

OPPORTUNITIES FOR CITIES IN THE AGE OF ARTIFICIAL INTELLIGENCE

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**Overview of report materials based on the Global Initiative on AI and Virtual Worlds
– Discovering the Citiverse [1]**

ABSTRACT

Cities generate vast amounts of information. Neural network models make it possible to process this data quickly. For example, predictive algorithms can forecast the load on power grids or identify problematic sections of roads. This publication was developed based on the Global Initiative on AI and Virtual Worlds – Discovering the Citiverse [1], which is a global multistakeholder platform launched by the International Telecommunication Union (ITU), the United Nations International Computing Center (UNICC) and Digital Dubai, and supported by more than 70 international partners. Review based on AI-Enabled Citiverse (Foundational Capabilities, A Strategic Blueprint and Use Cases for Cities in the Age of AI). The Initiative advances the development of the AI-enabled citiverse, where artificial intelligence, spatial intelligence, digital twins, and immersive systems converge to deliver real-world impact. It aims to ensure that this transformation is inclusive, trusted and interoperable, and that it serves people, cities and communities. AI-enabled citiverse constitutes a transformative, people-centric paradigm, enabling policymakers to harness these developments to build urban governance models. Examines the foundational elements that underpin urban intelligence, simulation, participation, interoperability, trust and inclusion, and assessing them through the lens of their relevance to urban governance and civic outcomes rather than on the basis of technical novelty alone.

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Introduction

The changes currently underway are creating a need for more integrated, adaptive, and human-centric models of urban digital development. Artificial intelligence (AI) is being actively deployed within intelligent transport systems (ITS), while "smart" cameras are capable of recognizing various objects and situations. Digital twins – virtual replicas of cities that aggregate data from sensors, cameras, and information systems – enable the simulation of diverse scenarios, ranging from shifts in traffic flow to the consequences of emergency situations. For instance, a digital twin can help optimize public transport routes or forecast loads on energy grids. Meanwhile, chatbots and voice assistants, powered by natural language processing (NLP) models, automate the handling of inquiries from citizens.

An "AI-enabled citiverse" [1] is more than just another technological trend or a functional upgrade to the traditional "smart city" concept. It represents a profound evolution toward intelligent, interactive, and immersive urban ecosystems that prioritize the human experience and societal well-being. Such an environment seamlessly integrates immersive virtual spaces, artificial intelligence, and smart urban infrastructure, all designed to enhance quality of life, optimize municipal services, and ensure the sustainable functioning of the city. In practice, this creates an adaptive urban ecosystem that allows citizens and municipal authorities to interact through data-driven processes and participatory mechanisms, ultimately leading to meaningful outcomes in urban governance.

The development of such an urban environment relies on foundational technologies and supporting structures that facilitate interaction, intelligent analysis, simulation, immersion, and the cultivation of trust across the entire city.

These foundations support key urban functions, enabling cities to:

- connect systems and data within the urban environment;
- facilitate intelligent management, modeling, and simulation of urban processes;
- create opportunities for immersive and interactive engagement;
- strengthen coordination among various institutions;
- establish trusted digital environments, while enhancing the efficiency and accessibility of urban services for citizens;
- foster conditions for expanded economic opportunities and broader civic participation in urban life.

Without these foundations, an "AI-enabled citiverse" cannot function as an effective urban ecosystem. The development of such an environment should not be viewed merely as a collection of technological components or digital layers. The creation of public value depends on how these foundational elements are transformed into holistic, outcome-oriented capabilities that improve governance, service delivery, and public well-being. This requires a fundamental shift in approach:

- from an emphasis on technology stacks to a focus on the functional capabilities of cities;
- from fragmented, autonomous tools to integrated and interoperable urban functions;
- from the simple implementation of digital solutions to the systematic creation of public value.

Thus, the core issue is not so much the availability of technology, but rather its effective transformation into capabilities that strengthen essential urban functions: governance, planning, coordination, service delivery, public engagement, and decision-making. Technology should be viewed as the bedrock that enables the development of urban capabilities.

This text explores how the technological foundations of an "AI-enabled citiverse" can be reconceptualized as operational capabilities – essential for cities to implement in practice – and how these capabilities contribute to the creation of more resilient and efficient urban systems.

