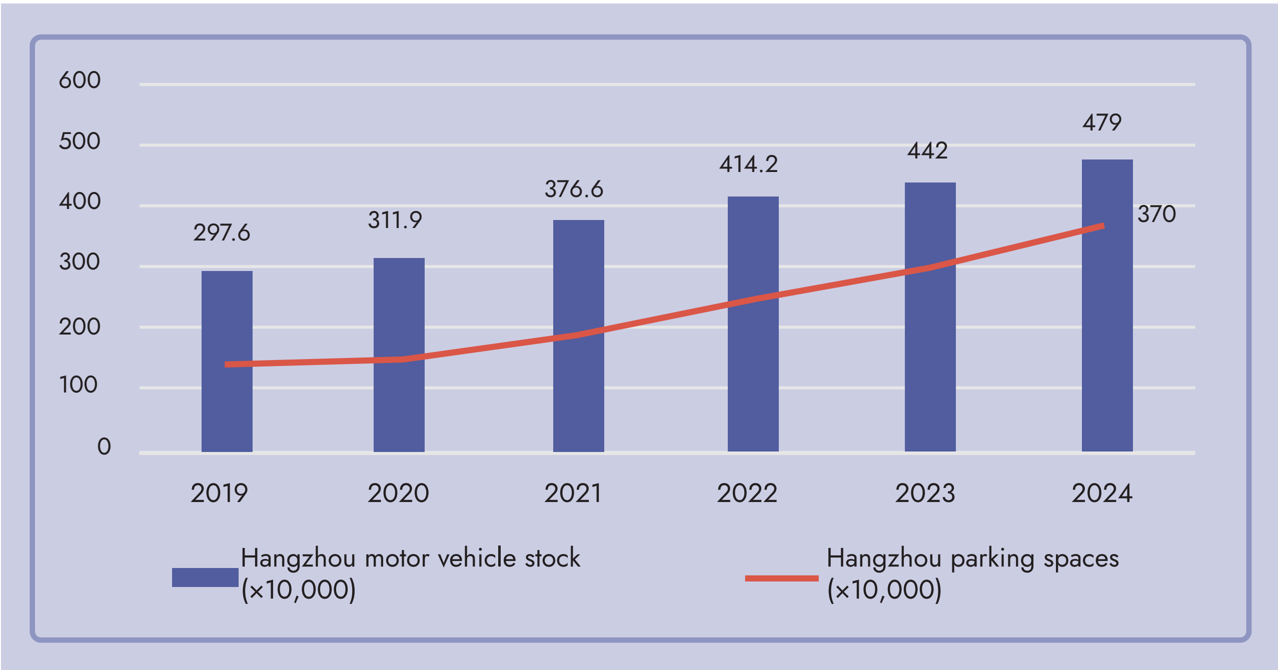


Figure 2–13: Vehicle ownership vs. parking spaces in Hangzhou

Source: Hangzhou Urban Management Bureau

(2) From Scenarios to a Holistic View: City Intelligence Enables a City as an Integrated Whole.

To address the complexities of cities and future uncertainties, solving major urban challenges requires not only technological intelligence but also the governance capacity of urban systems to ensure people-centred implementation. This capacity is essential for computing the optimal allocation of finite resources among multiple actors and diverse needs at the city scale, thereby enabling the city to function as a coherent whole. While China's capacity for integrated urban governance is still developing, the shift from scenarios to a citywide view is greatly driving the evolution of "City Intelligence." Initiatives such as Shanghai's "Unified Governance through One Network" and "One-Stop Government Services through One Network" exemplify this integrated governance model. The City Brain practice, which started in Hangzhou in 2016 and has been widely adopted across major Chinese cities, typically builds its technological architecture around the principles of "resource efficiency," "holistic governance," and "sustainable development," fostering the maturation of City Intelligence through practical, scenario-based applications. This transformation is evident in signature scenarios such as "One City, One Parking System," "Qinqing Online," "One More Hour for Tourism," and "Campus Brain."

"One City, One Parking System." Parking scarcity is a common urban challenge. For example, Hangzhou's main urban area currently has approximately 4.8 million motor vehicles but only 3.69 million parking spaces (Figure 2-13). The "One City, One Parking System" initiative treats all city parking facilities and spaces as a unified, allocatable resource to tackle urban parking challenges. This approach, featuring "Unified Governance through One Network, Integrated Visual Dashboard, One-Click Reservations, and Pay-after-Departure Parking," has delivered tangible results. It demonstrates that citywide resources can be tracked online and parking services allocated efficiently, serving as a successful practice in citywide integrated governance[26].

Hangzhou City Brain Parking System Platform has developed ten intelligent modules, including "Smart Sensing," "Smart Connectivity," and "Smart Parking." It integrates parking resources across the city, enabling real-time online data for over a million parking spaces, real-time aggregation and analysis of parking information, and citywide live parking monitoring. The platform quantifies service performance and has already connected 6,300 parking facilities and 1.82 million parking spaces. The "Pay-after-Departure" parking service now covers nearly all open, fee-charging parking lots in the city, with 4.8 million registered users. It has 460,000 active users who utilize the service at least 10 times per month, having cumulatively served over 380 million transactions. The average usage rate is close to 50 percent, with approximately 600,000 daily users paying via this method. The exit time has been reduced from 30 seconds to under 2 seconds, collectively saving over 3 million hours. The average daily parking space turnover rate has increased from 1.6 to 1.85 times (a 16 percent improvement), effectively creating capacity equivalent to 250,000 new parking spaces. By making parking more efficient, accessible, and inclusive, this system improves urban mobility (Figure 2-14).

"Qinqing Online" Smart Platform. The "Qinqing Online" scenario exemplifies a "people-centred" redesign of government processes and reflects the city's capacity for holistic service. The term "Qinqing (close and clear)" originates from the concept of "a new type of close and clean government-business relationship," which emphasizes a partnership that is both cordial and transparent. While urban pro-enterprise policies aim to foster industrial growth, traditional governance issues — such as information asymmetry between government and businesses, fragmented policy dissemination, cumbersome redemption procedures, and delayed fund allocation — have undermined their effectiveness. During the economic impact of the COVID-19 pandemic in 2020, many local governments introduced support policies to help businesses resume operations. However, many enterprises failed to apply in time due to a lack of policy awareness, creating a "last-mile" gap in policy implementation. The Hangzhou City Brain "Qinqing Online" initiative innovates with a direct-access model featuring: 1) zero documentation for application, 2) zero human intervention in approval, and 3) real-time fund disbursement upon fulfillment (Figure 2-15)[26].

By cross-referencing government big data, the "Qinqing Online" scenario intelligently identifies eligible enterprises, enabling business support resources to proactively match applicants. This shift from "people seeking policies" to "policies finding people" demonstrates people-centred process reengineering and intelligent capabilities for achieving scenario objectives. The "Qinqing Online" intelligent platform integrates multiple systems, streamlining the entire chain from policy release and interpretation to application requests and interactive communication, thereby reshaping organizational collaboration to form holistic capabilities. A standout case was the rollout of the national "Direct-to-Local" emergency aid fund, designed for fast, direct relief. Using Qinqing Online, officials processed 360,000 system checks, issued 149,000 direct payments, and delivered 10.9 billion yuan in

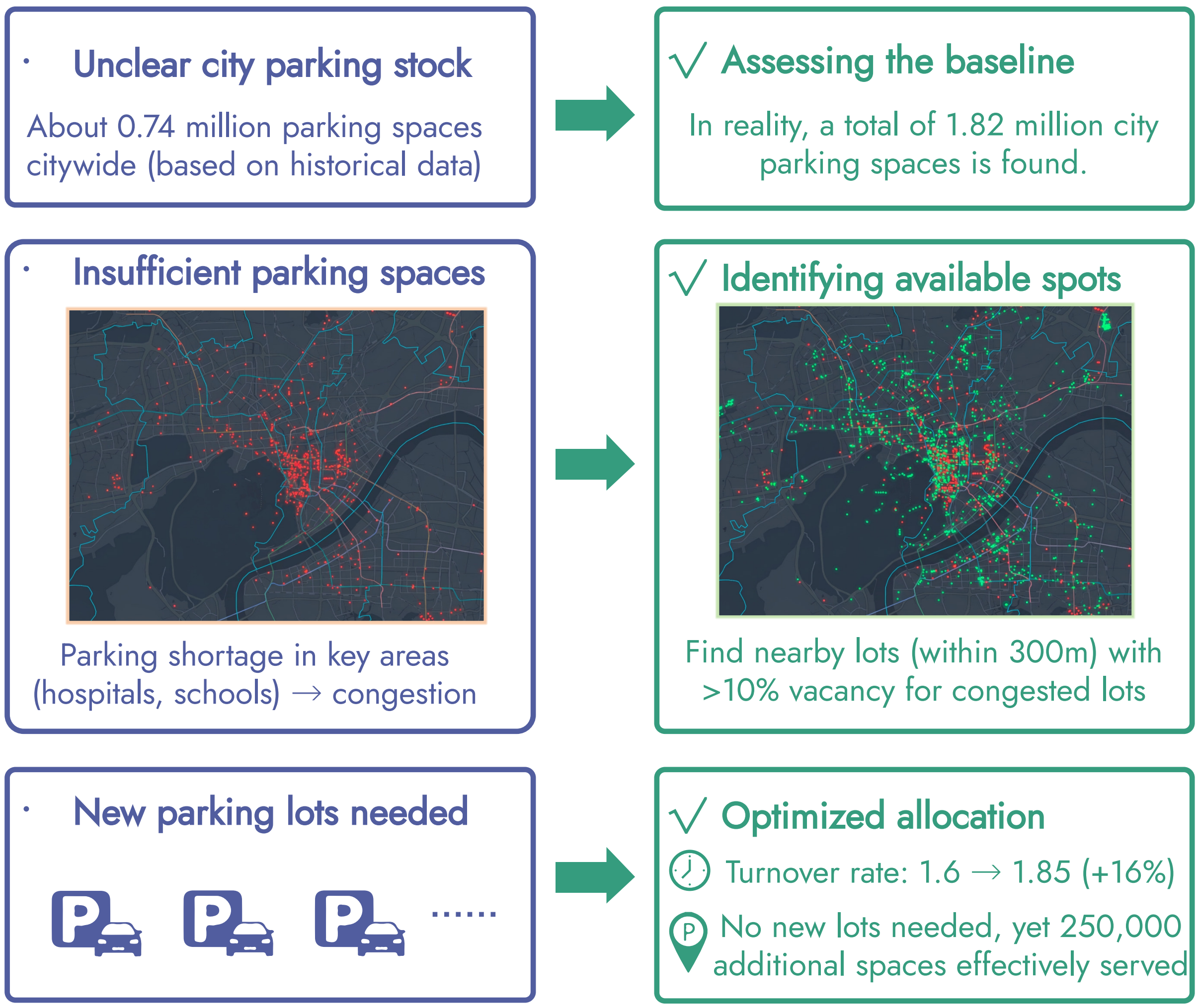


Figure 2–14: Hangzhou City Brain's "One City, One Parking Platform" scenario

Source: Hangzhou Urban Management Bureau aid — all within a single week, providing a critical lifeline to small and micro enterprises and individual businesses. It has cumulatively disbursed funds exceeding 100 billion yuan.

"One More Hour for Tourism." "One More Hour for Tourism" is a scenario focused on the cultural tourism industry and governance, aiming to save time for tourists exploring the city. The core of tourism is the visitor experience, and time is a scarce resource. Persistent challenges in cultural tourism governance — including arbitrary decision-making and inefficient ticketing and check-in — have hampered the visitor experience. According to estimates by the Hangzhou municipal government, providing tourists with an average of "one more hour" for touring and sightseeing could generate an annual tourism revenue increase of approximately 10 billion yuan. By leveraging the "City Brain," Hangzhou has developed the "One More Hour for Tourism" citywide comprehensive tourism service scenario. This initiative aims to enhance service and governance capabilities and bridge the following core gaps: On the demand side, the gap between tourists' personalized service needs and the slow response of traditional service models. On the supply side, the gap between the fragmented provision of public and commercial service resources and the need for precise matching with tourists' dynamic demands. For effective urban governance, multiple departments — such as culture and tourism, public security, and others — must coordinate to function as a "unified city entity." This imperative is precisely why the City Brain continually evolves to fulfill its role in enabling holistic, cross-departmental coordination (Figure 2-16).

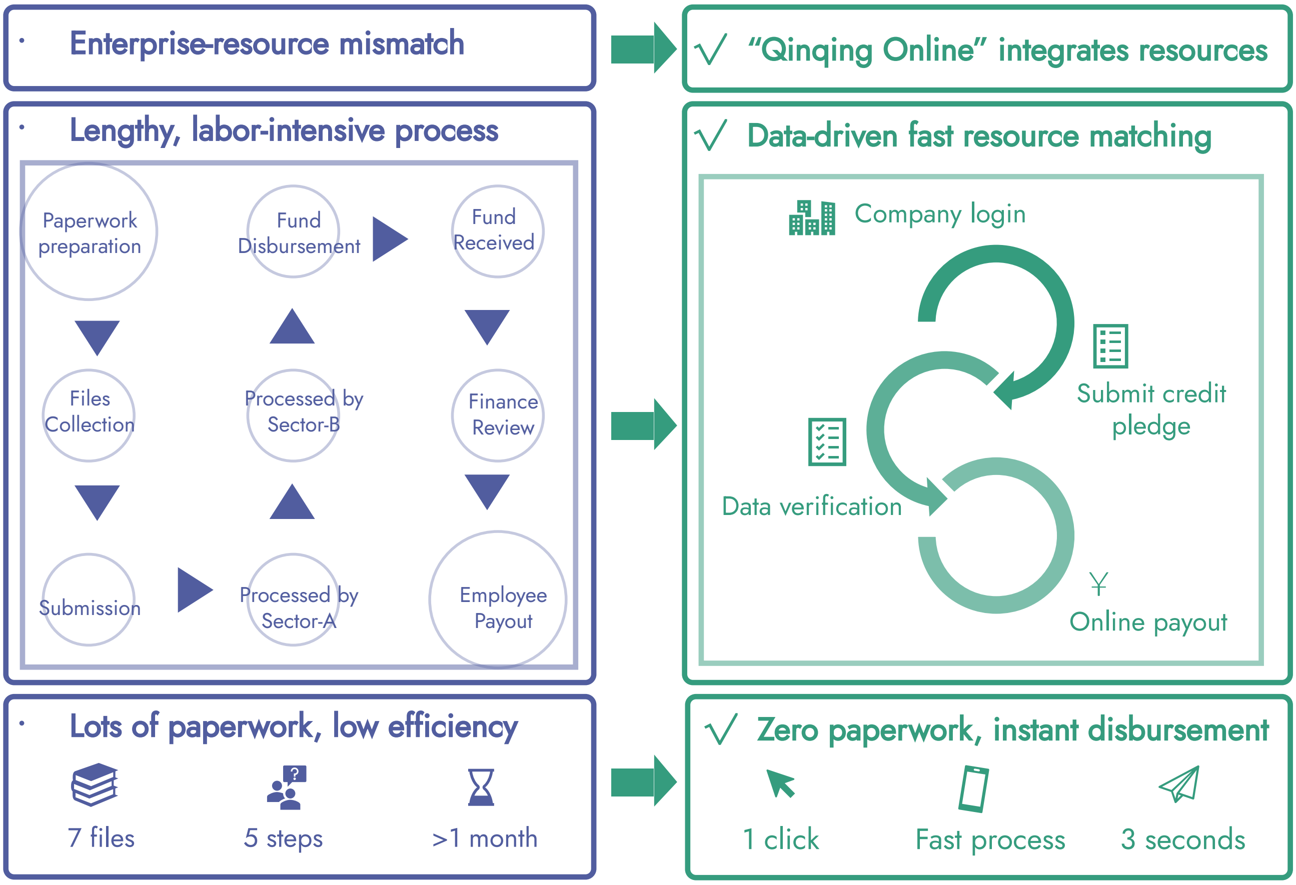


Figure 2–15: Hangzhou City Brain's "Qinqing Online" scenario

Source: Created by authors

This scenario has significantly reduced tourists' waiting times for scenic area entry, hotel check-in, transportation transfers, and luggage services. It effectively converts tourists' queuing time into time for sightseeing, consumption, and experiences, thereby optimizing resource allocation. This optimization is the result of an intelligent service upgrade driven by multi-departmental collaboration. Relying on the City Brain central system, it has successfully achieved deep integration of multi-chain data generated from scenic area gates, ticketing systems, hotel PMS systems, and check-in registrations, and has applied this integration to the continuous iteration of service scenarios. During the scenario development process, the government maintained a leading role while introducing market-based mechanisms and social capital, with government and enterprises collaborating to provide services, allowing tourists to gain an extra hour of sightseeing without extending their stay in Hangzhou, cumulatively serving 10.4166 million visitors.

Campus Brain. In 2021, Hangzhou City University pioneered the development of a "Campus Brain," drawing inspiration from the City Brain concept. This initiative established an architecture centered on "One-Brain Campus Governance, Dual-Side Empowerment" — concretely translating the "people-centred" philosophy into a "student-centered" approach to empower both the campus community and the institution's overall needs. The City Brain's holistic view of urban systems and resources directly informed the Campus Brain's methodology, emphasizing four key principles: holistic resource cognition, closed-loop decision execution, integrated and coordinated education infrastructure, and the construction of a modern, high-quality administration structure through the system's capabili-

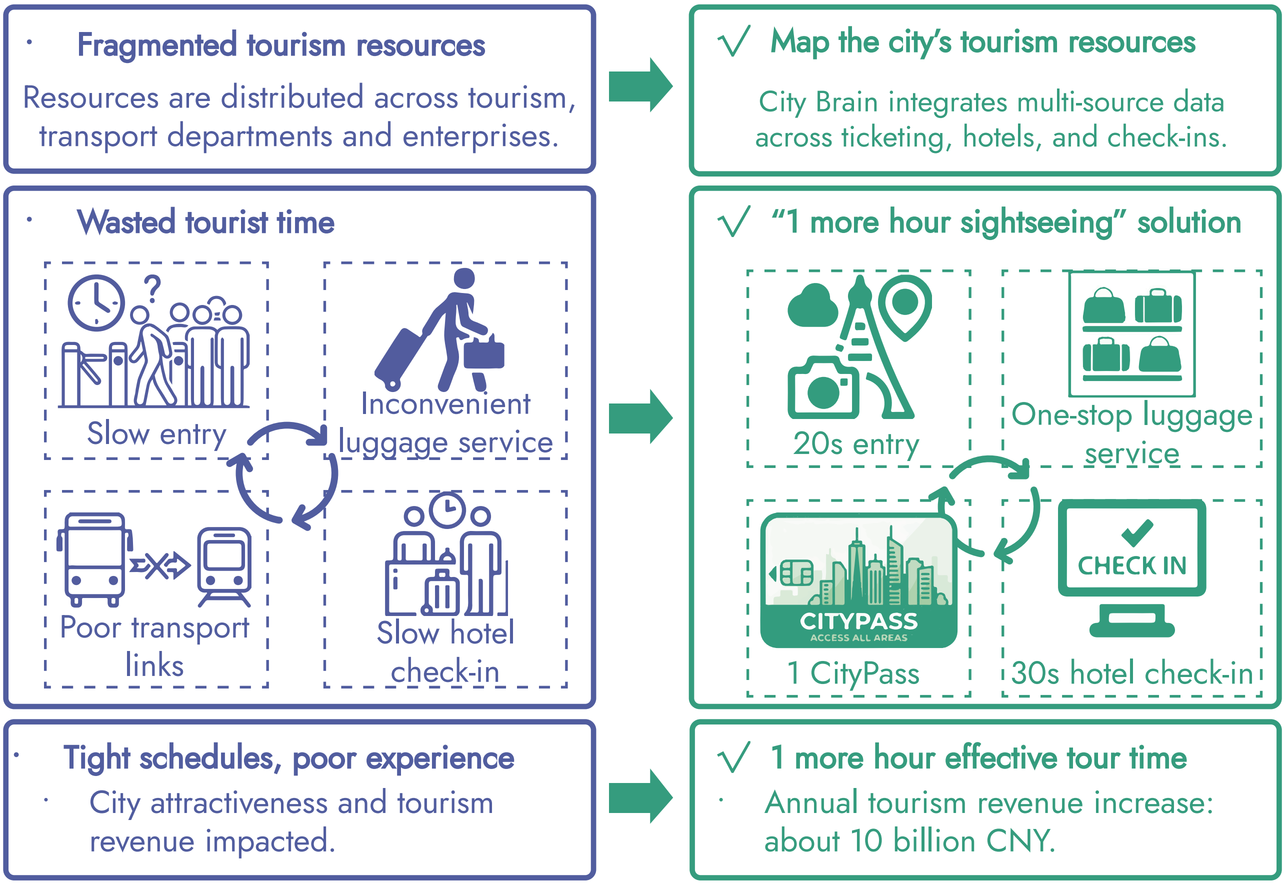


Figure 2–16: Hangzhou City Brain's "One More Hour for Tourism" scenario

Source: Created by authors

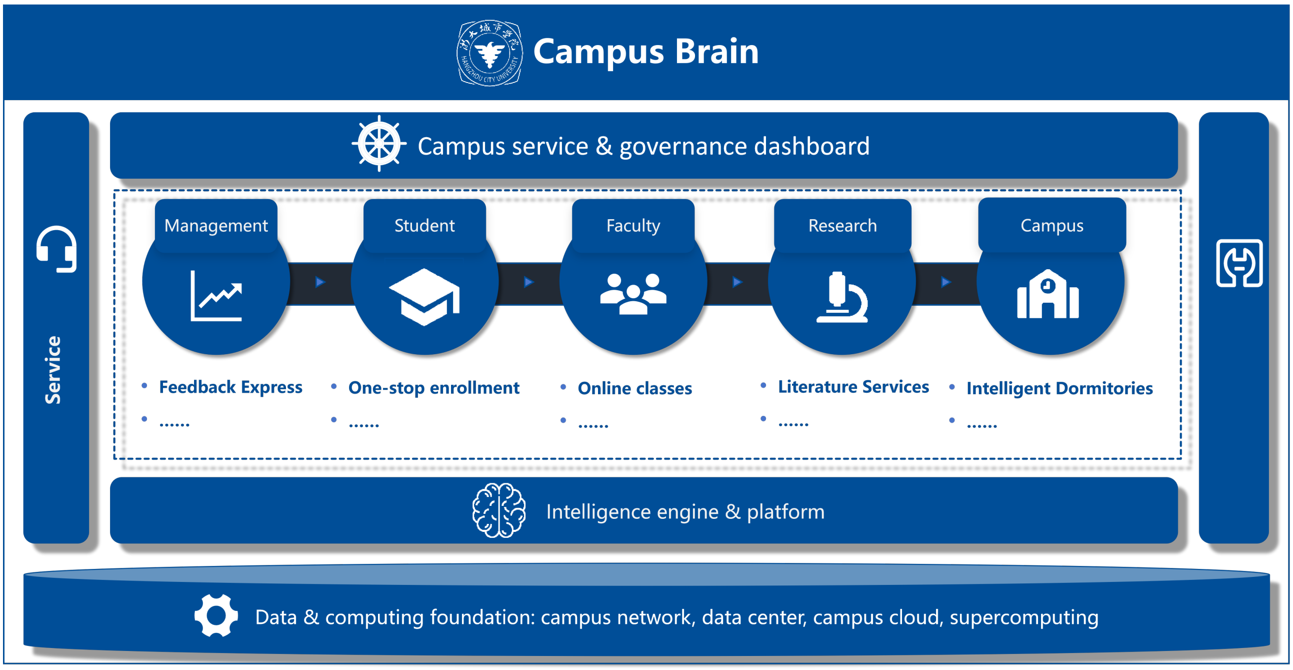


Figure 2–17: Campus Brain system framework

Source: Hangzhou City University

ties. As a result, the Campus Brain has shaped five major operational scenarios: digital-intelligent administration, student development, faculty affairs, research & innovation, and smart campus life. These encompass practical sub-scenarios such as "one-stop enrollment service," "digital-intelligent extended curriculum," and "instant reimbursement for book purchases." The ultimate goal is to achieve holistic smart campus governance, exploring pathways for the efficient allocation of educational resources and high-quality, sustainable development (Figure 2-17).