From technology to civic capabilities

The significance of an "AI-enabled citiverse" is defined not merely by a collection of advanced digital tools, but by how these resources are transformed into "civic capabilities" that enhance governance mechanisms. In an urban context, "capabilities" refer to practical and replicable ways of applying technology to support core city functions. It is essential to clearly distinguish between technologies, capabilities, and civic outcomes:

- Technologies encompass the tools, systems, and infrastructures that enable and support new forms of urban activity. In the context of an "AI-enabled citiverse," this includes artificial intelligence, digital twins, immersive and spatial interfaces, geospatial systems, sensor networks, communication infrastructure, and secure platforms for digital interaction.

- Capabilities are sustainable institutional capacities that emerge from the effective integration of technologies with governance mechanisms, data ecosystems, human potential, operational processes, and clearly defined public goals. They represent an organized and institutionalized ability to apply technology in support of essential urban functions.

- Civic outcomes are the socially significant effects achieved through the effective use of these capabilities – such as more responsive service delivery, increased urban resilience, better-informed (data-driven) decision-making, strengthened public trust, and broader, more inclusive citizen participation. These civic outcomes serve as the primary criterion for determining whether a digital transformation is creating genuine public value.

Table 1

Distinguishing Technologies, Capabilities, and Civic Outcomes

Layer	Meaning	Illustrative examples
Technologies	Tools, systems, and infrastructure that enable urban action	AI, digital twins, immersive interfaces, sensors, secure digital interaction
Capabilities	Repeatable institutional abilities enabled by technology and shaped by governance	Anticipatory governance, participatory planning, adaptive infrastructure management
Civic outcomes	Public results produced when capabilities are applied effectively	Responsive services, enhanced resilience, improved trust, more inclusive participation

This distinction clarifies the significance of technological convergence for cities. The result is not merely a more digitized urban environment, but one that creates public value more effectively.

In this context, five areas of transformation are particularly important:

- A profound understanding of urban systems.

By combining geospatial data, digital twins, simulation environments, and immersive interfaces, cities can make complex urban processes more visible, understandable, and navigable. This fosters a shared vision among urban planners, government bodies, and decision-makers.

- Proactive management.

The integration of data, artificial intelligence, and modeling tools helps to identify risks in advance, systematically explore potential scenarios, and prepare more deliberately for emerging challenges.

- Participatory planning.

Interactive and immersive urban environments make development plans and proposed solutions more accessible and comprehensible to residents. This creates the conditions for meaningful citizen engagement, allowing residents to explore alternatives, assess potential consequences, and provide well-founded, constructive feedback.

- Autonomous and adaptive infrastructure.

Interconnected infrastructure, real-time monitoring systems, and intelligent management mechanisms make urban services more flexible. This facilitates seamless service delivery, the implementation of predictive maintenance, and a more dynamic adaptation of infrastructure to changing conditions.

- Evidence-based policy development.

By leveraging comprehensive data, modeling, and analytical tools, cities can more rigorously evaluate various options – and the associated trade-offs – during both the preparation and implementation phases of decision-making. The practical significance of technological convergence lies not in the complexity of the technologies themselves, but in the opportunities and socially meaningful outcomes they enable. It represents an evolution in urban governance: a shift from fragmented perspectives to a shared understanding; from reactive administration to proactive action; from formal consultations to genuine citizen participation; from static systems to adaptive processes; and from ad hoc decision-making to continuous learning.

At the same time, such opportunities do not emerge automatically simply through the presence of digital tools. Realizing them requires the creation of an enabling environment – one that encompasses robust data management, system interoperability, secure and trusted digital interaction, advanced computational infrastructure, effective inter-institutional coordination, and inclusive access. Governance conditions must be in place to ensure that technologies are implemented transparently, accountably, and in alignment with the public interest. Without these conditions, technological convergence is likely to remain fragmented, and its impact uneven. Conversely, when the necessary conditions are established, cities gain a greater capacity to transform innovations into practical, effective tools.

Core civic capabilities and enabled outcomes in the ai-driven citiverse

The development of a "city of the future" (citiverse) – grounded in artificial intelligence technologies – relies on a set of key civic capabilities that transform a technological foundation into tangible, meaningful outcomes for the urban environment. These capabilities define how cities coordinate the operation of various systems, generate and

apply analytical insights, forecast and model future scenarios, ensure inclusive and participatory processes, and foster a secure, open, and accessible digital environment.

Cities have the capacity to aggregate, integrate, and coordinate data originating from administrative, geospatial, infrastructural, and operational systems.

This capability is critical, as the functioning of artificial intelligence, modeling systems, and "digital twins" depends on urban data – data that must be integrated, interpreted, and made available for use within robust, well-governed frameworks.

The elements listed below support this capability, enabling cities to consolidate and align their data.

1) Integrated urban data platforms.

- The consolidation of disparate systems, enabling data access and reuse across various municipal departments.

- Technologies (examples): data platforms, APIs, data pipelines, access control systems.

2) Geospatial data infrastructure.

- Linking various datasets to specific locations, objects, and networks, allowing cities to understand and manage their urban environment.

- Technologies (examples): GIS services, base maps, land parcel and address layers, building footprints, common spatial identifiers.

3) Real-time data streams (operational data).

- Facilitating continuous monitoring of changes within the urban environment, enabling a shift from static reporting to real-time situational awareness.

- Technologies (examples): IoT sensors, data streaming systems (real-time or low-latency), dashboards, alert systems.

4) Semantic interoperability.

- Ensuring that data from different systems can be accurately interpreted and used consistently by various departments, organizations, and digital services.

- Technologies (examples): common data models, standardized metadata, unified identifiers, controlled vocabularies, compatible APIs.

5) Federated urban data spaces.

- Enabling various stakeholders to securely share and utilize data while retaining control over it, without the need for full centralization.

- Technologies (examples): data-sharing platforms, access rights management systems, secure data-processing environments.

Enabling anticipatory governance and intelligent decision-making

When this capability is applied effectively, it contributes to:

- more responsive and reliable public services;
- improved resilience to disruptions and shocks;
- better-informed and more timely decision-making;
- more efficient allocation of public resources; and
- increased confidence in public decision-making processes.

This capability builds on integrated urban data and supports simulation, planning and operational decision-making across city systems.

Cities can anticipate risks, prioritise actions and support decision-making across urban systems.

The following elements support this capability by enabling cities to generate insight, anticipate change and inform action.

1) Predictive modeling.

- Identifying future conditions, risks, and demand patterns to support planning and proactive measures.

- Technologies (examples): machine learning models, statistical forecasting tools, simulation models.

2) Access to knowledge, communication, and service navigation.

- Ensuring that information of public interest and administrative knowledge are accessible, understandable, and actionable.

- Technologies (examples): large language models, generative AI platforms, conversational interfaces.

3) Urban analytics.

- Identifying patterns and risks, and deriving targeted analytical insights from vast and heterogeneous urban datasets.

- Technologies (examples): data analysis platforms, computer vision, geospatial analytics tools.

4) Support for operational and administrative decision-making.

- Translating analytical findings into concrete recommendations.

- Technologies (examples): dashboards, decision-support platforms, workflow management systems, notification tools.

Governance Issues

- Maintain human oversight and accountability when using high-impact systems, ensuring that levels of autonomy are appropriate to the context, risk, and the organization's level of maturity.

- Define tiered levels of autonomy and requirements for human intervention, including: (1) Fully human-controlled: AI provides recommendations, while a human makes the final decision; (2) Human-in-the-loop: AI operates under human supervision, with the possibility for human adjustment; (3) Autonomous with audit: AI operates independently, subject to subsequent review.

- Define the purpose, limitations, ownership, and avenues for redress for each AI system.

- Conduct regular testing for bias, drift, reliability, data quality, and user experience.

- Redesign business processes where necessary and sequence implementation accordingly.

- Utilize secure data sources and ensure appropriate transparency, civic engagement, and user testing.

Providing capabilities for modeling, testing, and planning at a systemic level

Effective use of this tool contributes to:

- reducing risks in government decision-making;

- more efficient and rational use of public resources;

- improved long-term planning outcomes;

- increased resilience to environmental, economic, and operational shocks; and

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- greater transparency in the processes used to evaluate and justify decisions.

This capability relies on integrated data and analytical insights, and supports more transparent and participatory engagement through immersive interfaces.

Cities can simulate, test and explore the impacts of policies, infrastructure changes and operational decisions before implementation.