Campus Brain builds upon the universal intelligent architecture of City Brain with localized adaptations, possessing generalization capabilities characterized by "universal core functions + scenario-specific customization." It comprises six core elements: 1) Digital Foundation: Serving as the data infrastructure, it encompasses network, sensing, and other resources to support real-time data collection, management, and governance. 2) Central System: This intelligent decision-making and management platform enables data governance, cross-departmental interoperability, and intelligent decision support. 3) Intelligence Engine: Powered by computing resources and model libraries, it supports algorithm training and optimization for multi-scenario applications, driving advancements in areas like education. 4) Scenario Intelligence: Focusing on domains such as teaching, it develops typical governance scenarios (e.g., "one-stop employment service") to achieve both targeted breakthroughs and systemic integration. 5) Command Center (Cockpit): A visualization platform for university and college-level administrators, it facilitates online monitoring of governance data and provides decision support, enhancing transparency and execution capability. 6) Open Platform: It provides foundational support capabilities like unified identity authentication, ensuring interoperability across different business systems[100].

2.4.3 Insights from China's City Brain practices

The widespread implementation of City Intelligence in China, grounded in the City Brain concept, has not only realized technical solutions, but has also yielded profound insights that transcend technology itself, spanning cognitive, methodological, and value dimensions. These insights are deeply rooted in China's unique context of rapid urbanization coupled with resource constraints, forming an endogenous logic that drives the systemic transformation of urban development paradigms. In 2025, China's Central Urban Work Conference systematically outlined the fundamental guidelines for urban development in the new era. At its core is a people-centred development philosophy, respect for the laws of urban growth, and the goal of achieving "Five Key Coordinations"[100]. This is also the historic shift of "AI + City" and it addresses the fundamental question of "what kind of cities to build and how to build them" in the "Era of Computing Power." City Brain, born from practical application, serves as the critical mechanism for translating this top-level design into tangible reality. It offers a wealth of valuable insights for urban development.

(1) People-Centred Governance: From Technology-Driven to Service-Oriented

The principle of "people-centred" fundamentally defines the mindset that should guide City Intelligence. The scenario-based practices of China's City Brain exemplify a shift from a technology-driven approach that served management needs, to a contextualized service-oriented approach that deeply understands human needs. This is a shift "from management to service." For instance, while upgrading a parking system for "contactless payment" focuses on the efficiency of fee collection, the "Pay-after-Departure" scenario focuses on providing convenience and saving time for drivers. This shift breaks away from the technocratic inertia of reinforcing control, steering instead toward a value reorientation centered on people — ensuring that "what is taken for granted and overlooked is worth changing (Figure 2-18)."

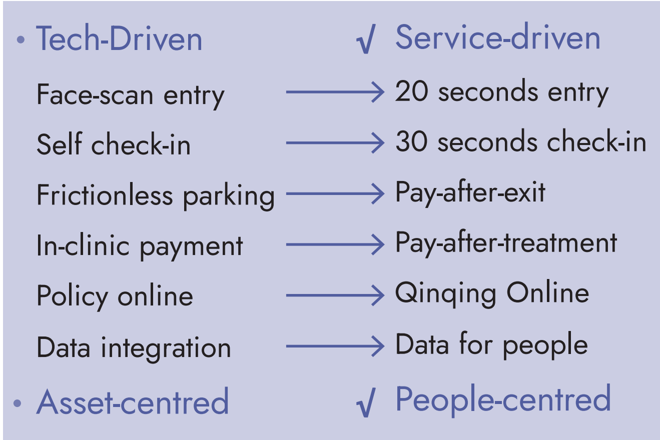


Figure 2–18: Hangzhou City Brain people–centred practices

Source: Created by authors

(2) A Holistic View of the City: From Government Sectors to the Urban Whole

The holistic view of City Brain naturally demands City Intelligence to identify structural misalignments via data. For example, by precisely quantifying that peak-hour "on-road vehicles" constitute only about 10 percent of the total car parc, it provides a scientific basis for optimizing urban space, scale, and industrial structure. Through real-time regulation of energy and environmental systems, it helps achieve a dynamic balance in the layout of production, living spaces, and ecology. The concept that "the city shall function as a whole entity" demands not only breaking down barriers between government departments to form a coordinated body, but also means that all city elements — government, enterprises, and society — must collectively constitute an integrated whole. This integration is essential for the efficient acquisition of City Intelligence, which in turn informs decisions and actions for highly efficient resource utilization. The Hangzhou City Brain "30-Second Check-In" scenario exemplifies this. Through its central system, it achieves deep coordination across six systems: the check-in platform, hotel PMS, access control, payment processing, OTA bookings, and hotel direct sales. This integration has slashed the average check-in process from 5 minutes down to just 30 seconds. Taking a hotel group as a case in point, all 258 of its hotels in Hangzhou are now connected to the City Brain's cultural tourism system. This services over 15,000 guest check-ins daily, has reduced labor costs by more than 30 percent, and has completely eliminated queuing during peak periods. Only City Intelligence constructed under such a holistic perspective possesses the capability to empower diverse urban scenarios.

(3) A New Understanding of Resource Efficiency: From Mapping the Baseline to Optimizing Utilization

The starting point of China's City Brain practice lies in a cognitive shift regarding the very nature of resource conservation. The assertion that "building a resource-efficient society is a social revolution" moves beyond the traditional, passive notion of "saving" to lead the systemic transformation toward highly efficient resource use and a structural shift in improving the utilization of natural resources through data resources. This innovative thinking crystallized into a pivotal proposition through practice — the "City Brain Question": Can 10 percent of a city's current resources support its sustainable high-quality development? Practices in cities like Hangzhou have provided an answer. They reveal that, for instance, only about 10 percent of the total registered vehicles are actually on the road at any given time, with the remaining 90 percent sitting idle. Similarly, the past hotel check-in process, which took 300 seconds, has been reduced to just 30 seconds through data-driven optimization, precisely cutting the time cost to 10 percent (Figure 2-19). In 2020, it was precisely by leveraging minute-level, citywide dynamic traffic flow data — achieving a state of "clear foundational data and comprehensive situational awareness" — that Nanchang lifted its vehicle restriction policy. Where there is work, there is data; the quality of data reflects the quality of work. Data empowers cities to map the baseline. By introducing people-centred metrics like "on-road vehicles" and "congestion index," cities create new indicators. These not only provide the transportation department with a basis for congestion-management decisions but also help residents perceive real-time road network conditions and plan their routes more efficiently. This unification of "governance precision" with "lived experience" demonstrates the efficacy of precise governance enabled by data resources.

(4) Rebuilding Trust: Intelligent Transformation Toward Urban Civilization

The civilizational value of the City Brain initiative lies in its use of data to rebuild social trust and credit mechanisms, fostering a new form of urban civilization in the digital age. The shift from "Pay-before-Departure" to "Pay-after-Departure" illustrates this well: the government's trust becomes the people's credit, and the people's credit becomes the city's civilization.

In Hangzhou, the "Pay-after-Departure" scenario has increased parking lot turnover efficiency by 40 percent. Moreover, over 99.5 percent of users who enabled the service had paid promptly or on time with seldom evasion[102]. This validates the behavioral logic that trust induces trustworthiness. In other social activities, this trust yields further gains. The "Pay-after-Treatment" scenario in healthcare has cut emergency response time by 35 percent. Meanwhile, platforms like "Qinqing Online" and "Access to Livelihood" employ a "commitment-based + post-verification" mechanism, enabling policies to reach businesses and individuals in seconds. This creates a positive cycle characterized by zero document submission, zero manual approval, zero waiting period for payout, and zero credit impact[103].

This trust is built on three verifiable pillars: end-to-end transparency in data, auditable decision-making in algorithms, and predictable outcomes in services. When traffic light timings are optimized by the global algorithms and subsidies are distributed automatically through intelligent matching, the system's "goodwill" becomes objective and verifiable. This trust, grounded in systemic certainty, translates into tangible social capital: businesses are more willing to invest because policies are fulfilled automatically, and citizens choose greener travel options because parking data is reliable. Each instance of fulfilled

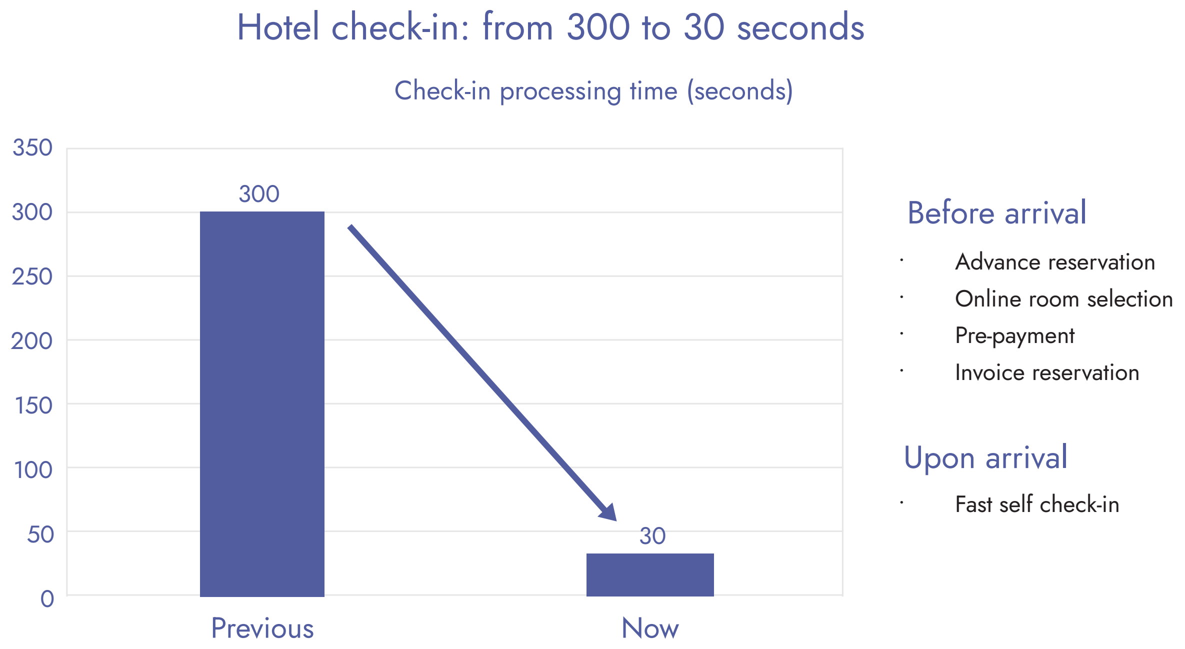


Figure 2–19: Hangzhou City Brain's "30–Second Check–In" scenario aims to save tourists' time resources

Source: Created by authors

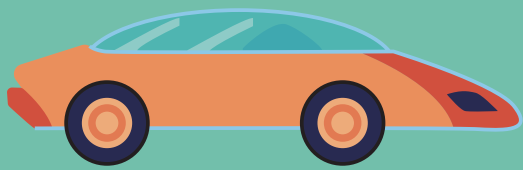
trust reduces the friction of societal operation, creating a "trust dividend" — a core indicator of urban progress and a symbol of the intelligent age.

Ultimately, the relationship between people and the city evolves from "command-and-obey" to "collaborate-and-evolve." City Intelligence infrastructure becomes the driver of governance reform — through institutional innovation — and the cultivator of a humanistic culture. It acts as a bond connecting government, society, and citizens, shifting governance from top-down management to multi-participant collaboration. Citizens become the "sensory neurons" of City Intelligence through data feedback, while the city becomes a "reliable partner" in daily life through precise services. This new compact, based on technological rationality and humanistic care, allows cities to maintain scale and efficiency while regaining the warmth and vitality of a living organism — truly advancing toward a trustworthy and sustainable form of civilization.

City Intelligence Evolution Roadmap

Chapter 3 City Intelligence Evolution Roadmap

03



The key to promoting sustainable development through building resource-efficient cities lies in the holistic intelligent transformation of the urban system. City Brain practices demonstrate that the successful evolution of City Intelligence must follow a four-stage pathway: Value Transformation → Data Foundation → Scenario Validation → Civilization Shaping.

This evolution must begin by establishing new values — deeply recognizing that a city is an integrated whole, that data is a decisive resource, and that the goal of urban intelligence is to ensure a high-quality life and advance sustainable urban development through optimized resource utilization.

Next, to map the baseline, resource flows and utilization efficiency must be precisely measured. The process of "mapping the baseline" unfolds across three levels: 1. Resources: metrics such as "on-road vehicles," water network leakage rates, and parking space turnover rates. 2. Overall urban operational status: real-time monitoring of the city's "vital signs." 3. Operational data and data quality: transforming daily operations into high-quality data resources. Key actions involve establishing an overall plan with phased implementation, building intelligent infrastructure as a pivotal lever, using real-world scenarios to refine both the infrastructure and governance, and establishing a comprehensive framework for security and legal safeguards around City Intelligence.

Scenario-oriented application is the critical step to validate the value of City Intelligence. Selecting cross-departmental, high-impact scenarios like "No Traffic Restrictions" and "Pay-after-Treatment," City Intelligence can restructure service flows by leveraging data flows, gradually achieving the leap from scenario-specific intelligence to citywide intelligence.

Ultimately, when intelligence becomes an endogenous capability of the urban organism, cities will foster a civilization based on trust, realizing a comprehensive transformation: from "targeted fixes" to "systemic optimization," from "pursuing scale" to "pursuing efficiency," and from "management and constraint" to "trust and activation." This process necessitates building an intelligence engine that integrates the trinity of data, AI models, and computing power, supported by robust security systems and legal safeguards. The ultimate value of City Intelligence can be validated by the "City Brain Question" — can 10 percent of a city's current resources support its sustainable high-quality development, thereby achieving an organic unity of technological progress and social value?

3.1 Building Resource-Efficient Cities Based on City Intelligence

The "AI + City" initiative aims to support cities in achieving high-quality and sustainable development in a resource-efficient manner through the capabilities of City Intelligence. As highlighted in a UN research report, resource-efficient cities can enhance productivity and foster innovation while simultaneously reducing costs and environmental impact[104]. To realize this goal, cities must possess holistic data connectivity and integrated governance capabilities. As defined by scholars such as Roche, "City Intelligence" is the ability to understand and navigate the physical and digital dimensions of "interconnected complex urban spaces"[105]. This underscores that merely deploying various sensors and technologies does not guarantee resource efficiency. The true utility of intelligent technology is realized only when a city adopts an integrated perspective on resource allocation.

Traditional smart cities are defined as urban environments that integrate information and communication technologies with infrastructure, architecture, everyday objects, and even citizens themselves, to address social, economic, and environmental challenges[112]. However, without a holistic intelligent strategy, these technologies often function in isolation, unable to fundamentally enhance resource utilization efficiency. Therefore, City Intelligence should focus not merely on technological investment but also on how technology can promote the integrated and systemic optimization of the city. This perspective aligns closely with the concept of "Earth Intelligence" proposed by the Group on Earth Observations (GEO) (Figure 3-1). This organization defines Earth Intelligence as the process of transforming raw observational data into actionable insights[72]: "We've pivoted from focusing solely on Earth observations to delivering Earth intelligence – making it accessible to everyone, everywhere. This transition from data and observations to intelligence is intentional, as data alone does not drive action[106]." Similarly, the development of City Intelligence should focus on evolving from data to insight. Massive volumes of urban data must be transformed — through advanced analytics, AI, and similar means — into actionable information for decision-making. Only then can this process truly drive a revolution in resource efficiency, moving beyond mere information accumulation. Intelligent technologies must be integrated into the city's overall operational logic. Thus, cities can break down silos between departments and

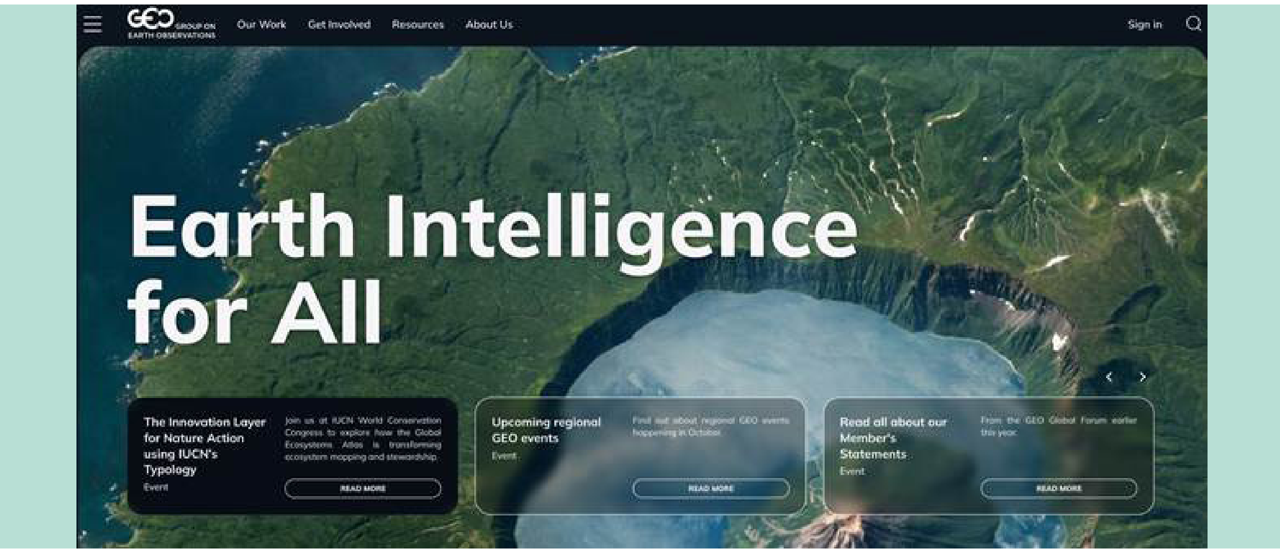


Figure 3–1: The Group on Earth Observation (GEO) proposed "Earth Intelligence"
Source: The Group on Earth Observation (GEO)

systems, enabling cross-domain optimization and resource allocation.

This strategy of leveraging City Intelligence to drive resource conservation also serves as a crucial technical prerequisite for achieving sustainable development. As noted earlier, resource efficiency must be considered within the framework of human development[111]. Guided by the UN's New Urban Agenda, which advocates "leaving no one behind" and "making cities inclusive, safe, resilient and sustainable," the development of City Intelligence must be centred on enhancing people's well-being, integrating social inclusion and ecological benefits into holistic planning. This shift epistemic enables cities to adopt a truly people-centered approach — one that not only accommodates growing needs but also respects the constraints of finite resources, thereby ushering in a new phase of sustainable urban development.

The evolution of City Intelligence manifests in three distinct levels: 1) Basic scenario applications represent the foundational level, where AI technologies are applied to specific urban tasks or processes — such as traffic-signal recognition or video-surveillance analysis. While effective in solving discrete technical challenges, this approach is often constrained by data silos and departmental barriers, limiting its ability to foster systemic synergy and offering only localized technical solutions. 2) The scenarios constitute an intermediate level, delivering integrated solutions for specific governance scenarios by combining multi-source data and domain expertise. 3) City-level intelligence represents the highest level, enabled by city-wide data networks and intelligence engines that support cross-domain, cross-department, and cross-level collaborative governance. These three levels also reflect three distinct perspectives and are not necessarily sequential stages; they may coexist and interact. The scenarios inherently incorporate smart technologies, while urban-level intelligence and its scenarios are intertwined, mutually reinforcing one another in practice.