In practice, it allows cities to:

- represent and model current urban systems and conditions in a dynamic and integrated way;
- test future scenarios, interventions, and external shocks;
- assess the impacts of policy and planning decisions before implementation;
- evaluate infrastructure performance under different conditions; and
- improve coordination across interconnected urban systems.

The following elements support this capability by enabling cities to represent, simulate, and test urban systems.

1) Dynamic digital representations of cities

- Creating integrated and continuously updated depictions of the urban environment.
- Technologies (indicative): 3D city models, geospatial data platforms, digital twin environments.

2) Scenario modeling

- Testing how urban systems respond to future conditions, interventions, or shocks.
- Technologies (indicative): simulation engines, scenario modeling tools, predictive models.

3) Infrastructure modeling

- Understanding the condition, performance, and interdependencies of infrastructure systems.
- Technologies (indicative): asset management systems, infrastructure models, sensor-integrated platforms.

4) Policy-testing environments

- Evaluating the potential consequences of planned decisions before they are implemented.
- Technologies (indicative): decision-support platforms, simulation environments, scenario analysis tools.

Cities can represent urban systems, plans, and models – and interact with them—in ways that allow people to visualize, navigate, and perceive them within a spatial dimension. This enables cities to shift from static, abstract methods of presenting urban information toward more interactive, accessible, and intuitive formats.

In practice, this allows cities to:

- present proposals for territorial development in a more accessible and understandable way;
- facilitate more meaningful public participation in planning processes;
- foster collaboration between municipal departments and various stakeholders;
- provide users with the ability to interactively explore the urban environment and different development scenarios;
- compare scenarios, test proposed solutions, and make well-informed, data-driven management decisions.

The elements listed below support the realization of these capabilities, enabling cities to represent, explore, and engage with the urban environment.

- 1) Collaborative immersive participation and design.
 - Enabling users to interact with the urban environment and perceive it as a navigable digital space, rather than as a static image.
 - Technologies (examples): XR (extended reality) platforms, immersive visualization systems, augmented reality (AR) and virtual reality (VR) devices.
- 2) Location-based interaction and on-site decision support.
 - Linking digital information to real-world locations, urban assets, and the environment to facilitate interaction within a spatial context.
 - Technologies (examples): geospatial positioning systems, spatial mapping technologies, integration with digital twins.
- 3) Immersive visualization of the urban environment.
 - Presenting complex urban data in intuitive, visual formats.
 - Technologies (examples): 3D modeling tools, visualization platforms, rendering engines, XR interfaces, spatial tracking systems.
- 4) Environments for collaborative planning.
 - Allowing multiple users to explore design proposals, compare various scenarios, and work with urban data within a unified digital space.
 - Technologies (examples): collaborative platforms, shared virtual environments, interaction tools.

Enabling scalable, resilient and real-time urban operations

This capability ensures the reliable functioning of systems related to data, analytics, modeling, and interaction, while also supporting service integration, identity management, and overall administration at a city-wide scale. Cities can manage their urban environment in real time and provide digital services, ensuring that computing power, storage resources, and communication channels can scale according to demand, maintain minimal latency, and remain reliable and resilient in the event of failures.

The elements listed below facilitate the realization of this capability, enabling cities to reliably process, store, and transmit data across various systems and environments.

- 1) Reliable delivery of digital services across all municipal functions.
 - Ensuring the reliable and scalable delivery of digital services across various departments through shared environments that support multiple functions and users.
 - Technologies (indicative): cloud platforms, shared application environments, data platforms, API gateways, microservices, containerized environments.
- 2) Low-latency and resilient operational response.
 - Supporting timely and reliable operational responses in situations where urban conditions change rapidly and delays would diminish service effectiveness.
 - Technologies (indicative): edge computing nodes, gateways, local processors, IoT devices, streaming platforms, event-driven architectures, low-latency network infrastructure.
- 3) Continuity, coordination, and stable performance.
 - Maintaining reliable, coordinated, and continuous digital operations as the volume of services, users, and data grows throughout the city.

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- Technologies (indicative): monitoring and observation tools, logging systems, backup and recovery systems, orchestration tools, cyber-resilience measures, failover infrastructure.