3.2 Mapping the Baseline: A Critical Prerequisite

"Mapping the baseline" is far more than a simple statistical exercise — it is the cornerstone and prerequisite of City Intelligence. It refers to the precise, real-time measurement of a city's actual operational status and resource stock, as an organic whole, across specific dimensions. This shifts governance from vague, experience-based "guessing" to accurate, quantifiable "knowing." "Mapping the baseline" involves three key levels: resources, overall urban functioning, and data.

(1) Baseline of City Resources: resources, resource flows, and utilization efficiency. For instance, it measures road capacity not just by total length, but by real-time vehicle volume — the actual "on-road vehicles." This precise insight from mapping the baseline supports decisions such as lifting traffic restrictions. Likewise, for utilities like water and power, mapping the baseline reveals losses between supply and consumption. Without leakage rates, effective conservation is unattainable. The same principle applies to spatial flows — from parking-space turnover to real-time public-space occupancy. Hangzhou's "One City, One Parking System" model illustrates this well, turning total parking counts into an actionable "Parking Index."

(2) Baseline of City Operation: overall urban operational status. These following parts will answer the question: "Is our city 'healthy' or 'unwell' at this moment?" Urban vitality indicators: During the pandemic, real-time vehicle counts reflected the pace of economic recovery — whether 50,000 or 500,000 vehicles were on the road served as a direct "pulse check" for the city. Public service supply-demand matching: Real-time monitoring of capacity versus need at hospitals, schools, and government service windows. System resilience metrics: Assessing how key urban systems withstand and recover from shocks such as heavy rainfall or health crises. This enables city managers to monitor urban "vital signs" in real time, much like a doctor reads an ECG, shifting governance from passive response to proactive intervention.

(3) Baseline of Work Data and Data Quality: This is the foundation that enables the first two parts. It answers: "What quality of data do our daily work generate?" Where there is work, there is data. The work in every government, business, or societal process is a data source. "No data" means "no effective work is being done." Data quality reflects work quality — inaccurate or delayed data signals chaotic processes and poor management. Clarifying this fundamental forces organizations, especially governments, to redesign workflows and modernize governance. The core aim is to take down "data silos" and transform departmental data into high-quality "fuel" for citywide analysis and decision-making. Through government-business-society collaboration, both head data and long-tail data can then be fully integrated to serve citywide governance.

Mapping the baseline requires data openness, sharing and integration. Cities worldwide are accelerating data-opening initiatives to lay the groundwork for intelligent resource management. The UN's World Smart City Outlook 2024 notes that global smart city development is shifting toward a people-centred approach, requiring substantial quantitative and qualitative data[107]. As a result, more cities are establishing open data platforms to share information on traffic flows, energy consumption, water use, green space coverage, and other key indicators. These open datasets form a "big data foundation" for intelligent decision-making and provide essential support for subsequent AI applications.

Meanwhile, the advancement of AI has provided cities with powerful new foundations for intelligence. Recent research highlights how breakthroughs in AI models and autonomous agents are transforming urban planning. They enable the generation of future scenarios, the interpretation of complex data, and intelligent assistance throughout the planning process[108][109]. Unlike traditional rule-based planning approaches, these foundational AI models allow cities — for the first time — to achieve integrated resource allocation from top-level design through to real-time optimization. By leveraging these models, cities can conduct pre-training on massive multi-source datasets to develop city-scale knowledge graphs and AI foundational models, thereby equipping citywide decision-making with general-purpose intelligence.

Based on this, cities are poised to achieve systemic resource optimization and an efficiency revolution. Research shows that applying AI to improve public transport routing, building energy efficiency, and traffic and emission control can foster more resilient, low-carbon, and resource-efficient urban environments[110]. Through AI-driven intelligence, cities can coordinate and optimize system-wide challenges — such as transportation, energy, and pollution — using fewer resources.

The figure (Figure 3-2) illustrates the spatial distribution and total number of vehicles on the road, identified using satellite remote sensing data. Taking the area within Beijing's 2nd Ring Road as an example, the data show a total of 106,129 passenger cars and 679 large vehicles — adding up to 106,808 vehicles in the region. Among these, only 40,784 were actually on the road. Even during peak hours, fewer than 50,000 vehicles are moving within the 2nd Ring Road. Although drivers experience severe congestion, a significant portion of road space remains underused. This paradox — traffic jams coexisting with wasted road capacity — compels city planners to reconsider the issue: congestion is not primarily caused by the actual car parc, but by a lack of systemic coordination. Enhancing governance and optimizing system coordination are therefore far more critical than simply restricting citizens' mobility through measures like license-plate restrictions.

The figure (Figure 3-3) shows the car parc and the on-road vehicles in several major cities,

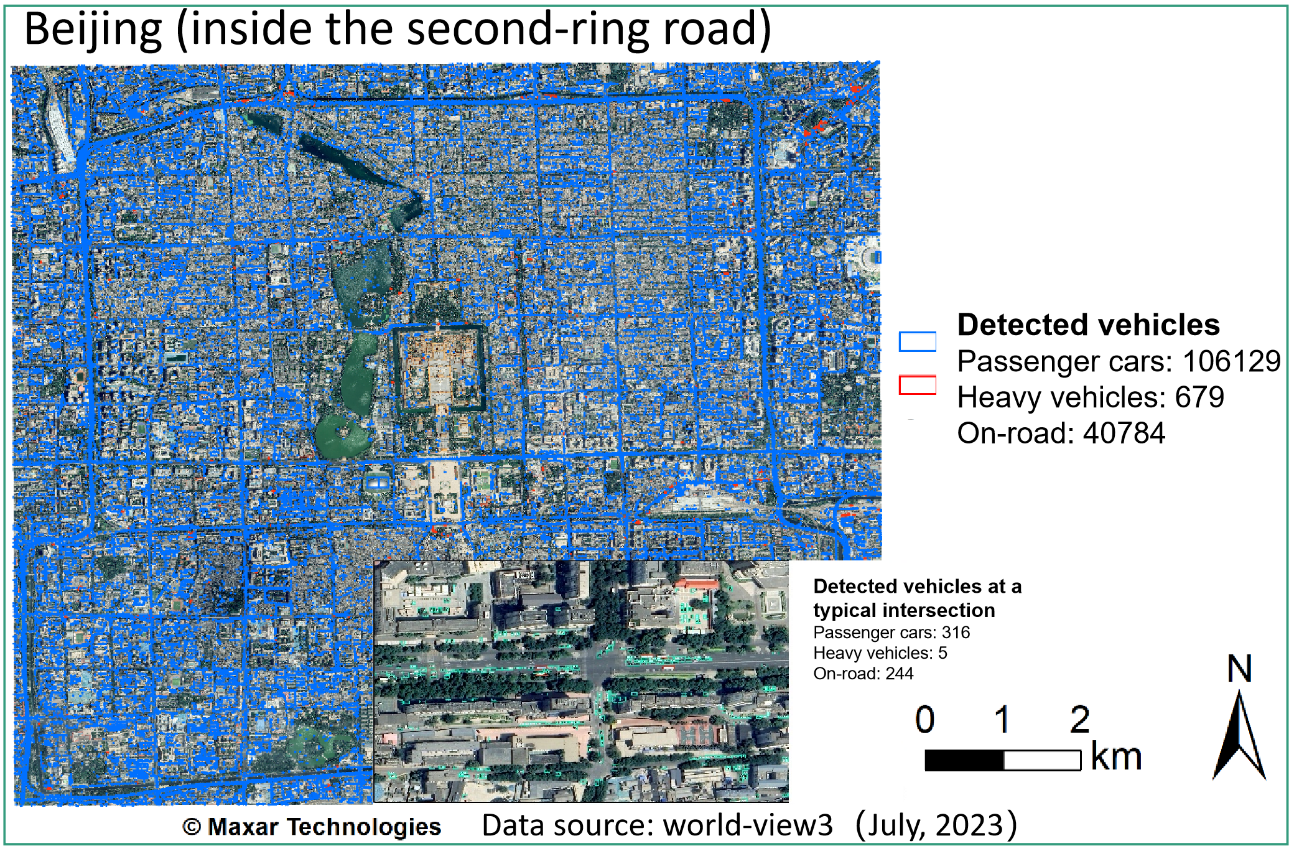


Figure 3–2: Satellite remote sensing data combined with AI models provides a low–cost city observation solution: on–road vehicle detection as an example

Source: Created by authors based on World–View3 satellite remote sensing data

based on satellite remote sensing data from Google Earth. For instance, in Bogotá, on June 24, 2025, there were 153,391 vehicles running on the road, accounting for 42.04 percent of the city's total vehicle volume. In Paris on June 19, 2025, the number of on-road vehicles was 100,748, accounting for 68.61 percent of the total. In New York, on June 17, 2025, 854,858 vehicles were running on the road, representing 47.32 percent of the total. In Shanghai, on June 5 2025, 907,929 vehicles were running on the road, making up 29.69 percent of the total. In Nairobi, on September 24, 2025, 51,069 vehicles were running on the road, as 22.85 percent of the total, while in Dubai, on the same day, 200,362 vehicles were running on the road, accounting for 28.65 percent of the total. Apart from Paris, where on-road vehicles exceeded half of the total, the on-road share in other cities was less than half, and in some cases even below one-third. If compared to the actual car parc in these cities, this proportion would be even lower. This underscores that mapping the baseline is a fundamental capability for City Intelligence. Whether governance decisions are based on total car parc or real-time on-road vehicles leads to different scales of resource allocation. This choice determines whether a city develops through resource over-consumption or through conservation and efficiency.

Looking ahead, reducing tech costs will further boost urban resource efficiency. The rise of open-source solutions reduces reliance on expensive hardware. For example, the dramatic reduction in satellite manufacturing and launch costs has created economies of scale. Commercial small satellites can now be built and launched for under a hundred thousand US dollars[111], enabling technologies like satellite remote sensing to acquire panoramic urban data at a large scale and low cost. Concurrently,

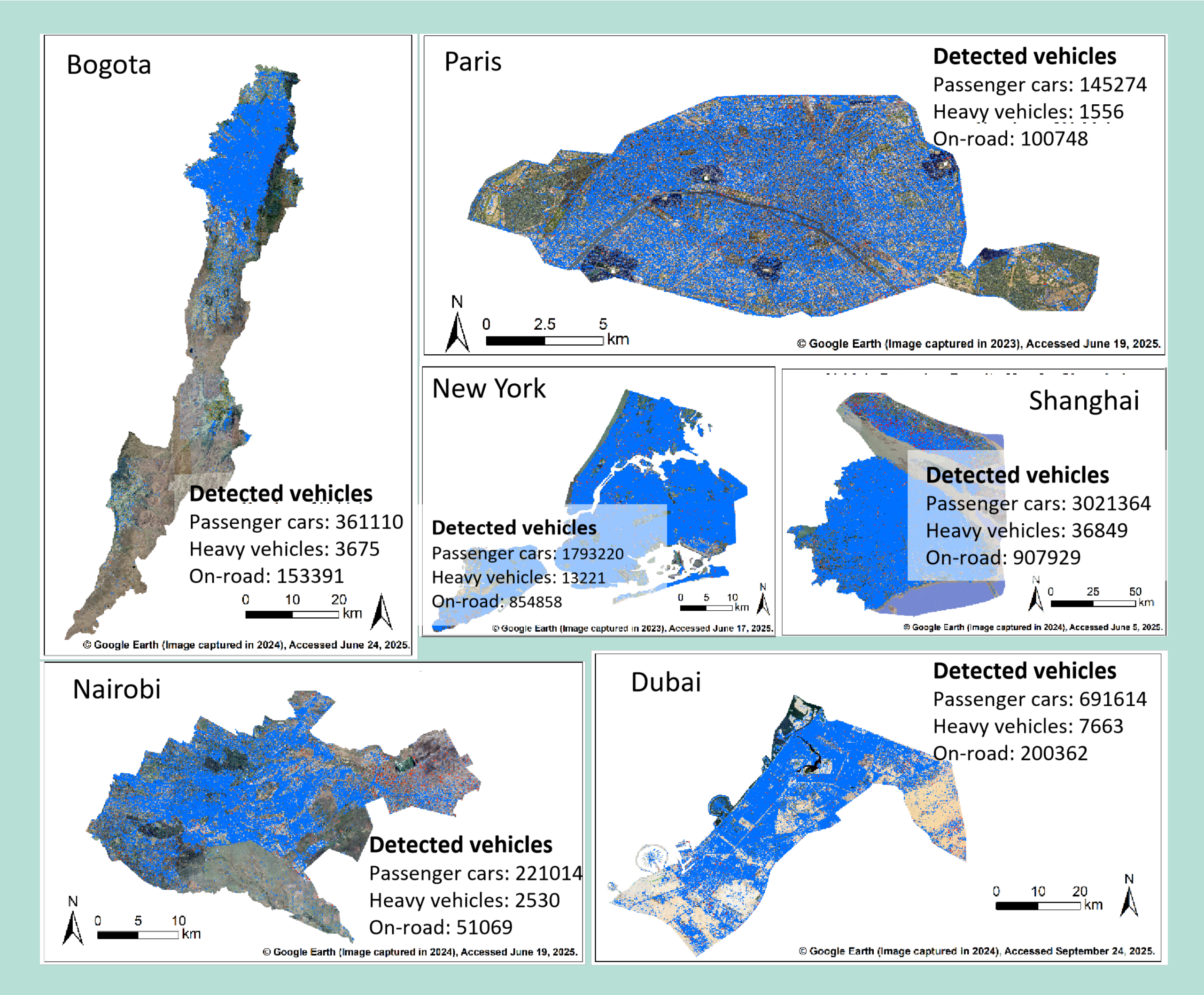


Figure 3–3: Mapping the baseline through satellite remote sensing data: observations of on–road vehicles in representative cities worldwide

Source: Created by authors based on satellite remote sensing data from Google Earth

the proliferation of distributed, low-cost sensor networks (e.g., for air quality monitoring) has significantly increased data coverage[112]. Furthermore, numerous Earth observation satellites now publicly release multi-spectral imagery, providing free observation data for monitoring urban land use, vegetation, and heat islands. This means that cities worldwide can share the cost of accessing space-based data, democratizing high-quality Earth observation resources. Less-developed cities can now obtain basic environmental and infrastructure information without investing in expensive ground sensors. By combining such data with information from existing in-city sensor networks and smart devices, they can establish a comprehensive data foundation for understanding resource use, laying the groundwork for future resource management. Empowered by City Intelligence, more cities have opportunities to leapfrog development stages, transition toward resource-efficient models, and take the initiative in future growth.

3.3 Guidelines for City Intelligence Implementation

City Intelligence provides the core capability for developing smart cities, as demonstrated by the practice and evolving understanding of the

City Brain. For an ordinary city to evolve toward possessing "City Intelligence" and thereby achieve people-centered, resource-efficient, high-quality development, it is far more than a one-off technology purchase. It is a profound governance revolution and a systemic undertaking.

3.3.1 Four Phases for Building City Intelligence

Phase 1: Reshaping Shared Vision and Values

Value realignment and a shared vision lay the cornerstone for transformation. Before any technological investment, a fundamental shift in values and mindset must occur. **1) Establish the Core Principle that "A City Functions As a Whole":** Thereby avoiding fragmentation and disjointed governance. Urban challenges like traffic congestion are not the responsibility of a single transport department; they are systemic outcomes shaped by planning, construction, management, and citizen behavior combined. City administrators are supposed to understand that while departmental boundaries exist for specialization, urban operations must be integrated. **2) Recognize that "Data is a Decisive Resource":** Data value must be prioritized alongside land and capital. Data is not a by-product of IT systems; it is a core output of work itself. **3) Define the Ultimate Goal of City Intelligence:** to ensure a high-quality life and advance urban sustainability by optimizing resource use.

Phase 2: Mapping City Baselines

Mapping a city's resource baseline is equivalent to developing its "digital senses." As the most decisive and protracted phase, which demands immense patience, it aims to shift the city's operations from "vague" to "clear." Operationally, this means acquiring the foundational data of infrastructure for City Intelligence. Key steps are: **1) Select Key Fields to Map the Baseline.** To start, for example, with transportation: follow Hangzhou's approach by first "counting vehicles" and "counting parking lots." To achieve real-time awareness of on-road vehicles. To take stock of critical resources, and monitor the flows and losses of water, electricity, and energy. **2) Build a Citywide Data platform.** To consolidate the "foundational data" identified across all departments and fields onto a unified platform. Rather than moving data, it involves standardizing, integrating, and making real-time data computable. **3) Configure Computing Infrastructure.** First, to make full use of existing infrastructure; then, to moderately develop necessary new capacity — such as cloud computing or data centers — based on actual need. This infrastructure is designed to be a public utility, like the power grid, providing the capacity to process massive datasets.

Phase 3: Scenario-Based Transformation

Scenarios provide a training ground for City Intelligence, enabling it to develop capabilities that address challenges beyond the reach of traditional urban governance. Building on the gathering of partial foundational data, cities should select high-impact scenarios where public pain points are most evident and cross-departmental collaboration is most urgent. These smaller-scale "smart" pilots demonstrate the value of integrated citywide intelligent governance. Choose flagship scenarios such as "congestion," "Pay-after-Treatment," or "Pay-after-Departure." These scenarios all involve multiple departments, have complex processes, yet deliver strong, tangible benefits to citizens. Therefore, restructure workflows driven by data flows. For instance, Hangzhou's "30-second hotel check-in" scenario updated government-business collaboration, significantly improving service efficiency and user experience. Nanchang's decision to lift traffic restrictions after mapping the baseline and holistic governance. It was not just optimizing a single intersection, but systemic action based on a comprehensive understanding of citywide traffic dynamics.

Phase 4: City Intelligence Emergence

This phase advances toward the higher level of a "City Intelligence." When the data foundation is solid and cross-departmental collaboration becomes routine, citywide intelligence begins to "emerge," ultimately reaching the ultimate goal of resource-efficient development. **1) From "Solution" to "Optimization":** The system is not only able to solve immediate problems but also able to predict and optimize holistically. For example, it can proactively simulate the comprehensive impact of a new policy on traffic, the environment, and the economy, thereby supporting science-based decision-making. **2) From "Optimization" to "Empowerment":** City Intelligence evolves into an open platform that serves not only the government but also empowers businesses and citizens. Entrepreneurs can leverage open traffic data to develop new applications, while residents receive personalized suggestions for travel, health, and daily life. **3) Trust Mechanisms and the Formation of a Digital Civilization:** Through City Intelligence, trust is built between the government, citizens, and enterprises. Government trust fosters public credibility, and public credibility becomes the fabric of urban civilization. Practices like "Pay-after-Treatment" are effectively constructing a trust-based society rooted in data. When trust serves as the lubricant of social operations, transaction costs across society drop significantly, and the level of civilization rises accordingly. This paves the way for truly high-quality, sustainable development along a "resource-efficient" path.

Regardless of a city's resource endowment or stage of development, the evolution toward "City Intelligence" fundamentally follows the pathway: Shared Vision → Data Foundation → Scenario Validation → Civilization Reshaping. It requires urban builders to hold a common vision and deeply integrate technology into the framework of governance. The ultimate aim is not to build a cold "machine city," but to return to the essence of what a city is: a living community where humans can live together more efficiently, more happily, and more sustainably (Figure 3-4).

3.3.2 Framework and Key Technologies of City Intelligence

The framework of City Intelligence is an organic and integrated system comprising data, AI models, and computing power. This framework transforms previously fragmented data resources and technological capacities from different departments and systems into stable public service capabilities. These capabilities address complex governance scenarios such as transportation, energy, the environment, and emergency response, thereby systematically enhancing resource allocation efficiency, governance effectiveness, and social welfare at the city scale. The overall structure of "computing infrastructure – data networks – intelligence engines – application scenarios" forms the critical foundation for City Intelligence to evolve from a technical capability into a governance capability (Figure 3-5).

Computing infrastructure sets both the productivity floor and capability ceiling for City Intelligence. On the one hand, training city models, cross-departmental analysis, and long-term simulations depend on stable and large-scale batch processing; On the other hand, traffic signal optimization, emergency dispatch, and energy load balancing demand online inference capabilities with low latency at the second or even millisecond level. This creates a new demand with more challenges to urban computing system. An effective urban computing system thus requires a layered, collaborative architecture backed by unified resource scheduling and energy management. Governance should prioritize establishing public computing pools, transparent allocation rules, and regional collaboration mechanisms to ensure computing resources serve public needs, emergencies, and essential operations — thereby preventing the digital divide from widening further.

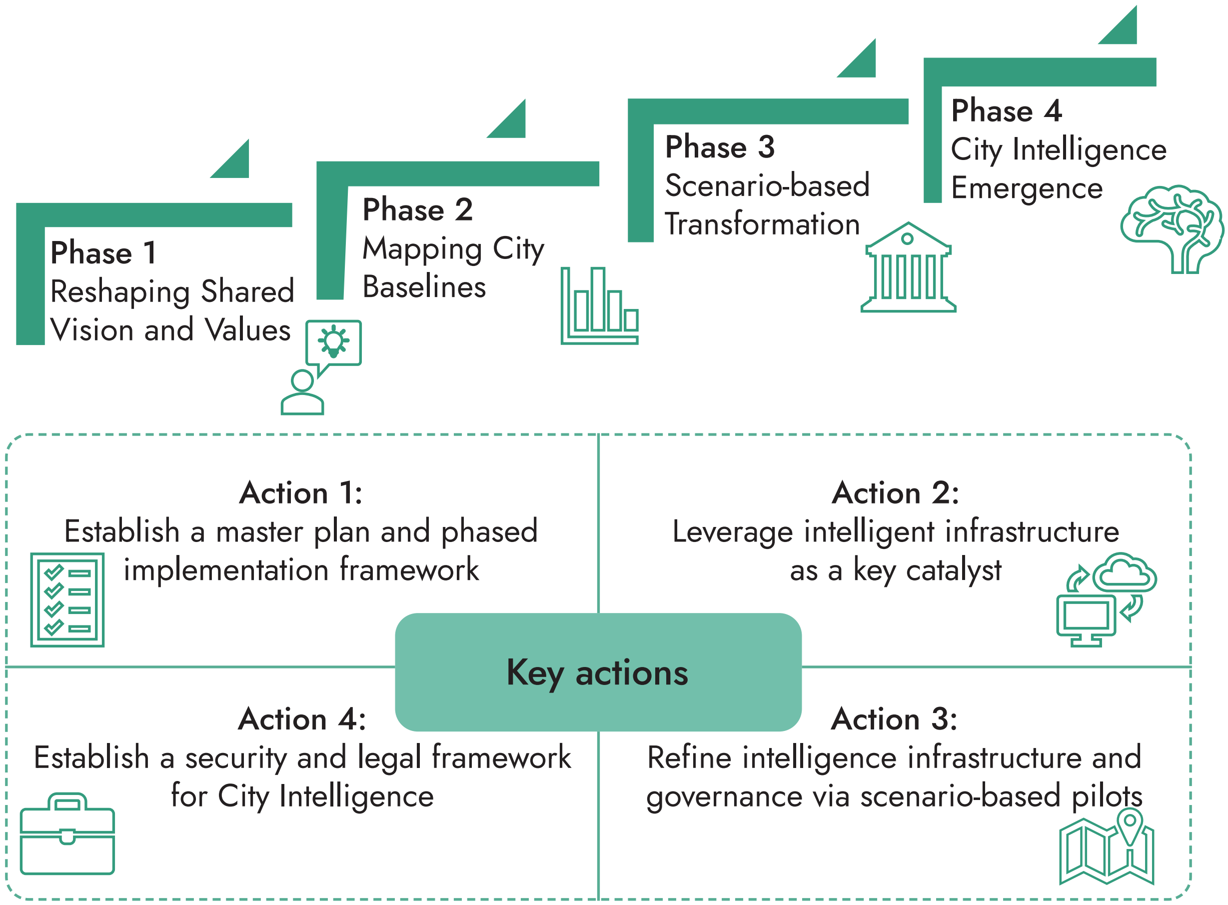


Figure 3–4: Phases and key actions for building City Intelligence

Source: Created by authors

Data networks constitute the digital foundation for cities to "map the baseline" and achieve citywide governance optimization. Modern cities have accumulated multi-source, heterogeneous data covering satellite remote sensing, ground-based and near-ground sensing, mobile and social sensing, as well as administrative and statistical data. However, their governance value depends on whether they can be transformed into a unified data asset system that is "computable, interoperable, and governable." To achieve this, a citywide data platform should be established, featuring a foundational architecture that includes unified meta-data management, spatiotemporal indexing, and stream-batch-integrated processing. Beyond this, a semantic interoperability layer — comprising urban ontologies, knowledge graphs, and spatiotemporal semantic embeddings — should be built. This layer integrates core elements like transportation, energy, the environment, land use, and population into a unified semantic framework, significantly reducing the friction cost of cross-departmental data integration and joint analysis.

An intelligence engine based on AI models is the core enabler for cities to advance from a "perceivable" stage to stages of being "understandable, simulative, and decision-capable." The engine of City Intelligence will ultimately be composed of a synergistic system of multi-lineage models, specifically including: First, multi-modal physical sensing models for unified representation and spatiotemporal embedding of data such as remote sensing and videos. Second, social behavior sensing models for precisely characterizing population flows, behavioral choices, and demand responses. Third, dynamic simulation models for short-term forecasting, cross-system linkage simulation, and counterfactual evaluation.

"AI + City" Technology Panorama		
Pillars	**Technologies**	**Capabilities**
Computing Infrastructure	City-scale computing, Cloud services, computing constellation, Heterogeneous architecture, supercomputing	City-level tasks online computing, Large-scale simulation, Multi-source data processing
City Observation	Space (satellite remote sensing), ground (video and multi-modal sensing), and social sensing (social media, navigation apps.)	From point-based to holistic sensing, From static monitoring to dynamic simulation, From single-city to transferable solutions
Data Network	Multi-modal data alignment & embedding, Multi-source data fusion, Spatiotemporal data integration, Semantic & knowledge modeling	Unified semantic cognition, Unified evaluation metrics, Unified baseline mapping
Intelligence Engine	Static perception model, Dynamic simulation model, City foundation models (LLM & multi-modal models), Multi-agent decision making	Multi-objective trade-offs, Simulation & risk forecasting, Solution evaluation & optimization
Scenarios	City planning (resilience, low-carbon, etc.), City operations (transport, power, etc.), Public services (healthcare, education, tourism, etc.)	Perceive-cognize-decide-act-feedback loop, People-centred precision service delivery, Resource-efficient holistic governance
Security	Data Security (data anonymization, trusted data spaces), Model Security (bias detection and mitigation, defense against adversarial attacks), System Security (trusted computing, cloud platform security), Governance Security (accountable and traceable decision-making)	Preventing data misuse, Avoiding black-box algorithms, Preventing loss of control over AI, Technology and governance for good

Figure 3–5: "AI + City" technology panorama

Source: Created by authors

Fourth, urban knowledge models for efficiently extracting expert knowledge from existing regulations, standards, and planning documents.

The long-term, reliable operation of City Intelligence must be underpinned by a dual guarantee system: security and rule of law. Within the security framework, a full-chain security architecture should be constructed, covering data – models – computing – applications – personnel. This system-wide approach must strengthen data security and privacy protection, algorithm and model security, critical computing and infrastructure security, as well as cyber-security and system resilience in cross-departmental collaborative operations. Within the rule-of-law framework, legal rules and institutional systems compatible with City Intelligence must be established concurrently. These should clearly define ownership boundaries, usage responsibilities, and accountability mechanisms for data and models. The principle of public interest priority must be established. Requirements for algorithm transparency, explainability, and auditability should be incorporated into statutory procedures. Through legislative authorization, technical standards, and continuous oversight, it is essential to prevent "black-box technologies" from undermining the legitimacy, fairness, and accountability of public decision-making. Only through the coordinated advancement of security and rule of law can City Intelligence, while improving efficiency, also gain a long-term, stable, trustworthy, and sustainable institutional environment for support.

3.3.3 Key Action Guidelines

Action 1: Establish a Master Plan and Phased Implementation Framework

The first step is to make a systematic and forward-looking master plan oriented toward achieving citywide urban governance through City Intelligence. This plan should define the vision, goals, and implementation pathway for City Intelligence development, providing strategic guidance for realizing the UN's New Urban Agenda and Sustainable Development Goal 11 (Sustainable Cities and Communities). At its core, the plan must be guided by the principle of citywide governance, breaking away from the traditional mindset of departmental silos and treating the city as an integrated, organic system in its design. Concretely, a "1+3+X" planning framework can be adopted: "1" represents one master plan for holistic urban governance, which sets the overarching direction and core metrics for the intelligent transformation. "3" corresponds to three interlinked, progressive phase objectives: "basic scenarios," "comprehensive scenarios," and "City Intelligence" (Table 3-1). This framework defines the key tasks for each phase, ensuring that the evolution of City Intelligence remains aligned with the process of sustainable development. "X" refers to X kinds of scenario-specific governance solutions, covering concrete fields such as transportation, energy, environment, and public services. This ensures the plan is both comprehensive and actionable.

Action 2: Leverage Intelligent Infrastructure As a Key Catalyst

Intelligent infrastructure serves as the foundation of data, AI models, and computing power for holistic urban governance. Its development must be systematically coordinated. For example, the initial action of Shanghai's "One-Stop Government Services through One Networks" and "Unified Governance through One Network" was to establish uniform data exchange standards and inter-agency coordination mechanisms. This was followed by the gradual integration of departmental business systems, ultimately forming a collaborative network spanning the entire spectrum of urban governance. Throughout this process, the parallel development of core infrastructure is essential. For data networks, this means creating citywide data resource catalogs and sharing mechanisms to dismantle departmental data silos. For intelligence engines, it involves building foundational city models and domain-specific model libraries to achieve a "Model-as-a-Service (MaaS)" capability. For computing infrastructure, it requires establishing distributed computing networks to meet the varied demands of different scenarios. Crucially, the development of intelligent infrastructure must avoid being technology-driven for its own sake. It should be guided by the actual needs of real-world applications. This approach fosters a virtuous cycle of "demand-driven capability, leading to deeper application," ensuring that infrastructure development remains closely aligned with the practical needs of urban governance. This shift from "technology-driven" to "demand-driven" construction provides robust, relevant support for citywide urban management.

Action 3: Refine Intelligence Infrastructure and Governance via Scenario-Based Pilots

Scenarios are the practical starting point for the evolution of City Intelligence. It should focus on enhancing the efficiency of specific governance scenarios to drive the improvement of intelligent infrastructure and the transformation of governance systems. By focusing on improving outcomes in concrete governance scenarios — such as traffic congestion, community eldercare, or flood emergency response — cities can simultaneously refine their smart infrastructure and reshape their governance systems. For example, Nanchang's "No Traffic Restriction" traffic policy replaced bans with intelligent measures, but soon revealed that signal optimization alone was inadequate for complex conditions. In response, the city launched features like the "Report on the Go" function in its "i-Nanchang" app and integrated data from transport, public security, and meteorological departments to build a comprehensive traffic awareness system. This not only enhanced governance efficiency but also spurred cross-departmental collaboration and process redesign. Similarly, the evolution of Hangzhou's "Green Wave" corridors from fixed-time plans to real-time dynamic control continuously pushed for the improvement of the city's traffic sensing network and algorithmic capabilities. Basic scenarios should be paired with scientific evaluation mechanisms, creating a closed loop of "application - assessment - improvement." This "application-driven development and outcome-guided refinement" approach prevents meaningless investment and ensures all development is firmly rooted in addressing genuine needs.

Following successful implementation of scenarios, cities need to advance from respective scenarios to a holistic whole view. The key lies in scenario integration, which requires establishing cross-field data-sharing and operational coordination mechanisms. Technology-wise, this relies on intelligence engines to interconnect data and decision-making capabilities across scenarios. For instance, coordinating transportation and energy systems to optimize charging networks, or linking heat-wave emergency response with urban planning to enhance spatial layouts. Governance-wise, it necessitates redesigning cross-departmental workflows to enable problem-oriented collaborative governance. Shanghai's "Unified Governance through One Network" exemplifies this shift — evolving from grid-based management to a three-tiered coordination system spanning over 30 sectors at block, district, and city levels. This demonstrates the transition from single-scenario management to citywide panoramic governance. Throughout this process, standards must lead the way, unifying data and process protocols. Equally important is a people-centred approach: service workflows should be designed around the needs of citizens and businesses, such as integrated services for "business start-up." Through this collaborative evolution from scenarios to a panoramic view, cities can gradually develop systematic and citywide governance capabilities, fundamentally shifting from "fragmented management" to "organic, integrated governance."

Action 4: Establish a Security and Legal Framework for City Intelligence

As cities grow more intelligent, security risks become increasingly complex and diverse, neces-

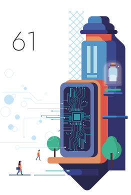


Table 3-1: City Intelligence Progression

Phases	Key Characteristics	Core Indicator
Basic Scenarios	This phases focuses on specific use cases to drive the development of integrated intelligent technologies at the scenario scale.	Dedicated data networks and intelligence engines are established for targeted scenarios, with the engines primarily taking the form of "vertical-domain models" to support fine-tuned, scenario-specific applications.
Comprehensive Scenarios	This is a critical transitional phase in the evolution of City Intelligence, aiming to consolidate fragmented scenario-based governance capabilities into citywide systemic solutions.	The core achievement is the formation of shared data networks and intelligence engines across multiple scenarios. The intelligence engine evolves into a hybrid architecture of "city foundation model + multi-scenario models."
City Intelligence	City Intelligence reaches maturity and the city gains the capability to evolve dynamically like an organic system, enabling holistic and systemic resource allocation with high efficiency.	The development of citywide data networks and intelligence engines is realized, culminating in an integrated capability of "city foundation model + multi-field models."

sitating a comprehensive, multi-layered security and governance framework. This framework is supposed to advance along two parallel dimensions: tech-for-good and governance-for-good, aiming for development that is people-centred, secure, and trustworthy.

For tech-for-good, three key actions of security should be conducted: Implement data classification, lifecycle management, and explore trusted data spaces and regulated sharing mechanisms to protect sensitive information. Enhance transparency and explainability of algorithms, conduct audits for critical systems, and mitigate bias and discrimination. Strengthen multi-layered protection for networks and infrastructure, and introduce sandboxes and benchmark testing to improve overall security. For governance-for-good, mechanisms must be established for ethics review, public participation, and oversight accountability, ensuring that intelligent applications align with societal values and international human rights principles. Simultaneously, cross-departmental and cross-sectoral security collaboration should be promoted to enhance capabilities for the instant identification, warning, and response to risks. As noted in the September 2024 United Nations report, Governing AI for Humanity[113]: AI governance must be grounded in the UN Charter, international human rights law, and other agreed international commitments, such as the SDGs. Public participation mechanisms are vital to safeguard citizens' rights to information and involvement in intelligent decision-making, thereby enhancing social trust and embodying the principle of "inclusive participation."

A sound legal framework forms the institutional foundation for both City Intelligence and citywide governance. It not only provides a stable environment for technological innovation but also offers regulatory support for dismantling data silos and clarifying rights and responsibilities. This ensures that development adheres to the core values of being human-centered, secure, and trustworthy. The implementation and impact of the Hangzhou Ordinance on City Brain-Enabled Urban Governance powerfully demonstrate the crucial role of legal safeguards in enabling integrated urban management (Figure 3-6). Guided and governed by the Ordinance, the Hangzhou City Brain has achieved three fundamental shifts: **1) From "Discretionary Data Sharing" to "Legally Mandated Data Collaboration":** The legal mandate has broken down departmental barriers, transforming data cooperation from an optional practice into a compulsory requirement. **2) From "Technology-Driven Innovation" to "Institutionally Guaranteed Innovation":** A stable institutional environment has been established, ensuring the sustained and continuous evolution of the City Brain. **3) From "Government-Led Management" to "Multi-Stakeholder Collaborative Governance":** By clearly defining the rights and obligations of all parties, a legal framework has been created that actively involves the government, businesses, and citizens in the collaborative process of urban governance.

3.4 Future City Intelligence Outlook

Within the United Nations framework, AI and global climate change have emerged as two of the world's most critical agendas. City Intelligence is uniquely positioned at the intersection of both. The deep blue curve in the Figure 3-7 illustrates the exponential growth in global carbon emissions since the 1950s. This surge was not primarily a consequence of the early Industrial Revolution, when resource use was relatively contained, but rather accelerated with widespread electrification. The peak of this curve aligns with China's 2030 carbon peak target, while the red line marks the emission threshold required to achieve carbon neutrality by 2050 or 2060 (Figure 3-7). Prior data reveals that the technological breakthroughs of the past century largely intensified resource consumption and emissions. However, the coming three to four decades demand a far steeper decline toward net-zero emissions. This stark timeline underscores the unprecedented urgency of the transition. Only through digital transformation and systemic change driven by City Intelligence can we break free from traditional technological paradigms. This approach can efficiently drive the decarbonization process, avoiding a mere continuation of high-emission models. The "City Brain Question" captures both the capability and the ultimate vision of City Intelligence: "Can 10 percent of a city's current resources support its sustainable high-quality development?"

Looking ahead, the evolution of City Intelligence will move beyond mere technological optimization. It is poised to drive a paradigm shift in urban development — one fundamentally centered on resource efficiency. Its ultimate goal is to use City Intelligence to propel sustainable and inclusive growth, endowing cities with an organism-like capability for holistic cognition, global coordination, and autonomous evolution. This is the key to breaking the traditional link between linear resource consumption and urban growth. By giving city a "brain" — leveraging City Intelligence to digitally reconfigure urban operations — resources can be conserved and allocated with unprecedented global efficiency. By gathering a citywide "digital foundational dataset," the use of traditional resources like electricity, water, transportation, and land will be precisely modeled, monitored in real time, and dynamically optimized. Traffic signals will no longer be respective timers but neurons in a dynamic, citywide traffic-flow equilibrium. Building energy consumption will shift from passive adaptation to active participation in grid flexibility. This systemic revolution in resource efficiency is the only viable path for cities to

Hangzhou Ordinance on City Brain-Enabled Urban Governance

(Adopted at the 30th Meeting of the Standing Committee of the 13th Hangzhou Municipal People's Congress on October 27, 2020; Approved at the 25th Meeting of the Standing Committee of the 13th Zhejiang Provincial People's Congress on November 27, 2020)

Article 1 This Ordinance is formulated in accordance with relevant laws and regulations and in light of the actual conditions of this Municipality, for the purposes of promoting and standardizing the empowerment of urban governance by the City Brain, protecting the lawful rights and interests of citizens, legal persons, and other organizations, advancing innovation in governance methods, models, and concepts, modernizing the urban governance system and governance capacity, and building a new type of smart city.

Article 2 This Ordinance applies to activities related to the empowerment of urban governance by the City Brain within the administrative area of this Municipality.

Article 3 For the purposes of this Ordinance, the term "City Brain" refers to a digital system and modern urban infrastructure composed of elements such as a Central System, systems and platforms, digital cockpit, and application scenarios. It is built on and supported by data, computing power, algorithms, and other foundational elements, utilizes new technologies including big data, cloud computing, and blockchain, and aims to promote comprehensive, whole-process, and citywide modernization of the urban governance system and governance capacity.

Article 4 Work on empowering urban governance through the City Brain shall adhere to the principles of integrated planning, intensive development, public and business convenience, innovation-driven progress, holistic intelligent governance, and security controllability.

Article 5 The Municipal People's Government shall strengthen leadership and coordination of work to empower urban governance through the City Brain, incorporate such work into the national economic and social development plan, and formulate relevant policies.

The People's Governments of districts, counties (county-level cities) shall be responsible for promoting and coordinating work on empowering urban governance by the City Brain within their respective administrative areas.

……

Figure 3–6: Local regulation: Hangzhou Ordinance on City Brain–Empowered Urban Governance

Source: Hangzhou People's Congress Website (www. hzrd. gov. cn) escape the constraints of extensive growth and advance toward high-quality, sustainable development.

While grounded in universal principles and technology, each city can develop its own demand-driven, distinctive form of City Intelligence. More significantly, the logic of energy and resource efficiency intrinsic to City Intelligence, when combined with the global ethic of equitable sharing, can foster collaborative development among cities. A global, urban open-source ecosystem for City Intelligence could emerge. From taking one city as a whole to taking all cities worldwide as a whole, advanced cities shall be responsible for opening their proven algorithms, platform architectures, governance practices, and even data, AI models, and computing power as "urban digital public goods" to the whole globe, especially to cities in developing countries. This would directly empower late-adopter cities, enabling them to acquire critical capabilities for boosting resource efficiency at low cost and high speed, bypassing the old "high-consumption, high-pollution" development path and collectively tackling the climate crisis. This is not merely technology transfer; it is a conscientious choice to avoid global duplication of effort and resource waste, pooling collective wisdom to address sustainability challenges. This shift is already on the way, with satellite manufacturing and operational costs falling dramatically, the technological divide has been narrowed. Looking forward, future City Intelligence systems will likely depend on shared satellite platforms. Cities won't need to build expensive individual sensor networks; instead, they can access real-time environmental, climate, and infrastructure data via shared satellite constellations at minimal marginal cost. This will powerfully accelerate the democratization of City Intelligence.

Ultimately, the hallmark of a future city with advanced City Intelligence will not be economic prosperity alone, but the maximization of public

Annual CO_2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry. Land-use change emissions are not included.