Enabling trusted, secure and inclusive digital interaction

This capability enables trusted interaction within digital services and platforms, and supports the provision, coordination, and management of interconnected urban systems. This is critical, as the functioning of digital services, platforms for civic engagement, and interconnected systems depends on the ability of users to authenticate themselves, exchange data, and conduct transactions with the assurance that their privacy and security are protected.

In practice, this allows cities to:

- securely verify the identity of users and organizations as they interact with digital services;
- protect personal data and ensure privacy during digital interactions;
- provide secure access to services, platforms, and systems;
- facilitate trusted digital transactions and approval processes.

The elements listed below contribute to the realization of this capability, ensuring secure, trusted, and private digital interaction.

1) Digital identification systems.

• Verifying the authenticity of individuals, organizations, and systems within digital services through secure authentication, identity assurance, and accountability mechanisms.

- Technologies (examples): digital identification systems, decentralized identifiers (DIDs), authentication services, identity management platforms.

2) Privacy protection.

- Ensuring the responsible handling of personal data.
- Technologies (examples): consent management systems, data protection tools, privacy-enhancing technologies.

3) Cybersecurity.

• Protecting digital systems, identity data, transactions, and urban infrastructure against unauthorized access, disruptions, and cyber threats—including those amplified by the use of artificial intelligence.

- Technologies (examples): encryption tools, security monitoring systems, access control mechanisms.

4) Trusted digital transactions.

• Enabling agreements, signatures, and exchanges in an online environment with guarantees of reliability and legal validity.

- Technologies (examples): digital signature platforms, verification systems, tools for conducting secure transactions.

Enabling interoperable and open urban systems

This capability enables systems, data, and services to function as an interconnected ecosystem, while also fostering scalability, integration, and the long-term development of an urban digital environment. Cities can facilitate the seamless collaboration of data, systems, and services across various departments, platforms, and providers. This is a critical aspect, as an "urban metaverse" (citiverse) – leveraging artificial intelligence – relies on shared data flows, reusable digital components, and the ability to integrate new services, all without system fragmentation or vendor lock-in.

The elements listed below support this capability by ensuring the interoperability of systems, data, and services throughout the entire urban environment.

1) Minimal Interoperability Mechanisms (MIMs).

- Providing a common, practical framework for interaction between various systems and platforms.

- Technologies (examples): APIs, common data models, metadata structures, interoperability standards.

2) Open standards and data models.

- Enabling data and systems to be understood, shared, and reused across different platforms and domains.

- Technologies (examples): open data standards, common schemas, conceptual frameworks for interoperability.

3) API and service integration.

- Ensuring reliable and efficient interaction between systems and services, as well as the exchange of data between them.

- Technologies (examples): API gateways, integration platforms, service interfaces.

4) Open and modular architectures.

- Supporting flexibility, scalability, and the future evolution of systems.

- Technologies (examples): modular platforms, microservices architectures, interoperable systems.

Enabling accessible and inclusive digital environments

This capability ensures that the benefits of data, intelligence, simulation and digital services are accessible to all users, thereby making inclusion a core principle of the AI-enabled citiverse. Cities can design digital services, platforms and interfaces so they are accessible and usable by people with different abilities, languages, literacy levels, devices and levels of digital access. This capability is essential because the AI-enabled citiverse can only be human-centric if participation and service access are inclusive and designed for diverse users from the outset. In this context, accessibility and inclusion are not optional features but core requirements for the design and delivery of digital services.

This capability enables cities to move from fragmented and exclusionary digital services and environments to accessible, inclusive and widely usable digital environments.

In practice, it allows cities to:

- design services and interfaces that are accessible to diverse users;
- support multiple languages, interaction modes and assistive technologies;
- provide alternative access channels across devices and connectivity levels;
- support participation in digital processes in an inclusive and equitable way and reduce barriers to accessing services and engaging with urban systems.

The following elements support this capability by ensuring services and interfaces are accessible and inclusive.