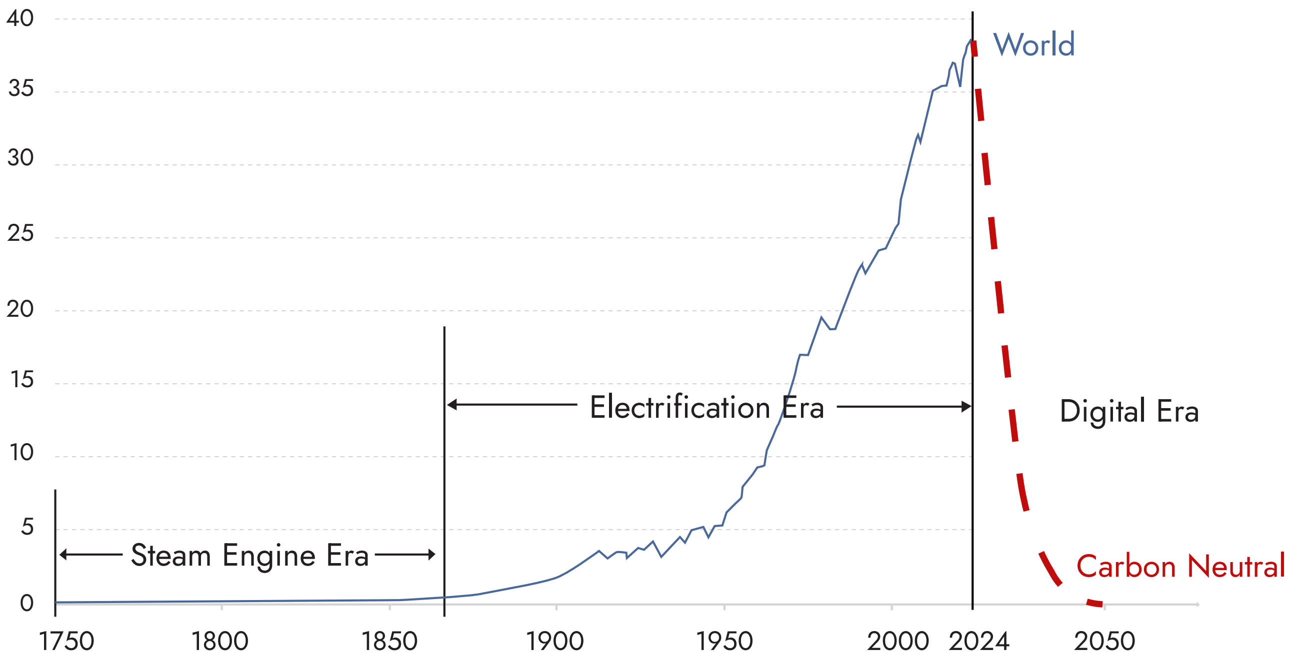
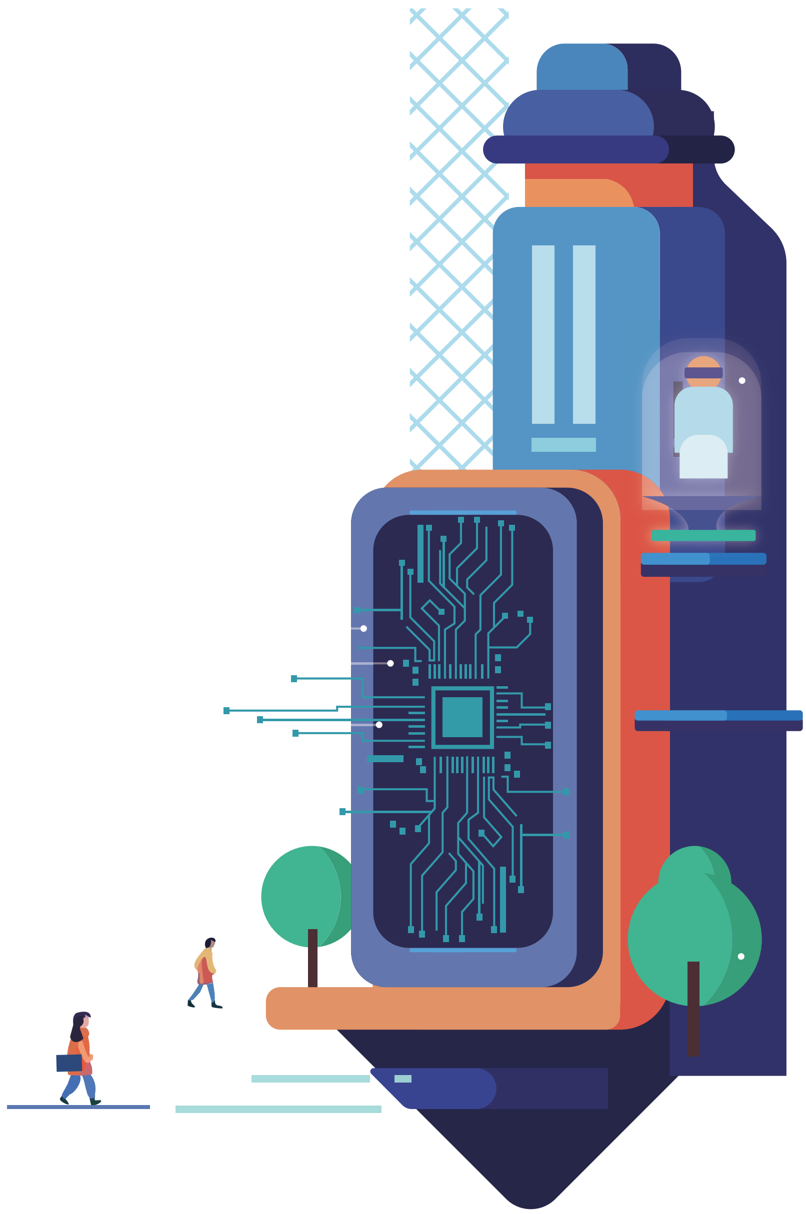


Figure 3–7: In the Digital Era: achieving carbon neutrality through resource efficiency via City Intelligence

Source: Created by authors Based on charts from "Our World in Data" well-being, environmental quality, and urban resilience while minimizing per-unit resource consumption. It will transform from a massive consumer of resources into a self-optimizing, regenerative organic entity. This marks the transition from an industrial urban civilization obsessed with "scale expansion" to a digital urban civilization defined by intelligence, measured by well-being, and shared by all.

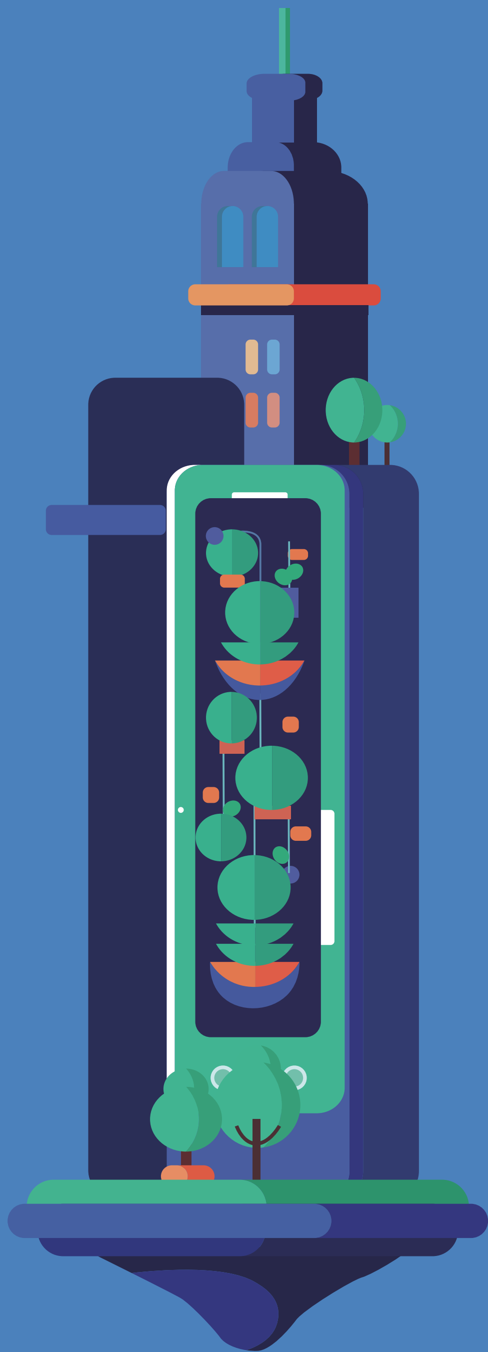


04 Case Studies

Chapter 4 Case Studies

04

This chapter presents six city case studies and six scenario-based cases, each analyzed with a focus on four key aspects: the core challenges addressed, the vision and goals, the implementation strategy, and the insights drawn in relation to the UN SDGs. The aim is to provide Chinese strategies and solutions to support City Intelligence development in other cities worldwide.



4.1 City Cases

4.1.1 Hangzhou City: Exploring Urban Sustainable Development Based on the "City Brain" Concept

(1) Background and Challenges

In 2016, seeking a systematic solution to urban challenges, Hangzhou embarked on an unprecedented exploration by targeting its severe traffic congestion. At that time, the city's car parc had reached 2.598 million, giving it the highest car parc per thousand residents among all provincial capitals in China. This made Hangzhou one of the nation's most congested cities, yet traditional traffic management methods proved inadequate to address the root causes of the gridlock. Meanwhile, residents increasingly expected smarter and more efficient urban services. Faced with mounting pressures from population growth, resource constraints, and environmental challenges, Hangzhou urgently needed a new governance model featuring cross-departmental integration and innovation to improve urban operational efficiency, enhance public services, and achieve balanced, sustainable economic and environmental development.

(2) Vision and Goals

With the goal of building the "Hangzhou City Brain," the city leveraged its data resources to conduct real-time, holistic urban analysis, optimize the allocation of public resources, refine governance, and advance sustainable development. Its core vision was articulated as: "A city that thinks, for a better life; optimal resource use, for maximal governance efficiency." In 2020, the Hangzhou Ordinance on City Brain-Empowered Urban Governance defined the City Brain as "a digital system and modern urban infrastructure aimed at promoting comprehensive, whole-process, and citywide modernization of the urban governance system and governance capacity." Through an integrated and intelligent

Figure 4–1: Example of city panorama displayed on Hangzhou City Brain 1.0 digital cockpit

Source: Hangzhou Municipal Bureau of Data Resources public data platform, it enables data sharing, fosters cross-departmental business collaboration, empowers the development of application scenarios, and ultimately facilitates the effective allocation of urban resources[114].

(3) Strategies and Implementations

1) Infrastructure for the City Brain was built to coordinate resources across the entire city through a central system. By integrating data systems from over 50 departments, the initiative broke down silos, enabling data sharing and unified orchestration (Figure 4-1). Relying on a "platform + big data + AI" framework, urban management transformed into data-driven collaborative governance, enhancing the utilization of public resources and the efficacy of administration. The Hangzhou experience with City Brain was distilled into replicable legislative language, fostering a unified understanding and leveraging legislation to provide the "catalytic force" for empowering urban governance through City Brain[115].

2) The operational model of "One Brain Governing the City, Empowering Dual-Side" was refined through scenario-driven development. Guided by the objectives of practicality, usability, desirability, and durability, the strategies focused on identifying targeted entry points to develop comprehensive solutions, emphasizing practical effectiveness, intelligent decision-making, and direct service delivery. Scenarios served as the tangible, digital expression of how the City Brain empowers urban governance. By enabling data collaboration, resource digitalization, and process re-engineering, cross-domain applications were built to address specific problems and needs. This approach continuously accumulated and refined governance capabilities, drove innovation in governance models, and systematically built an accessible service system. Innovative "scenarios" were created, and a replicable methodology for digital governance based on these pilots was established. Application scenarios such as "Qinqing Online," "Enjoyable Tourism," "Pay-after-Departure" parking, and "Sub-District Governance" were created to form a comprehensive digital governance solution for megacities[116].

3) City Intelligence was leveraged to build modern governance capacity for megacities. Over 10 intelligent agents were created, such as "Qinqing XiaoQ", "Hang XiaoYi", and "Hang MinXing (a civil administration intelligent agent developed on Hangzhou City Brain)", while continuously strengthening the foundational "Three Unified Networks" governance framework: "One-Stop Government Services through One Network" aims to improve the optimal business environment. "Unified Governance through One Network" aims to improve citizens' sense of security. "Unified Administration through One Network" aims to improve government public service. This framework elevates a more scientific system architecture and more effective application scenarios, advancing the modernization of megacity governance.

(4) Achievements and Insights

After nearly a decade of implementation, Hangzhou City Brain has delivered significant results across multiple dimensions: In terms of urban governance efficiency: traffic congestion has been notably improved. While car parc increased by 65 percent, the congestion index remained largely unchanged. Key corridors were optimized with green wave signal coordination, earning Hangzhou the 2024 World Smart City Award for "Transportation." In terms of public security: Hangzhou has become one of China's fastest-responding cities. Its rapid accident handling and clearance mechanism cut average police dispatch and resolution time from about 20 minutes to under 5 minutes, enabling proactive risk mitigation. A digital public safety foundational infrastructure was established, launching 45 applications with associated monitoring participants and indicators. In terms of government services, by integrating cross-departmental data, Hangzhou led in scenarios like "No More than One Visit" and "One-Stop Government Services through One Network," improving both the business environment and citizen satisfaction. In terms of digital economy, the initiative has spurred the growth of local AI and cloud-service enterprises, attracting digital talent. In 2024, the value-added of Hangzhou's core digital economy industries accounted for 28.8 percent of its GDP. Most importantly, the City Brain has driven a fundamental transformation in governance philosophy — from a government-led model to a new paradigm of collaborative governance.

The practices of Hangzhou City Brain closely align with several UN Sustainable Development Goals (SDGs), including SDG 11 (Sustainable Cities and Communities), SDG 9 (Industry, Innovation, and Infrastructure), SDG 16 (Peace, Justice, and Strong Institutions), and SDG 13 (Climate Action). In September 2025, Hangzhou City Brain was recognized with the "Sustainable Cities and Communities" award at the 3rd BRICS Urban Future Forum held in Moscow.

This innovative initiative offers four key insights: 1) It remains people-centered and case-oriented, with success measured by public satisfaction and tangible benefits. 2) It focuses on building integrated digital-intelligent systemic solutions to enhance governance systems and capacities. Facing a megacity with 12.38 million permanent residents and over 16 million people served daily, it achieved comprehensive coordination of massive foundational data across all levels and sectors, achieving system and data interoperability, and — through data synergy, operational coordination, and public-private collaboration — ensuring services are delivered directly to residents, businesses, and grassroots governance units. 3) It implemented concrete actions guided by the principles of "data-driven, collaborative, resource-efficient, and rule-of-law" governance. "Data-driven" means using data resources to optimize public resource allocation, such as starting congestion management by first accurately counting vehicles. "Collaborative" refers to integrating data, operations, and organizations to make the city function as an organic whole. "Resource-efficient" focuses on reducing urban resource waste and improving utilization efficiency, providing precise support for sustainable development. "Rule-of-law" entails establishing systematic regulations and policies around data and intelligent systems to ensure security and development advance together.

4.1.2 Shanghai: Transforming Megacity Governance from Digitalization to Intelligentization

(1) Background and Challenges

As an international metropolis and economic hub with a population exceeding 24 million[117], Shanghai shoulders the strategic mission of building itself into an "International Digital Capital." The city faces intensifying complexities in megacity governance, where traditional siloed departmental operations have led to inconvenient public services, imprecise government decision-making, and growing supply-demand mismatches. In late 2020, Shanghai Municipal Party Committee and Government issued the Opinions on Comprehensively Promoting Shanghai's Urban Digital Transformation, formally launching the systematic digital transformation of the megacity.

(2) Vision and Goals

The "14th Five-Year Plan for Comprehensively Promoting Urban Digital Transformation in Shanghai" released in 2021 defines the "1+4" target system[118]. One overall goal is: by 2025, Shanghai will have achieved remarkable results in comprehensively promoting urban digital transformation, built a domestic first-class and international leading digital benchmark city, and basically established the overall urban digital framework. This framework comprises interconnected city digital infrastructure including the base, hub, and platform; an integrated city digital entity covering economic, life, and governance digitalization; and a city digital governance system involving government, market, and society in co-governance. It aims to achieve an initial comprehensive transformation in production and life, enable data elements to empower all domains, and reshape concepts and rules across the board. The basic framework for building an international digital capital will take shape, laying a solid foundation for establishing a world-influential international digital capital by 2035. In addition, the plan includes 16 specific indicators in four aspects. This target system closely follows the principle of "a city built by and for the people," centers on meeting public needs in production and daily life to advance digitalization, and aims to enhance citizens' sense of fulfillment. Meanwhile, through institutional safeguards such as the "Shanghai Data Regulations," data security, privacy protection, and technological innovation are advanced in parallel to ensure a steady transformation.

(3) Strategies and Implementations

Overall digital infrastructure development: Shanghai focuses on building a new foundational urban digital base, with the core concept of integrated resource planning and smart city development. It is creating a "digital base" comprising the urban data hub system, AIoT sensing network, and common technology enabling platform. The city's operational "Unified Governance through One Network" platform serves as the "brain hub" for digital governance. Since its city-level launch in 2019, it has integrated multiple departmental business systems and applications, connected a three-tier governance network, centralized operations with numerous connected IoT sensing devices, aggregated urban operational data, and enabled real-time panoramic situational awareness. Concurrently, the government service "One-Stop Government Services through One Network" platform is being advanced to consolidate administrative items, break down barriers, and achieve efficient data flow and collaborative approval processes. The "Shanghai Data Regulations" issued in 2021 provide the legal framework for data governance. The promotion emphasizes multi-participant collaboration, utilizing mechanisms like "unveiling the list and appointing the leader" to attract participation in tackling key challenges, and building platforms to provide data interface services. A preliminary three-tier architecture of "digital base + intelligent hub + application scenarios" has been established, forming a concerted force for citywide digital transformation.

People-centred digital services: Shanghai's digital transformation is guided by the "city for the people" concept, closely centered on the needs of citizens and enterprises. The "One-Stop Government Services through One Network" platform reform facilitates public affairs handling, incorporating a vast number of service items for full coverage, handling millions of cases with high user activity. The promotion of electronic certificates and seals reduces required materials and processing time, resulting in high satisfaction. A digital life service system covering the entire lifecycle has been created, introducing digital life scenarios across multiple fields. In healthcare, numerous services are provided, with specific conveniences offered for senior citizens.

Sustainable smart governance: In promoting digital transformation, Shanghai prioritizes green development and urban resilience building digital technology enhances urban energy efficiency and reduces carbon emissions, exemplified by smart energy management platforms achieving significant energy savings in certain public buildings and industrial sectors. The "Unified Governance through One Network" platform strengthens the capacity to perceive and prevent environmental and safety risks, enabling pre-emptive warnings. Digital means optimize transportation structure, promoting low-carbon travel, with a noted decrease in peak congestion index. Digital economic development follows sustainable principles, evolving toward green and low-carbon models.

(4) Achievements and Insights

In recent years, Shanghai has achieved notable results in urban digital transformation, continuously enhancing governance efficacy and comprehensive competitiveness. In governance, leveraging the "Unified Governance through One Network" platform, Shanghai has established an urban operational system of "three-level platforms, five-level applications," achieving comprehensive urban operation awareness, intelligent forecasting, and integrated resource coordination. Shanghai's City Operations Management Center has integrated 185 systems and 730 applications from 50 departments, forming a real-time, dynamic, and integrated platform for overall city operations management. Regarding public services, as of the end of 2023, the "One-Stop Government Services through One Network" main page provided access to 3,705 service items, of which 3,326 could be fully processed online, achieving an actual online processing rate of 82.9 percent and a satisfaction rate of 99.94 percent. Integration of services in the Yangtze River Delta region progressed smoothly, realizing mutual recognition of 40 types of electronic certificates and cross-provincial handling of 171 services, with 895 dedicated offline service windows established[119]. In the economic development sphere, Shanghai actively cultivates a highland for the digital economy. In 2023, the added value of the city's strategic emerging industries reached 1.169250 trillion yuan, a year-on-year increase of 6.9 percent, accounting for 24.8 percent of GDP. Digitalization is deepening toward intelligence, facilitating the vigorous rise of applications like "AI + Manufacturing." In 2025, Shanghai issued the "Implementation Plan for Accelerating the Development of 'AI + Manufacturing'[120]," launching the "Modeling Shanghai: AI + Manufacturing" initiative to promote deep integration of AI and manufacturing, empower new industrialization, and cultivate new quality productive forces.

Shanghai's digital transformation and intelligent development practices as a megacity comprehensively responds to SDG11 (Sustainable Cities and Communities), SDG9 (Industry, Innovation, and Infrastructure), SDG16 (Peace, Justice, and Strong Institutions), and SDG13 (Climate Action).

Key insights include: 1) Top-Level Design and Coordinated Advancement: formulating the "1+3+6" task and indicator system while planning concurrently for the economic, life, and governance fields; 2) Dual Approach of Data Empowerment and Rule-of-Law Security: effectively governing data resources with legislative support; 3) Adherence to the Principle of "a City Built by and for the People": with public satisfaction as the sole criterion; 4) Combination of Scenario Traction with Technological Innovation: prioritizing breakthroughs around high-frequency matters to form a virtuous cycle; 5) Fostering a Multi-Stakeholder Co-Governance Ecosystem: encouraging market entities, social organizations, and citizens to jointly participate in digital transformation, cultivating an open innovation environment.

4.1.3 Shenzhen: Intelligent Allocation of Urban Educational Resources

(1) Background and Challenges

Shenzhen, a high-density megacity, saw its school-age population surge by approximately 100 percent between 2010 and 2024, creating acute tensions between the supply of and demand for educational resources. The allocation of these resources faces three main challenges: 1) Space Allocation: A disconnect exists between the dynamic distribution of the population and the static layout of schools, leading to the coexistence of "over-subscribed schools" and "under-utilized facilities." 2) Data Resources: Critical data on land use, buildings, and stakeholders are scattered across different departments and updated asynchronously, hindering data-driven, precise decision-making. 3) Inter-Departmental Coordination: Lengthy cross-departmental processes struggle to respond quickly to the city's evolving educational needs. These challenges not only increase public service costs but also constrain educational equity and sustainable urban development. The core question became: how can City Intelligence technologies be leveraged to transform educational resources into shareable public goods, achieving "precise allocation and dynamic balance."

(2) Vision and Goals

Shenzhen is committed to building a "data-driven, people-centered" intelligent decision-making system for educational planning. Its overarching goal is to leverage the city's digital infrastructure to establish an AI-powered central platform. This will enable a closed-loop management process of "dynamic monitoring → planning optimization → targeted supply," ultimately enhancing the service level and scientific spatial planning of educational facilities. The aim is to enable Shenzhen to transform into a model city for public well-being.

(3) Strategies and Implementations

The project followed a strategy of "top-level design with layered implementation." First, the data foundation was strengthened by creating a high-precision, city-wide 3D model. Through a unified spatial coding system, multi-source data was integrated to establish a thematic database linking land, buildings, housing, people, and facilities, enabling precise management and cross-departmental sharing of key information. Second, systematic AI models specifically for compulsory education planning were developed. This process involved analytical models for forecasting and balancing student enrollment capacity, assessing service accessibility and coverage, and optimizing site selection for educational facilities to support resource allocation decisions. Third, an intelligent decision-making chain was established. Building upon a unified AI hub, traditional assessment models were transformed into AI agent, thereby creating a closed-loop, self-optimizing decision-making system. Integrated with the AI hub, the system provides proactive risk alerts and triggers coordinated actions across agencies, ensuring faster and more targeted planning decisions (Figure 4-2).

(4) Achievements and Insights

Shenzhen's intelligent educational resource allocation approach has significantly enhanced the scientific rigour and governance efficacy of education planning. By integrating a vast monitoring and assessment network — encompassing 794 standard urban units, nearly 3,000 schools, and approximately 21 million residents — the system provides a data-driven foundation for optimizing resource allocation, effectively alleviating imbalances in school place supply and demand. Planning efficiency has been revolutionized: with system assistance, over 500 projects have undergone review, reducing approval times from several days to mere hours and boosting processing efficiency by roughly 50 percent.

This approach directly addresses the challenges posed by a surging school-age population and aligns closely with key United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 10 (Reduced Inequalities).

The project is instructive in its governance model. Through two core innovations — "pan-domain, full-element data correlation" and a "hybrid AI model-driven intelligence hub" — it overcomes the data silos and coordination hurdles typical of traditional planning. This has propelled Shenzhen into a new era of planning characterized by data-driven decision-making and inclusive, participatory governance.

4.1.4 Guangzhou: Empowering Precise Urban Governance with AI

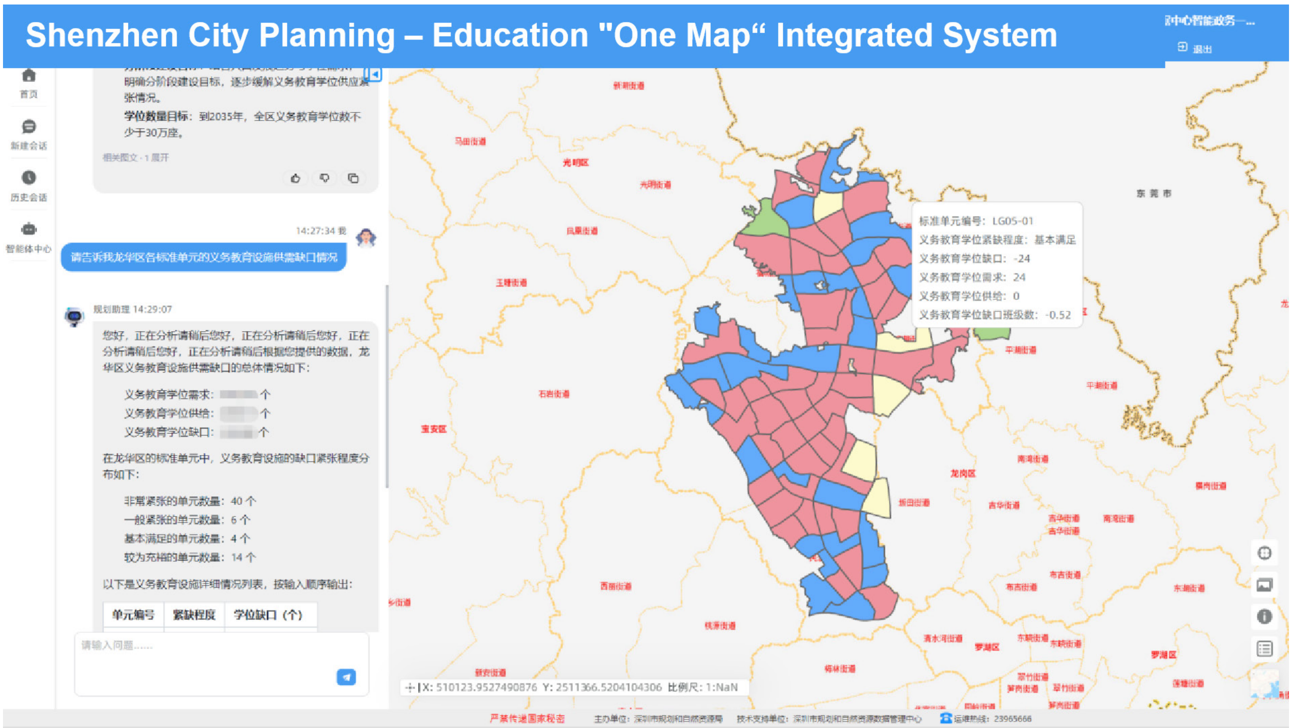


Figure 4–2: Macro–level monitoring and early warning for educational facility planning and layout

Source: Shenzhen Planning and Natural Resources Data Management Center

(1) Background and Challenges

As a high-density megacity, Guangzhou faces a universal challenge: the fragmentation and inefficient utilization of physical, data, and social governance resources. 1) Fragmented Physical Resources: Equipment such as drones is siloed across departments, resulting in a low-altitude airspace utilization rate below 40 percent and incurring annual waste due to redundant patrols. 2) Isolated Data Resources: Data remains compartmentalized with incompatible formats across departments, obstructing effective coordination. For instance, the lack of interoperability between environmental and urban management data significantly impedes efficient pollution source tracing. 3) Ineffective Coordination of Social resources: Governance primarily adopts a "reactive" stance. The absence of channels for public participation hinders the implementation of precise and timely interventions.

(2) Vision and Goals

To address these challenges, the Guangzhou Urban Planning and Design Survey Research Institute, guided by the vision of making urban governance resource utilization "more efficient, equitable, and sustainable," is developing an "integrated sky-to-ground" intelligent governance system. This aims to transform scattered resources into shareable public assets. The core goals, pursued through the "Guangzhou Eagle Eye" system, are: 1) Increase low-altitude resource utilization efficiency. 2) Enable citywide response capability for governance incidents. 3) Establish a cross-departmental data platform to improve decision-making efficiency. 4) Reduce urban operational costs and introduce interfaces for public participation, fostering a "government-led, socially co-governed" ecosystem.

(3) Strategies and Implementations

Implementation progresses in three phases: Phase One: Focus on building a unified platform and digital base. A centralized comprehensive drone service system will be established for unified scheduling of all equipment. A digital twin foundation, built upon a spatiotemporal GIS 3D engine, will provide a high-precision spatial framework (Figure 4-3). Phase Two: Involve algorithm development and scenario empowerment. A cross-scale intelligent recognition model library will be developed and packaged into "drag-and-drop" tools for grassroots use. Phase Three: Deepen collaboration and public engagement. Cross-departmental data-sharing mechanisms will be institutionalized, and public application interfaces will be opened. Citizens will be able to report issues via mobile devices, with AI-assisted automated task dispatch and resolution, forming a collaborative governance loop.

(4) Achievements and Insights

The "Guangzhou Eagle Eye" system has delivered significant results. 1) It established a highly responsive, comprehensive low-altitude sensing network capable of a rapid five-minute response to any target within its coverage area. 2) It markedly enhanced urban governance efficiency and safety, more than doubling operational efficiency compared to traditional inspection methods. 3) It catalyzed the development of the low-altitude economy, unlocking the potential of a future trillion-yuan-scale industry. This project aligns closely with several UN Sustainable Development Goals (SDGs) for 2030, including SDG 11 (Sustainable Cities and Communities), SDG 9 (Industry, Innovation, and Infrastructure), SDG 16 (Peace, Justice and Strong Institutions), and SDG 13 (Climate Action).

Its core value lies in reconceptualizing the governance of physical, data, and social resources through City Intelligence. No longer treating assets like drones or data as "departmental property," the system transforms them into inclusive governance elements. This practice demonstrates that the key to refined governance in high-density cities is "using intelligence to break down resource silos," thereby enabling synergies among decentralized assets. Drone fleets create a three-dimensional urban monitoring network, intelligent analytics convert disparate data into actionable insights, and multi-participant governance mobilizes broad public participation. This governance innovation allows Guangzhou to achieve simultaneous gains in efficiency, quality, and green development, offering valuable insights for the sustainable development of other cities.

4.1.5 Chengdu: Intelligent Traffic Management Around Hospitals

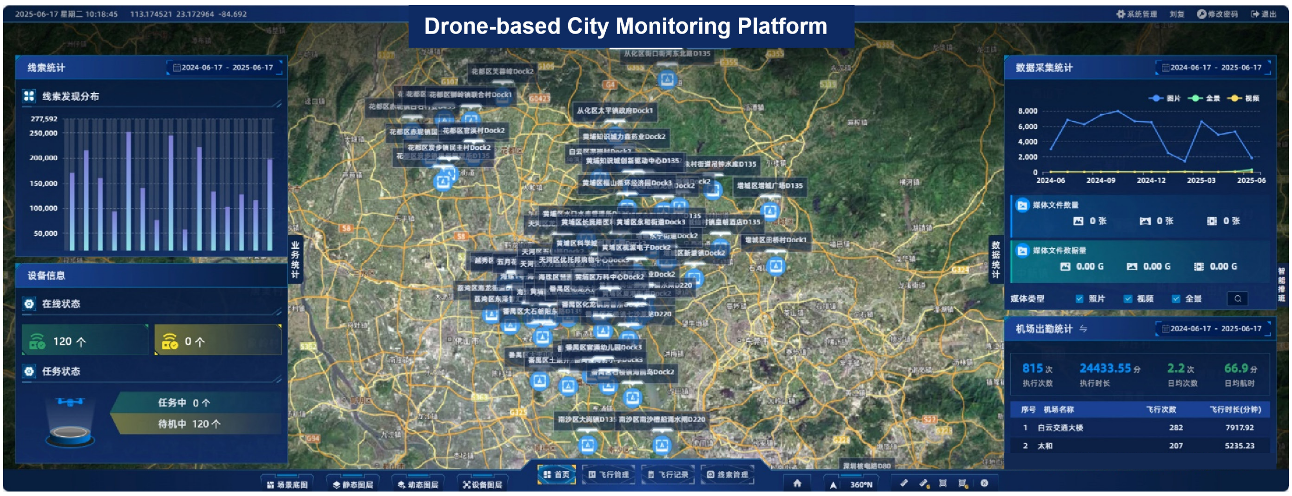


Figure 4–3: "Guangzhou Eagle Eye" intelligent drone dispatch and control platform

Source: Guangzhou Urban Planning and Design Survey Research Institute

(1) Background and Challenges

The area surrounding major urban hospitals such as Chengdu's West China Hospital, which handles nearly 20,000 daily outpatient and emergency visits, represents a microcosm of intensive resource utilization conflicts. The specific manifestations of its traffic congestion are: 1) The pedestrian-vehicle conflict is severe, and the mixed traffic flow at entrances and exits causes slow traffic flow and high accident risks during morning peak. 2) The parking space supply and demand is imbalanced, the severe shortage of parking spaces within the hospital leads to vehicle queues spilling onto adjacent roads, causing futile cruising and decreased traffic efficiency. 3) The non-motorized vehicle transportation is a mass, with over 7,000 shared bikes and electric vehicles for food delivery occupying traffic lanes daily, the pedestrian accessibility for patients is significantly influenced. 4) The traffic flows are not separated, various traffic streams converge at bottleneck sections, creating a dilemma of "single-point congestion, area-wide impact."

(2) Vision and Goals

The Traffic Management Bureau of the Chengdu Municipal Public Security Bureau aimed to resolve the congestion challenge through "resource optimization and holistic coordination" without large-scale engineering expansion. The core quantitative objectives were: First, reduce the area congestion index from 3.28 to below 2.5; Second, increase parking guidance accuracy, reducing unnecessary vehicle circulation; Third, reclaim pedestrian and cycling space, reduce non-motorized vehicle lane occupancy rates; Fourth, reduce pedestrian-vehicle conflict to mitigate delays caused by lane weaving; Through comprehensive governance, the goals included decreasing energy waste and pollution emissions, and promoting green transportation development.

(3) Strategies and Implementations

A comprehensive "Data-Driven + Functional Zoning + Intelligent Guidance" solution was implemented. 1) The Approach Began with Data-Supported Diagnosis: comprehensive data collection on traffic flow and queueing was used to precisely identify the root causes of congestion and traffic patterns. 2) Functional Reorganization and Zoning: the area was innovatively divided into a "Northern Zone (for outpatients and drop-off/pick-up)" and a "Southern Zone (for emergency/parking)" to achieve traffic separation. A "timed pedestrian street" was established at key bottleneck sections, effectively mitigating pedestrian-vehicle conflicts. 3) Intelligent Guidance and Traffic Dispersal: coordination with navigation and ride-hailing platforms directed vehicles to their designated zones based on appointment type, while dedicated drop-off/pick-up areas were delineated to standardize order.

(4) Achievements and Insights

The implementation of the West China Hospital regional traffic coordination and optimization plan has yielded significant results, fully demonstrating the value of "data-driven precise allocation + people-centred resource balancing": Firstly, traffic efficiency improved: The area's congestion index dropped by 25.6 percent, from 3.28 to 2.44, reducing the duration of morning rush hour congestion by approximately half an hour. Traffic flow speed on Di'anxin Road increased significantly. Secondly, emergency medical access became more efficient: The time required to transport patients to the hospital decreased by 10 to 20 minutes compared to before the implementation (Figure 4-4).

This successful case study aligns closely with several United Nations Sustainable Development Goals (SDGs), including: SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

The key insight is that a combination of data-led planning, staggered usage of road space by separating different travel demands, and

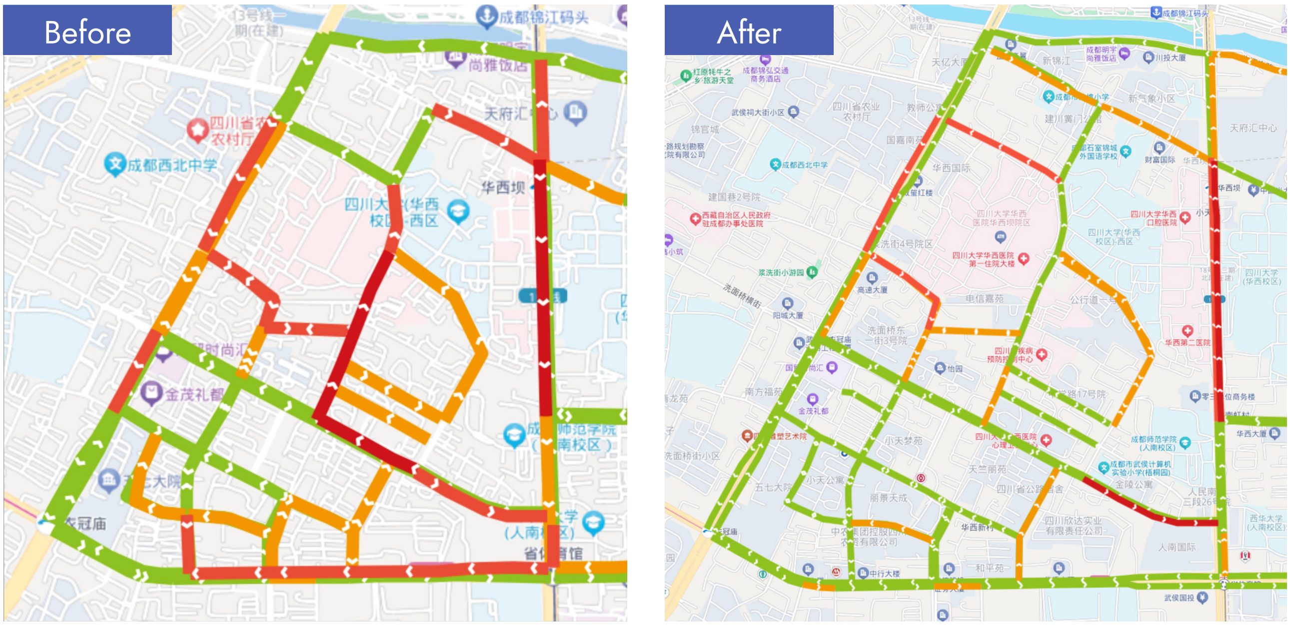


Figure 4–4: Traffic conditions before and after congestion mitigation around West China Hospital of Sichuan University in Chengdu

Source: Chengdu Municipal Public Security Bureau Traffic Management Bureau

multi-participant collaboration can establish a sustainable governance framework. The solution to traffic congestion in high-density public service hubs lies not in physical infrastructure expansion, but in the intelligent, fine-grained reorganization of limited spatial resources through City Intelligence.

4.1.6 Wuhan: Intelligent Solutions for City Planning

(1) Background and Challenges

Urban planning, as a knowledge-intensive domain, confronts distinct challenges in the new era. 1) There is a disconnect between decision-making and public needs, with an over-reliance on expert experience and a lack of real-time data insights, making timely responses to diverse citizen demands difficult. 2) Data fragmentation is a major obstacle, with siloed data across departments hindering collaborative governance and the equitable distribution of knowledge. 3) Barriers to public participation are high, as citizens face dual challenges of professional and digital literacy, complicating the effective implementation of the "city built by and for the people" principle. 4) Effective integration of General Artificial Intelligence remains problematic, as large models lack in-depth understanding of planning regulations, local culture, and people-centred, limiting their direct application outcomes.

(2) Vision and Goals

The Wuhan Planning & Design Institute proposed an innovative, AI-driven new system for urban planning to shift decision-making from "experience-driven" to "data-intelligence-driven and people-centred." The vision is to build a multi-modal AI-assisted decision-making platform centered on "DaPu," a foundational planning-specific model. This aims to transform traditional planning models, operationalize the principle of inclusivity by dismantling technical and knowledge barriers, and enable equitable participation in urban co-creation and governance. The goal is to establish a sustainable and replicable new planning paradigm, offering insights and solutions from China for cities worldwide, particularly in developing countries.

(3) Strategies and Implementations

Implementation follows a phased approach guided by the principle of "resource foundation building – scenario pilot – system integration – standard replication": Phase one establishing the Resource and Technology Base. Integrating over four decades of professional data builds a unified, systematically encoded "planning resource pool." Concurrently, the "DaPu" planning large model is developed (Figure 4-5), and a triadic integration framework linking semantics, spatiotemporal data, and technical specifications is established. A cross-departmental collaborative governance mechanism is also instituted in this phase. Phase two piloting High-Value Scenarios. Pilot projects in high-impact areas such as industrial planning, public participation, and public petition handling validate and demonstrate the efficacy of AI-enabled solutions, thereby laying the groundwork for broader application. Phase three achieving Full-Link "Data-Model-Service" Synergy. Efforts focus on creating seamless synergy across the entire data-to-service value chain and establishing a closed-loop system for optimizing resource efficiency. Phase four replicating the Model. Modularizing the proven technical architecture and governance mechanisms forms a standardized, replicable smart planning solution package for adoption by other cities.

(4) Achievements and Insights

The implementation has delivered significant results in three key areas: 1) It empowered the synergistic development of industry and urban space, providing planning and spatial configuration support for nearly a hundred industrial projects. This aided the government in optimizing industrial layout and making investment attraction decisions, promoting the integrated, symbiotic development of industry, urban space, and residents' lives. 2) It significantly enhanced

Figure 4–5: Exclusive AI model (DaPu) for Wuhan space and land planning

Source: Wuhan Planning and Design Institute (Wuhan Transportation Development Strategy Institute) governance efficiency and resource allocation, handling over 5,000 public petition cases annually. Human resource input was reduced from six staff members to one, with an 83 percent reduction, and the processing time per case was shortened by 30 to 60 seconds. Overall efficiency improved by approximately 90 percent compared to traditional methods, achieving a 99 percent timely response rate. 3) Innovative breakthrough, where the pioneering tri-partite fusion framework addresses the professional limitations of general-purpose AI models, enables mutual empowerment of social and technical resources through online learning, transforms professional tools into user-friendly natural-language applications, and shifts planning from "expert-only" to an "accessible-to-all." At its core, Wuhan's practice redefines planning logic through intelligence, balancing scientific rigor with people-centred care and aligning with the UN 2030 Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities), SDG 16 (Peace, Justice and Strong Institutions), and SDG 9 (Industry, Innovation and Infrastructure).

Key insights include prioritizing integrated data resources by establishing unified coding and sharing protocols; lowering participation barriers through inclusive design to unlock the value of resources; and focusing on institutional safeguards over technology, where effective cross-departmental collaboration requires clear accountability and "human-in-the-loop" oversight to prevent resource misallocation.

4.2 Scenario Cases

4.2.1 Efficient Integration of Urban Public Infrastructure Resources

(1) Background and Challenges

Cities worldwide face three core challenges in managing public infrastructure like communication base stations and public display terminals: Inefficient operations & maintenance: Reliance on traditional threshold-based alerts results in weak predictive capabilities. Reactive public service responses: Gaps in assistance for vulnerable groups create "blind spots" in coverage. Static resource allocation: Equipment runs on empirically set parameters, leaving multi-modal data underutilized. The root is the lack of an AI-driven closed loop of perception, analysis, and decision-making.

(2) Vision and Goals

BOE Technology Group Co., Ltd. (BOE) aims to build an "'efficient, resilient, and people-centred' City Intelligence sensing system." By leveraging device-edge-cloud synergy, it unifies governance infrastructure and data resources to achieve dual optimization in resource utilization and service responsiveness. Its core quantitative goals include reducing the rate of unexpected downtime for critical facilities and improving operational efficiency; shortening response times for assisting vulnerable groups; lowering equipment energy consumption through AI dynamic optimization; and enhancing the utilization efficiency of data resources and the integration rate of multi-modal data, thereby improving the accuracy of AI models in identifying abnormal activities.

(3) Strategies and Implementations

Implementation followed three phases: Phase one established the data resource foundation through deploying AI-Ready sensors to collect multi-modal data, building an integrated database linking "device-environment-space" relationships, and gathering the foundational data of metrics for optimization; Phase two conducted scenario-based pilots, including validating the predictive maintenance model on communication base stations and employing remote sensing intelligence for anomaly detection in public spaces — subsequently triggering alerts to rescue services — thereby testing both technical efficacy and people-centred value. Phase three constructed an "edge-cloud collaborative" intelligent system by enhancing edge computing capabilities, deploying a cloud AI platform integrating various analytical engines, and ultimately achieving cross-scenario synergy (e.g., linking base station failure warnings with public information dissemination) (Figure 4-6).