- 1) Principles of inclusive design.
 - Designing digital environments that are accessible from the outset to a wide range of user groups.
 - Technologies (examples): accessibility standards, inclusive design concepts, testing tools.
- 2) Accessibility in immersive environments.
 - Ensuring that immersive and spatial interfaces are usable by people with various sensory, cognitive, or motor impairments.
 - Technologies (examples): accessibility features in extended reality (XR) technologies, multimodal interaction tools, assistive interface technologies.
- 3) Multilingual and assistive interfaces.
 - Providing users with access to services in multiple languages and through the use of assistive aids.
 - Technologies (examples): translation tools, accessibility software, assistive technologies.
- 4) Equal access to digital services.
 - Ensuring that services are accessible regardless of the device used, connection quality, or level of digital literacy.
 - Technologies (examples): solutions for low-bandwidth network conditions, multichannel service delivery platforms, accessibility tools.

City-level outcomes depend on how foundational capabilities are combined and applied within the broader urban ecosystem. Their value lies in how these various capabilities interact with one another, facilitating effective urban governance and service delivery.

A strategic blueprint for cities in the age of AI



To manage a city effectively, its leaders must understand the many global factors that are reshaping urban reality [3]. Taken together, these technological, economic, and social forces confront cities with the challenge of large-scale transformation. Such systems must account for the following aspects:

- Climate and environmental instability.

- Unprecedented progress in artificial intelligence.
- Economic restructuring and the development of digital industries.
- Evolving citizen expectations and levels of trust.
- The complexity of governance processes.

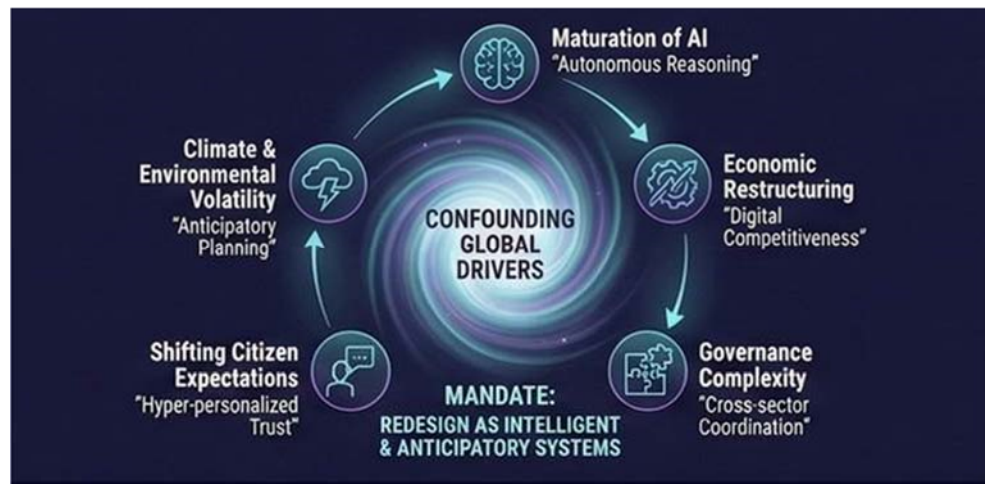


Fig. 1. The Great Convergence and the Confounding Trends

Historically, urban technologies have been narrowly focused on optimizing physical infrastructure – such as improving the efficiency of energy grids or refining the operation of traffic lights. The concept of a "citiverse" (urban metaverse), rooted in the use of artificial intelligence, shifts the focus toward unlocking human potential, strengthening civic engagement, enabling data-driven decision-making, and creating public value.

This provides city leadership with enhanced capabilities for strategic foresight. By transitioning toward "cognitive" and autonomous city models, officials can ensure that decisions are based on empirical evidence, increase governance transparency, and make public administration more agile.

Technologies alone do not transform cities; rather, it is the new functional capabilities they enable that drive change. To capitalize on these emerging opportunities, the underlying technologies must be demystified – presented to city administrators not as abstract technical concepts, but as practical tools for urban development:

- Virtual worlds that create immersive environments: Technologies such as the "spatial internet" and advanced 3D visualization methods transform complex urban data into intuitive, immersive settings. This allows urban planners, residents, and government officials to literally "step inside" future developments, facilitating collaborative design, agile planning, engineering assessment, cross-departmental decision-making, and effective coordination among various municipal services.

- Artificial intelligence that provides analytical capacity and autonomy: Advanced AI systems endow cities with the ability to perform complex logical analysis, predictive modeling, and rapid, autonomous responses. Through this, static urban systems are transformed into "cognitive networks" capable of anticipating crises – ranging from optimizing energy distribution during peak loads to rerouting emergency services around traffic congestion – and adapting to changes in real time.