(4) Achievements and Insights

Key results include: 1) Enhanced Infrastructure Efficiency: Unexpected downtime at communication base stations was magnificently decreased, and dynamic parameter adjustment reduced the average energy consumption of public terminals; 2) A Qualitative Leap in Public Service Responsiveness: In cities such as São Paulo, Brazil, and Suzhou, China, the system has significantly shortened emergency response times and achieved high accuracy in AI-powered activity detection. 3) Full Realization of Data Value: It has enhanced the utilization rate of multi-modal data fusion and improved the accuracy of fault prediction, creating a "smarter-by-use" data ecosystem. The core innovations lie in the technological and the approach-oriented dimensions: Technologically, the "edge preprocessing + cloud deep analysis" collaborative architecture reduces cloud workload, while specially trained industrial-grade remote sensing models enhance control precision; Methodologically, humanistic concerns (e.g., aiding vulnerable groups) are systematically integrated into the intelligent sensing framework, achieving synergy between "efficiency and empathy."

This "AI + Remote Sensing" practice not only strengthens infrastructure resilience but also aligns profoundly with the UN 2030 Sustainable Development Goals, including SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 10 (Reduced Inequalities).

The key insight lies in redefining resource governance logic — using intelligence to break down data silos, collaboratively optimize resource allocation, and achieve a unified advancement of technological performance and social well-being.

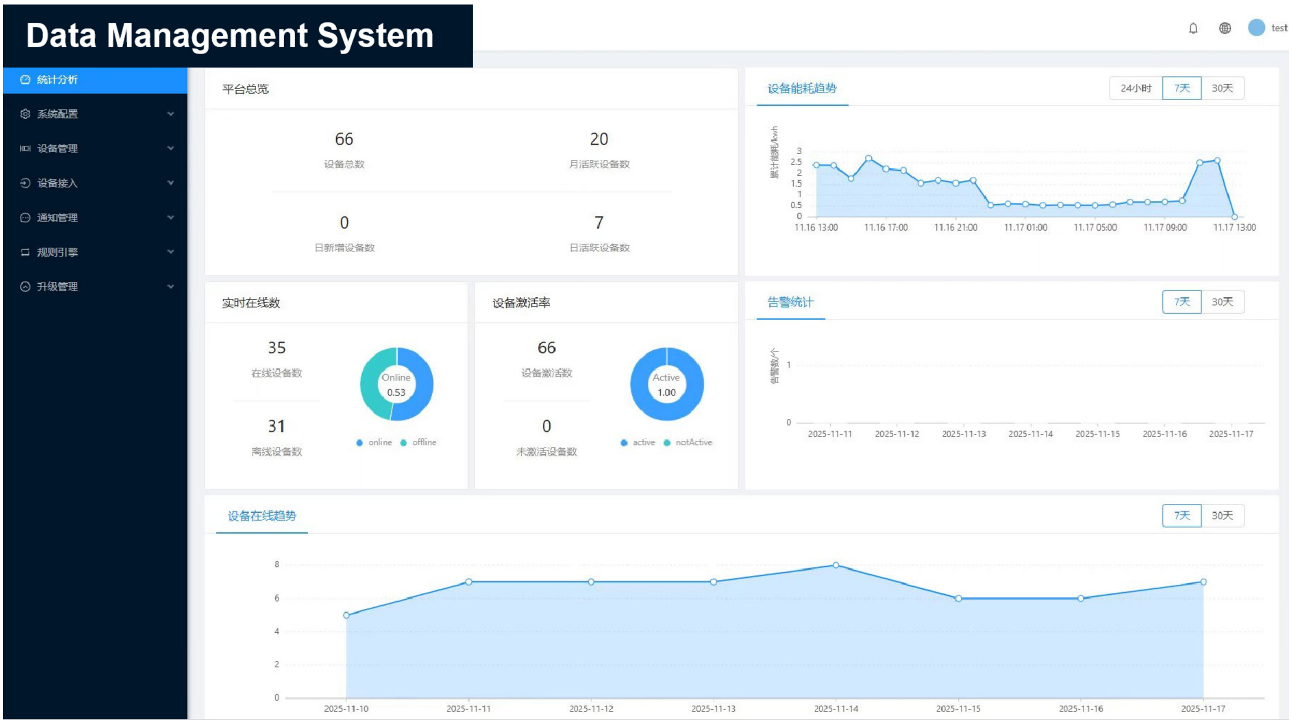


Figure 4–6: Data management platform of BOE intelligent city observation solution

Source: BOE Technology Group Co., Ltd.

4.2.2 Intelligent Management of Urban Solid Waste

(1) Background and Challenges

Solid waste incineration is a core method for achieving urban waste reduction, resource recovery, and harmless treatment, and its resource utilization efficiency directly impacts urban governance costs and the achievement of "dual-carbon" goals (carbon peak and carbon neutrality). Currently, China's waste-to-energy industry faces three major challenges: 1) Dormant data and reliance on experience, where vast amounts of real-time operational data remain unintegrated and underutilized, combustion control heavily depends on manual expertise, resulting in significant fluctuations in main steam flow and low energy conversion efficiency; 2) High resource consumption and environmental pressure, driven by complex waste composition and long process delays, along with traditional control methods, leading to high consumption of environmental reagents (e.g., for de-acidification and de-nitrification) and low electricity generation per ton of waste; and 3) High manual operation intensity, characterized by operators performing over 1,300 adjustments daily and expending energy on repetitive tasks, thereby leaving limited capacity for safety oversight and rapid response to anomalies.

(2) Vision and Goals

Beijing Chaoyang Environment Group Co., Ltd. aims to drive full-chain intelligent waste incineration through AI, shifting the industry from "experience-dependent" to "intelligence-driven," with specific goals including developing an intelligent incineration system suitable for waste with complex composition and high moisture content; reducing the consumption of desulfurization and denitrification consumables by over 3 percent; decreasing main steam volatility by more than 10 percent; and achieving an automatic operation rate exceeding 90 percent.

(3) Strategies and Implementations

The initiative was systematically advanced in four phases: Phase one built the data resource pool by collecting data from combustion and environmental protection systems along with flame video footage using standard protocols, establishing a unified data pool after cleaning and correlation to lay the analytical foundation; Phase two developed core engines by overcoming key bottlenecks with industrial-scale computer vision models that convert flame video into quantitative metrics, effectively replacing manual observation; Phase three conducted single-plant pilot validation, testing and validating the intelligent perception, prediction, and control engines in a real-world operational setting, which optimized system performance and significantly reduced reliance on manual intervention; and Phase four enabled standardized replication through rolling out the mature system across the corporate group, crucially codifying tacit "master-operator expertise" into a structured knowledge base to create a replicable package of technical and managerial solutions for broader industry adoption (Figure 4-7).

(4) Achievements and Insights

The project has delivered significant results across three key areas: 1) Improved Resource Efficiency: the main steam flow stability increased by over 36 percent, electricity generated per ton of waste rose by over 2.4 percent, an additional approximately 6 million kWh of green electricity was generated annually, the per-unit consumption of desulfurization and denitrification consumables decreased by over 3 percent, thereby achieving synergistic "pollution reduction and carbon mitigation"; 2) Optimized Human Resources: the automatic operation rate exceeded 98 percent, daily manual adjustments decreased by 86 percent, enabling staff to focus on higher-value inspection and decision-making tasks.

The core innovation encompasses both technological and model dimensions: technologically, it pioneers a computer vision AI foundation model and a multivariate predictive engine specifically designed for incineration scenarios; in terms of model innovation, it establishes an "operational experience digitalization" mechanism that codifies expert operators' tacit knowledge into a reusable knowledge base, thereby solving the industry's knowledge transfer challenge. This practice strongly supports the waste management principles of reduction, resource recovery, and harmless treatment, and its achievements align closely with several UN 2030 Sustainable Development Goals, including SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

The key insight is that data serves as the "core fuel," while intelligent technologies must be "deeply tailored to industrial contexts," with model innovation being as crucial as technological innovation; ultimately, the deep integration of AI with industrial operations represents the essential pathway to overcoming traditional sectors' resource efficiency bottlenecks and achieving a dual win for both economic and environmental performance.

4.2.3 Direct Access to Inclusive Green Finance Through Intelligence

(1) Background and Challenges

Taizhou City, a pilot zone for small and micro enterprises financial reform, faces three core dilemmas in promoting inclusive green finance: 1) Difficulty in identifying green credit, as small and micro enterprises use loans for diverse purposes, making it hard for traditional manual reviews to accurately determine their "green" status, resulting in high identification costs and resource misallocation; 2) Difficulty in assessing small and micro enterprises' green performance, due to their small scale and fragmented data, coupled with a lack of unified evaluation standards, which prevents financial institutions

Figure 4–7: Chaoyang Environmental Group's AI-powered intelligent incineration monitoring system

Source: Beijing Chaoyang Environmental Group Co., Ltd.

from precisely assessing their green credentials; Consequently, most of the finance were distributed to large enterprises and few green credit were acquired by small and micro enterprises; and 3) Difficulty in sharing green information, where relevant data is scattered across over 30 sectors without effective sharing mechanisms.

(2) Vision and Goals

Beijing Trans FinTech Ltd. and the People's Bank of China Taizhou Branch aim to build an intelligent-driven service system for "identifying, assessing, and sharing green information." The goal is to break down data silos and optimize financial resource allocation. Specific targets include: reducing green credit identification time and increasing accuracy; increasing the share of inclusive green loans to small and micro enterprises and improving cross-departmental green information sharing.

(3) Strategies and Implementations

Implementation was structured in four phases: Phase one built the data foundation by establishing the "Taizhou Inclusive Green Finance Data Middle Platform" to tackle information asymmetry, aggregating over 400 million data points from 30+ departments, applying privacy-preserving computation to create a "green information database for enterprise," and developing basic "green identification" and "green assessment" modules; Phase two piloted in local industries by focusing on Taizhou's characteristic sectors such as mold manufacturing and auto parts, developing industry-specific keyword libraries, refining green evaluation models, and creating transition-finance catalogs for key industries like pump manufacturing; Phase three constructed the end-to-end "Green Access for Small and Micro Enterprises" Platform by integrating all functionalities and opening interfaces to financial institutions and government, thereby significantly boosting service efficiency; and Phase four standardized and replicated the model by formalizing the practice into provincial-level standards and exporting the replicable service model to other cities (Figure 4-8).

(4) Achievements and Insights

Key results include: 1) Optimizing financial resource allocation by facilitating the identification of 77,000 green loans worth over 260 billion yuan, which raised the share of inclusive green loans to small and micro enterprises above 8 percent; 2) Catalyzing a green transition by completing green performance assessments for 14,600 small and micro enterprises, certifying over 35 percent as green entities eligible for credit support; 3) Effectively utilizing data value through enhanced cross-departmental information sharing, which transformed raw data into actionable "green credit profiles" for businesses.

The core innovations of this practice lie in the following fields: in terms of model, it pioneered an end-to-end digital financial services closed loop; technologically, it applied AI and privacy-preserving computation to resolve the tension between data security and utilization; and with regard to standardization, it developed the "Inclusive Green Credit Support Catalog," thereby filling an industry gap. This practice aligns deeply with the UN 2030 Sustainable Development Goals, particularly SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 10 (Reduced Inequalities), and SDG 13 (Climate Action).

The key insight is that promoting the integrated development of inclusive finance and green finance depends on establishing secure and reliable data sharing, developing practical, scenario-driven AI technologies, and building a standardized, replicable framework.

4.2.4 Circular Regeneration of Urban Biomass Resources

(1) Background and Challenges

With rapid urbanization, China generates over

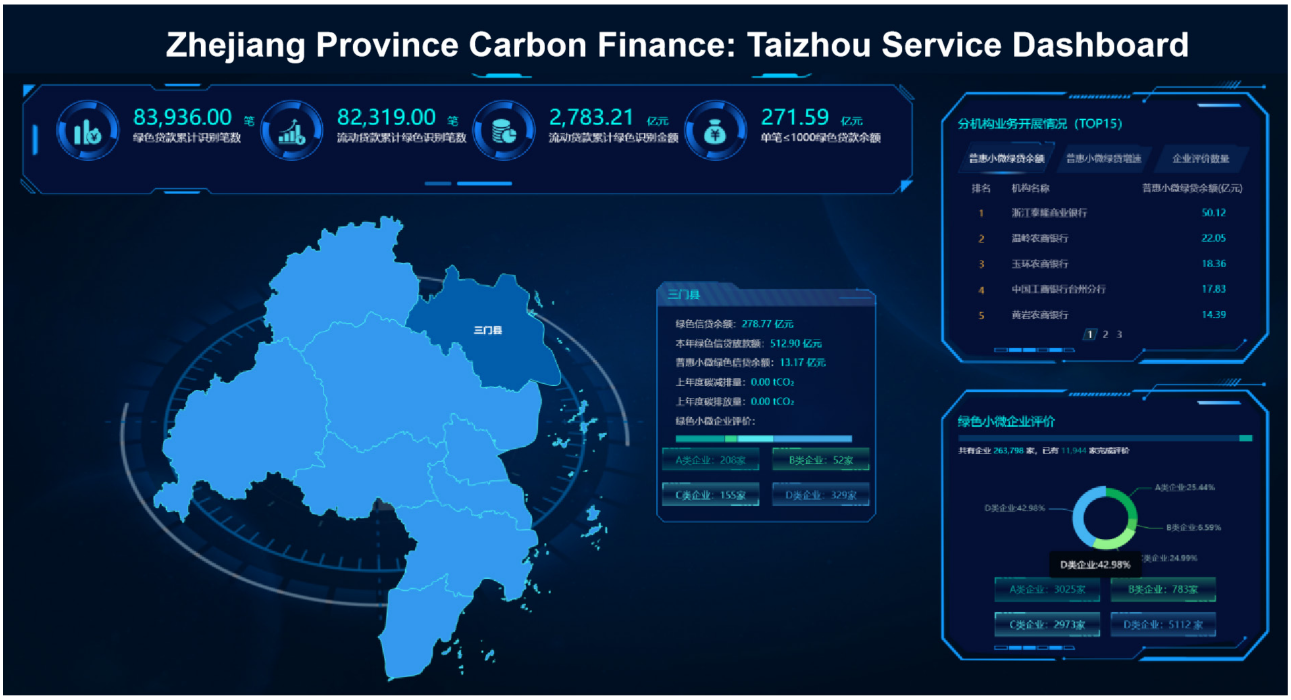


Figure 4–8: "Green Access for Small and Micro Enterprises" digital dashboard at the People's Bank of China Taizhou Branch

Source: Beijing Trans FinTech Ltd. and People's Bank of China Taizhou Branch

ten billion tons of biomass waste annually. For megacities, traditional methods of landfilling and incineration prove inadequate, as their inefficiency leads to wasted land resources and ongoing pollution. Crucially, they fail to establish resource circularity, leading to waste, subsidy dependency, and unsustainability. As a pilot "zero-waste city," Shenzhen urgently needed intelligent solutions to build a circular bio-economy.

(2) Vision and Goals

Inspro Science Ltd. focuses on "empowering insect-based bioconversion with AI," aiming to shift urban waste management from "end-of-pipe treatment" to "source reduction and high-value utilization." Specific goals include: achieving an annual increase of over 15 percent in the comprehensive high-value utilization rate of urban biomass waste; through AI intelligent control, enhancing black soldier fly bioconversion efficiency by 30 percent and reducing operational costs by 20 percent; and establishing a replicable "AI + insect bioconversion" model for biomass waste treatment along with its commercialization pathway, thereby supporting the city's low-carbon transition and integration into a circular bioeconomy.

(3) Strategies and Implementations

Implementation followed three phases: Phase 1: The data foundation was established by collecting waste and black soldier fly growth data from multiple cities to build a feature library and training dataset, thereby laying the groundwork for intelligent control; Phase 2: Technology development achieved breakthroughs in three core areas, namely an AI-based environmental control system, a growth monitoring system, and a digital twin platform for process optimization; and Phase 3: Scenario pilots were conducted in Xiegang Town, Dongguan City (semi-automatic) and Yantian District, Shenzhen City (fully automatic) to quantitatively validate technological effectiveness, resource efficiency gains, and business model feasibility (Figure 4-9).

(4) Achievements and Insights

The initiative achieved a multi-faceted breakthrough in environmental, economic, and social benefits: 1) It completed the construction and successful operation of two pilot projects, thereby gradually advancing the transformation of urban biomass waste treatment from "incineration/landfilling" toward "high-value utilization," fostering public consensus on low-carbon environmental practices. 2) A government-enterprise data-sharing mechanism enhanced the transparency of environmental governance, increasing public participation in waste sorting by 25 percent. 3) Resource efficiency saw marked improvement, achieving an annual increase of over 15 percent in the comprehensive high-value utilization rate of urban biomass waste. Fourth, it established a model for cross-sector "AI + Environmental Protection" collaboration, attracting five research institutions to join the technology development and contributing to the formulation of two international standards.

Core innovations encompass three key dimensions. Technologically, replacing traditional experience-based methods with AI-driven environmental control and digital twins has enhanced process precision. In terms of model, establishing the sustainable "government guidance + corporate operation + market feedback" framework has fostered a viable business ecosystem. In terms of governance, creating a data platform enables collaborative oversight among government, enterprises, and the public.

By converting waste into high-value resources, this practice fundamentally redefines waste as a resource and presents a new paradigm for building "zero-waste cities," aligning deeply with the UN 2030 Sustainable Development Goals, specifically SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 2 (Zero Hunger).

Figure 4–9: Digital twin systems for resource utilization of organic solid residues at Shenzhen Yantian Ecological Zone

Source: Inspro Science Ltd.

The key insight is that managing urban biomass waste depends on "activating resource value through intelligent technology," which unifies environmental and economic benefits to transform "waste" into genuine "wealth."

4.2.5 "5G + AI" Empowering Urban Events and Traffic Governance

(1) Background and Challenges

As cities pursue high-quality development, public expectations for safe, convenient, and more thoughtful services are rising. Traditional governance models struggle to balance efficiency and user experience in complex public scenarios like major sporting events and daily mobility. They often lack tailored support for women, senior citizens, and people with disabilities, and their reliance on intensive human and material resources is unsustainable.

(2) Vision and Goals

The 2025 Shanghai Suzhou Creek Half Marathon showcased the pivotal role of the Haina Town Smart Traffic System in Putuo District, Shanghai City. China Mobile Communications Group Co., Ltd. (Shanghai) leveraged integrated "5G-A + AI" innovations to help upgrade event management and urban services from "organizational coordination" to "intelligent, citywide governance," aiming to use technology to enhance the inclusivity, accessibility, and people-centered quality of city services.

(3) Strategies and Implementations

To achieve the above vision, the project adopted an integrated implementation pathway comprising four interconnected dimensions: "policy guidance, platform support, scenario-driven application, and ecosystem collaboration." 1) Policy Guidance: Building upon the overarching digital-transformation frameworks established by the Shanghai Municipal Government and Putuo District Government, the project designated key pilot zones along the Suzhou Creek corridor and within Haina Town as primary testbeds for innovation. 2) Platform Support: Led by China Mobile, a unified data middleware platform and an AI decision-making engine were constructed. This integrated technological capabilities including 5G-Advanced (5G-A) networks, digital twin systems, and large-language-model algorithms, forming a reusable and scalable technical foundation. 3) Scenario-Driven Application: Focusing on two highly complex and socially significant domains — marathon events and multi-dimensional traffic management — the project developed flagship demonstration applications for "Smart Sports" and "Intelligent Connected Mobility." This approach enabled a leap from isolated technological breakthroughs to systemic integration. 4) Ecosystem Collaboration: A multi-stakeholder coordination mechanism involving "government, enterprises, and the community" was established to break down data and service silos. Throughout the implementation, a user-centric design philosophy was paramount. The project embedded features such as multilingual interaction interfaces, female-specific services, and accessibility guidance functions. This ensured that technology was leveraged to genuinely serve and empower "people", rather than merely aiming to replace "human" roles.

(4) Achievements and Insights

The project achieved significant results across two scenarios: at the Suzhou Creek Half Marathon, the event completion rate reached 99.55 percent, the AI system automatically generated 4,329 personalized race recap videos with 69.2 percent actively downloaded by runners, and livestream views exceeded 500,000; while in Hainan Town, the 3D intelligent traffic system reduced the peak-hour congestion delay index by 15 percent, decreased average walking commute time from 11 minutes to 7 minutes (a 36 percent reduction), and achieved a 93 percent success rate with AI route guidance, effectively alleviating spatial mismatches in the high-density urban area. This initiative closely aligns with

UN Sustainable Development Goals, including SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 10 (Reduced Inequalities), and SDG 16 (Peace, Justice and Strong Institutions), offering a replicable model for intelligent large-event management and inclusive urban services.

Key insights include: 1) Technology must serve real-world needs; 2) City Intelligence requires a long-term, platform-based, standardized, and iterative mechanism, as exemplified by the development of two exportable capabilities: an "AI Engine for Events" and a "Traffic Coordination Model;" 3) Public engagement is crucial for successful implementation, demonstrated by initiatives like "Digital Experience Camps" and "AI Interaction Workshops" that lowered barriers to use, boosted public acceptance and participation, and laid a social foundation for broader future adoption.

4.2.6 Optimized Integration of Innovation Resources in a Featured Town

(1) Background and Challenges

As one of Zhejiang Province's first "Featured Towns," Hangzhou Yun Qi Town faced four core challenges during its transition from a traditional industrial zone to a regional innovation hub. 1) Fragmented Innovation Resources: Critical assets such as high-performance computing power and specialized scientific instruments were often monopolized by a few entities, limiting accessibility for small and medium-sized enterprises. This led to underutilized public assets and redundant private investments. 2) Lack of Coordination Mechanisms: Industry, academia, government, and capital operated without a unified collaborative platform, resulting in inefficient resource allocation and weakened collective innovation momentum. 3) Mismatched Living Resources: Initial planning was overly "production-oriented," lacking appealing living and cultural spaces for young talent, which hampered attraction and retention. 4) Mounting Sustainability Pressures: Soaring energy consumption from growing computing and data demands posed a serious challenge to the campus's energy efficiency and low-carbon development.

(2) Vision and Goals

To address these issues, Yun Qi Town established a vision for digital-intelligent transformation centered on "resource sharing, efficient collaboration, low-carbon friendliness, and talent livability," and set four quantifiable goals. 1) Build a large-equipment sharing platform to lower innovation costs for enterprises. 2) Create the "Xi Xiaofu" smart government service system to provide precise profiles for 176,000 business entities and delivers 24/7 intelligent services. 3) Build a tech-youth-friendly community to attract over 100,000 global innovators annually to participate in various innovation activities, fostering a sustainable talent ecosystem. 4) Implement intelligent energy management to achieve average campus energy savings of at least 15 percent, with key enterprises reducing carbon emissions by over 100 tons annually.

(3) Strategies and Implementations

The town adopted a phased transformation strategy based on a digital technology platform, emphasizing three key points: 1) Establishing mechanisms for equipment and data sharing to create a public innovation resource pool; 2) Designing people-centred soft environments through space renovation and service enhancement to retain talent; 3) Introducing AI for energy optimization while employing institutional tools (such as low-carbon accounts) to guide sustainable behavior.

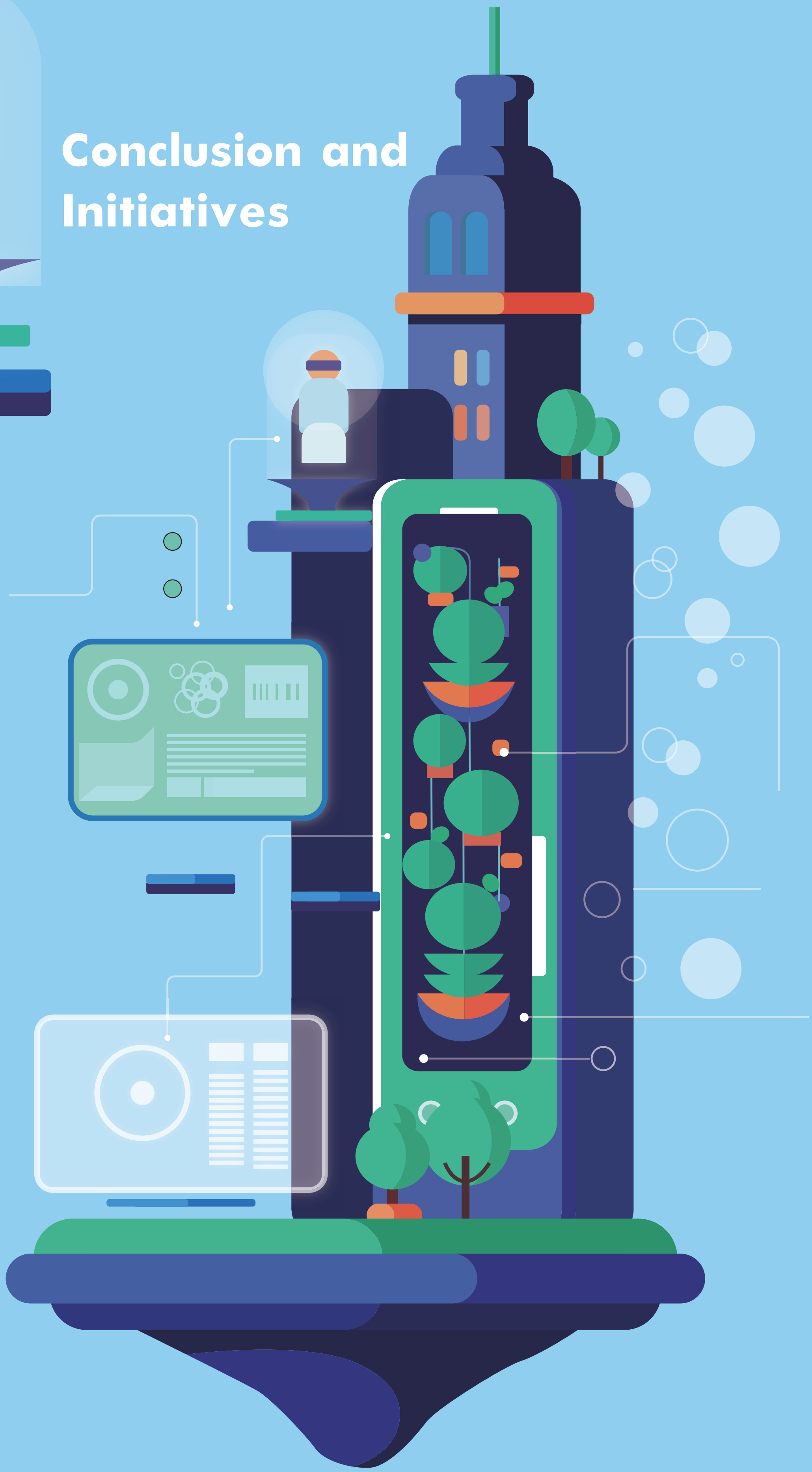
(4) Achievements and Insights

The transformation has delivered results across three dimensions: First, resource efficiency has been enhanced through platforms such as the "Xi Xiaofu" intelligent government system, which connects 176,000 market entities and provides round-the-clock services, alongside a shared large-scale equipment platform hosting 1,956 devices, collectively lowering corporate R&D thresholds by approximately 40 percent; Second, talent and industrial clustering have been strengthened, with annual events like the Yun Qi Conference attracting over 100,000 innovators, the town incubating more than 1,000 technology firms including 12 unicorn companies and 23 listed companies; Third, progress on green development is evident as the campus achieves average energy savings exceeding 15 percent after the transformation, while certain key enterprises reduce annual carbon emissions by over 100 tons.

The core value of Yun Qi Town's digital-intelligent transformation lies in redefining the synergy between resources, innovation, and livability, thereby converting resources into inclusive public assets that generate multiple benefits. This aligns closely with the UN Sustainable Development Goals, including SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

The town provides a systematic, three-pronged model — encompassing resource sharing, institutional innovation, and a people-centered approach — for the digital-intelligent transformation of industrial zones. It offers a key insight: while integrating resource pools is a prerequisite and institutional coordination is as vital as technology, the ultimate goal of optimizing resource efficiency is to serve people by harmonizing industrial demands with lifestyle needs.

05 Conclusion and Initiatives



Chapter 5 Conclusion and Initiatives

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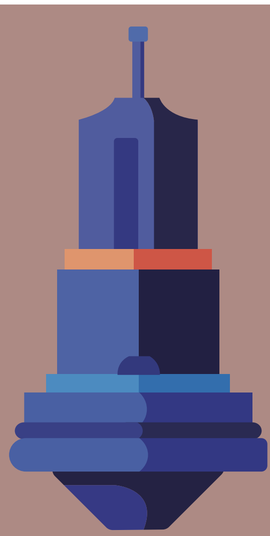
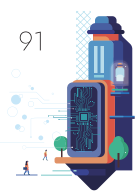


To advance the shared goal of sustainable urban development, this report adopts the "resource-efficient city" as its central theme, systematically explaining how cities can achieve high-quality development within finite resource constraints and proposing a new paradigm driven by City Intelligence. China's City Brain initiatives exemplify pioneering practices for the global development of City Intelligence, with their framework constructed upon four core principles: people-centricity, systems thinking, resource efficiency, and sustainability. This vision is realized through the deep integration of data, models, and computing power — a trinity that enables City Intelligence to render resources computable, collaboration feasible, and utilization sustainable. Specific practices such as achieving "faster traffic flow without traffic restrictions" and "greater transport efficiency without road expansion" have demonstrated the possibility of "supporting sustainable urban development with only 10 percent of current urban resources."

This chapter proposes the initiatives for urban builders and Global initiative and actions for "AI + City." Individuals and grassroots social organizations shall actively participate in developing and upgrading people-centred City Intelligence. Industry and academia shall collaborate on the research and development to promote public smart solutions for City Intelligence. Urban leaders and developers shall focus on problem-oriented, scenario-based good governance through City Intelligence. National and local governments shall systematically advance the development of intelligent infrastructure and establish supportive institutional frameworks. Resource-efficient cities shall be built to create a better life with fewer resources. AI shall be leveraged to comprehensively support the development of resource-efficient cities. City Intelligence construction shall be advanced to promote "AI + City" through a holistic approach. A people-centred philosophy shall be upheld to foster scenarios of good governance. A global network of intelligent cities shall be established to share urban governance experience. An open-source ecosystem for City Intelligence shall be cultivated to broaden access to AI advancements.



5.1 AI-Driven Sustainable Urban Development

To achieve the common goal of "sustainable urban development," within the transformative framework of the "City Brain" paradigm, this report centers on the concept of the "resource-efficient city." It systematically explains how cities can achieve high-quality development within finite resource constraints and proposes City Intelligence as a core driving force for a new development paradigm.

The unsustainability of current urban models stems first from a dual constraint: the absolute limits of physical resources and the structural inefficiency of their use at the systemic level. The path of urban development trading high consumption for convenience and high emissions for prosperity has stalled — or even reversed — progress toward many global sustainability targets. Yet, cities are not just the locus of these problems; they are also the source of solutions. They concentrate over half the world's population, energy use, and carbon emissions as well as the most advanced technology, capital, and governance capacity. To address unsustainability at its core, the essential shift is from scaling up resources to making the most of what we have, and from adding more inputs to working smarter with less. Looking forward, global urban development must advance well-being and opportunity while taking responsibility for climate, health, and equity. The principles of people-centered approaches and the direction of resource efficiency, green and low-carbon development, and inclusive resilience are becoming a shared value consensus across cultures and political systems.

The core proposition of this report is "substituting new physical resource inputs with urban data and governance optimization," so that the efficient flow of data supports the conservation of material flows. During this transition, City Intelligence becomes the crucial technological lever and the engine for a holistic urban transformation encompassing politics, economy, and culture. Traditional "smart city" practices often remained at the level of technology stacking and siloed sectors, failing to yield systemic benefits. The City Brain concept, in contrast, redefines urban development and governance from a holistic and people-centered perspective. City Intelligence technology framework views the city as a "system of systems." Furthermore, it integrates human expertise with data, AI models, and computing power to create a closed loop of perception, analysis, and decision-making. This approach makes the seemingly impossible achievable: easing traffic without new roads, securing water without new sources, and cutting energy use without added hardware. At its essence, this is an attempt to trade data for resources, replace redundancy with algorithms, and optimize structures with intelligence, aiming to catalyze a fundamental paradigm shift in urban development and human progress.

As AI advances globally, conditions for implementing City Intelligence are now maturing. First of all, open data systems in major cities have strengthened, with remote sensing and IoT enabling a holistic urban view. Following this, open-source AI foundation models and accessible research ecosystems have significantly lowered the development barrier. Together, these provide cities a low-cost, high-value, and widely accessible foundation to build upon. China's "City Brain" initiatives offer pioneering examples for global City Intelligence. Their defining features include a people-centered approach, holistic coordination, resource conservation, and the parallel pursuit of institutional reform and technological innovation.

Looking ahead, a city's competitiveness may no longer hinge on the scale of its physical expansion, but on its ability to render urban resources computable, collaborative, and reusable through intelligence. In terms of capability, city-specific AI foundation models will become universal intelligent components. When combined with local, high-quality data and computing platforms, they will form intelligence engines capable of generating optimal, on-demand solutions. In terms of equity, open data and open-source models will enable small and medium-sized cities to make decisions on a level playing field, bridging the gap between low cost and high intelligence. In terms of governance, cities will evolve from "application-driven" models to "scenario-to-panorama" systemic governance. This approach will treat human experience and resource efficiency as equally critical metrics, institutionalizing and replicating successful pilot outcomes.

As demonstrated by China's experience, when data flow, model evolution, and organizational collaboration enter a dynamic, reinforcing cycle, the goal of "achieving high-quality and sustainable urban development with only 10 percent of current urban resources" shifts from a hypothetical question to a tangible, continuous, approachable pathway defined by both technology and governance. Guided by the vision of a shared future for humanity, City Intelligence will carry the promise of propelling global cities toward a common future characterized by low consumption, high well-being, and strong resilience.

Less is more for better life.

5.2 Recommendations for City Contributors

Developing City Intelligence is not a singular technical project, but a societal transformation that requires the broad participation of diverse participants. To advance a shared, sustainable urban future through City Intelligence, we propose individual citizens, social organizations, the private sector, governments, academia, and national policymakers to act together according to their respective capacities and responsibilities (Figure 5-1).

Individuals and Organizations

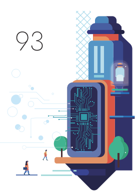
Co-create People-centred City Intelligence

City Intelligence begins where people gather: individuals and organizations generate the highest-quality data, while communities and public spaces form its essential workshops. Its development must be a collaborative exploration, shaped by the diverse participants within each scenario — community groups, nonprofits, schools, small and medium-sized enterprises — rather than a single authority. We advocate co-creation and participatory design, placing residents and grassroots organizations at the heart of scenario design. The process should start from real-life needs and grounded solutions, driving continuous refinement of the technologies and models that support it.

Industry and Academia

Collaborate on City Intelligence as a Public Good

Given the strong nature of City Intelligence as public goods, we call on industry to embed ethical principles — such as fairness, transparency, and explainability — throughout the entire lifecycle of product development and operation. This includes proactively conducting algorithmic impact assessments and accepting societal oversight. Academia should strengthen interdisciplinary research in AI, technology ethics, urban science, and public policy to provide the theoretical foundation and talent pipeline for the responsible development of City Intelligence. We particularly call on industry-academia collaboration to tackle critical technologies and develop replicable solutions. Efforts should focus on breakthroughs in key areas like City Intelligence models, privacy-preserving data fusion, and edge computing, while defining ethically and socially beneficial application pathways. Furthermore, there is a shared responsibility to develop



modular, standardized, and low-cost intelligent solutions. This will lower the adoption barrier for small-and medium-sized cities, especially in developing countries, promoting inclusive development on a global scale.

City Operators and Builders

Advance Scenario-based Solutions for Good Governance

The key to building City Intelligence lies in consistently focusing on solving concrete urban sustainability challenges and avoiding the pitfall of "technology for technology's sake." We therefore call on urban leaders and developers to adhere to a "problem-oriented, scenario-driven" approach, which entails prioritizing the development of solutions for scenarios where public impact and social benefits are most tangible, proactively establishing partnerships with technology firms and research institutions to align technology and policy around specific problems and scenarios, and engaging the public in the iterative development of City Intelligence through consultations and feedback mechanisms, so as to ensure that the benefits of intelligent development reach all residents, with special attention paid to vulnerable groups.

National and Local Governments

Establish Infrastructure and Institutional Frameworks

A critical enabler for City Intelligence is the establishment of a national-level strategy and roadmap that defines the vision, priority areas, and phased objectives, while in parallel, local governments must craft their own localized implementation plans to account for specific resources and challenges. We advocate that both national and local governments increase investment in public data openness and supporting infrastructure while safeguarding security and privacy, which involves systematically opening and sharing government data to unlock its public value. Furthermore, City Intelligence should be recognized and planned as a new type of essential public infrastructure, requiring forward-looking investment and integrated planning. In addition, we urge governments at all levels to enact timely legislation and policies for City Intelligence, which should balance innovation with risk mitigation by clearly defining operational boundaries and "red lines." To foster responsible innovation, we recommend mechanisms such as regulatory sandboxes and dedicated innovation funds, as these allow for testing new technologies and models in controlled, real-world environments before wider deployment.

5.3 "AI + City" Global Collaboration Initiatives

Against a backdrop of global climate change, intensifying resource constraints, and unprecedented urban complexity, cities have become crucial participants in achieving the UN 2030 Agenda for Sustainable Development. The new wave of technological revolution, led by AI, is reshaping how cities operate, allocate resources, and are governed. "AI + City" is more than just applying smart technologies in urban settings. It represents a new paradigm of urban civilization — one that achieves higher-quality development with fewer resources. To this end, we sincerely propose this global collaboration initiative for "AI + City" (Figure 5-1) to foster an open, shared, collaborative, and secure ecosystem for City Intelligence.

Figure 5–1: Global initiative and actions for "AI + City"
Source: Created by authors

(1) Build Resource-Efficient Cities: Less is More for Better Life

Facing multiple constraints on energy, land, water, and the environment, the traditional model of urban development reliant on high investment and high consumption is no longer sustainable. The core mission of building resource-efficient cities is to achieve a systemic leap in resource allocation efficiency through intelligent means. This supports higher-quality public services and better urban living with reduced resource consumption and environmental impact. This shared vision can be taken as an updated version of the sustainability concept:

- From "scale expansion reliant on resource consumption" to "resource efficiency driven by substantive growth."
- From "external constraints" to "internal optimization."
- From "sectoral efficiency" to "systemic efficiency."

(2) Leverage AI to Support Resource-Efficient City Transformation

Achieving the goal of a resource-efficient city hinges on using the construction of an City Intelligence system as the key driver to advance the deep, city-scale application of AI.

Through the coordination of "computing - data - AI models," City Intelligence enables precise, citywide, and dynamic optimization of resources across their entire lifecycle. Four key mechanisms shall be established to achieve this goal:

- Demand-side precision sensing: Utilizing urban observation and perception networks to monitor the real-time supply and demand, as well as its changing trends, of energy, water, transportation, and public services.
- Supply-side intelligent scheduling: Employing predictive models and reinforcement learning to coordinate resource allocation across departments and systems and reduce structural waste and duplicated investment.
- System-level efficiency leap: upgrading from "siloed conservation" to "synergistic gains" in citywide energy efficiency and resilience.
- Sustained operation and feedback assessment: transforming AI into an "enduring capacity" for urban resource governance, rather than a short-term project or an isolated tool.

(3) Advance "AI + City" Evolution Through a Holistic Approach

The development of "AI + City" must adhere to a holistic approach, guiding the process from urban observation to the formation of genuine City Intelligence. This is dictated by the very nature of cities as "ultra-complex giant systems." By adhering to a holistic view, "AI + City" will evolve from mere technology stacking to systemic evolution, gradually forming a sustainable, scalable, and governable City Intelligence system. This holistic view encompasses three essential dimensions:

- Resources as an integrated whole: Energy, land, water, ecosystems, transportation, and public services form a highly interconnected system requiring coordinated governance.
- Data as an integrated whole: Breaking down sectoral data silos to create a unified, cross-scale, cross-domain, and cross-temporal data foundation.
- Organization as an integrated whole: Fostering collaborative governance among government, businesses, communities, the public, and research institutions.

(4) Co-Design People-Centred Good Governance Scenarios

The essence of creating good governance scenarios for "AI + City" is "starting from people's needs and aiming for governance-for-good." This requires a problem-and scenario-driven approach, following a path of "scenario traction — technology adaptation — institutional alignment — scaled adoption." Good governance must be embedded throughout the scenario's planning, development, and operation.

- In terms of planning, the foundation is laid through "value alignment" and "inclusive design," shifting from a "technology-driven" mindset to one that is "problem-driven" and "value-driven." From the outset, the scenario must clearly define: what specific urban problem it addresses, who it serves, and what public value it creates, thereby ensuring purpose-for-good drives the initiative from the start.

- In terms of development, a trustworthy ecosystem is built on "rule of law and transparency," embedding compliance and ethics directly into the technical architecture by design. Upholding the principles of "secure, reliable, and controllable" map the baseline for trustworthy City Intelligence.

- In terms of operation, service efficacy is enhanced through "responsive action" and "continuous learning," establishing a dynamic loop for performance evaluation and feedback. Metrics should encompass not only technical indicators such as "system throughput" and "response time," but also social outcomes including "citizen satisfaction," "service accessibility," and "fairness across different groups." Crucially, an effective coupling between human decision-makers and AI-augmented decision-making processes must be ensured.

(5) Foster an Intelligent City Network for Collaborative Learning

To prevent the fragmentation, redundant investment, and technology monopolies that could emerge from "AI + City" initiatives, there is an urgent need for a transnational, interdisciplinary global network of intelligent cities to share urban governance experience, which will serve as a critical platform for shifting City Intelligence from siloed technical exploration to institutionalized global cooperation. Its core missions would include:

- Coordinating standards: Driving the development of global standards for City Intelligence technologies, data protocols, and ethical guidelines.

- Enabling co-development: Facilitating capacity building and technology transfer between developed and developing nations.

- Promoting sharing: Encouraging cross-city sharing of experiences and joint pilot projects in areas like heatwave response, traffic management, carbon reduction, and public safety.

- Fostering collaboration: Building a multi-participant collaborative network that connects governments, international organizations, research bodies, technology firms, and civil society.

(6) Open City Intelligence Resources to Share AI Innovations

To support the sustainable and inclusive development of City Intelligence, we propose jointly building a global open-resource ecosystem, such as citybrain.org, focusing on four key areas:

- Holistic city observation: a system will provide City Intelligence with globally comparable and transferable observational capabilities across cities.

- City foundation data and AI models: a "universal underlying representation" to support cross-city simulations, policy testing, and system evaluations.

- City Intelligence engine: a city-scale decision-making engine integrate data and models to enable cognitive reasoning, scenario simulation and forecasting, thereby supporting critical decision-making scenarios.

- City Intelligence service platform: an open service system that integrates collaborative governance, multi-participant co-governance, and open research.

"AI + City" is not merely a technological innovation project; it is a global collaborative endeavor concerning the evolution of human urban civilization. By jointly advocating for a shared value of "**less is more for better life**," promoting smarter, fairer, and safer governance model, and co-creating an open, shared, and inclusive ecosystem of digital public goods, we will steer cities away from traditional high-resource consumption paths toward a new, efficient, and intelligent development paradigm. Together, we can build and live in safer, greener, more inclusive, and sustainable future cities.

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