- Digital twins that provide systemic intelligence: the ability to dynamically model the consequences of specific decisions, resource allocation, and infrastructure loads across interconnected urban systems, using up-to-date data. This makes it possible to foresee

how a single change in policy or infrastructure will ripple through the entire urban ecosystem.

- A robust foundational database that ensures "AI sovereignty": at the core of all these capabilities lie secure digital infrastructure, federated data spaces, and scalable system architectures. These foundations guarantee that a city retains sovereignty over its data, protecting citizens' privacy while simultaneously ensuring the interoperability required for a fully realized, AI-driven urban environment.

The true benchmark for such an urban environment is not its technological complexity, but its capacity to expand human potential. This approach rejects technology for technology's sake; it is rooted, instead, in the principle of human-centricity.



Fig. 2. Human-Centric by Design

- Natural language as a universal interface: using complex digital services will no longer require technical literacy or the ability to navigate cumbersome municipal portals. Citizens will be able to interact directly with city institutions – eliminating bureaucratic hurdles and accessibility barriers, and making governance truly inclusive.

- Human-level intelligence for urban problem-solving: by integrating data on the urban environment (via AI) with feedback from residents and advanced analytical capabilities, cities can harness an intellectual capacity comparable to that of thousands of experts to address the specific challenges of individual neighborhoods.

A future-oriented city does not merely react to change; it anticipates it. Transitioning to an AI-enabled urban ecosystem fundamentally transforms the experience and outcomes for all key stakeholders in city life:

- Strengthening local sectors: creating an environment that attracts global talent, venture capital, and cutting-edge industries.

- Scalable skills development: preparing the local labor market, civil servants, and municipal staff for the profound economic transformations driven by AI.

- Hyper-personalized urban services: shifting from a "one-size-fits-all" approach to services meticulously tailored to the specific needs, life context, language, and accessibility requirements of each resident.

- Immersive civic engagement: enabling communities to visualize projects and participate meaningfully in the planning and development of their own neighborhoods.
- Expanding civic inclusion: ensuring that individuals with specific accessibility needs or lower levels of digital literacy can fully access urban services through human-centric digital solutions that provide the necessary support.



Fig. 3. Envisioning the AI-Enabled Citiverse Ecosystem for Cities

Priorities for actual city needs

The selection of priority areas for technology deployment should be guided by a city's economic reality and geographical characteristics:

- Coastal Metropolis: A city facing the challenge of rising sea levels requires advanced predictive tools for flood modeling, resilient infrastructure planning, and real-time environmental monitoring.
- Industrial Hub: A city undergoing large-scale transformation might focus on leveraging artificial intelligence to optimize transport flows, upskill the workforce, model supply chains, and monitor the active reduction of harmful emissions.
- Rapidly Growing Urban Center: A city experiencing swift population growth can utilize AI technologies to model scalable housing projects, optimize new utility networks, and deploy autonomous public transport systems.

Artificial intelligence and the concept of a "digital city" (citiverse) provide the necessary architecture and functionality, while the city itself defines its own strategic mission. AI technologies and spatial computing are evolving exponentially, and the rules of the new digital economy are being shaped today. Delay inevitably leads to technological dependency, as well as fragmented and inefficient public services. By acting proactively, municipal authorities can exert a direct influence on governance principles, data sovereignty, and ethical standards within their local digital ecosystem.

Early adopters will set global standards. By investing in the development of AI technologies and the corresponding capacity, city authorities can build essential institutional capabilities, attract talent, and reach a level of operational maturity that enables them to manage urban processes with confidence. To help cities seize this unique opportunity and translate international dialogue into concrete, local-level transformation, the International Telecommunication Union (ITU), the UN International Computing Centre (UNICC), and Digital Dubai – in collaboration with experts from around the world – have launched the "Global Initiative on AI and Virtual Worlds: Discovering the Citiverse" [2]. The

goal of this initiative is to bridge the gap between ambitious visions and their practical implementation on the ground.

The cities of the future will be defined by more than just their physical infrastructure. Their character will depend on their capacity to respond to change, the level of immersive connectivity they offer, and an unwavering commitment to fostering human potential.

The transition from traditional "smart cities" to cognitive, proactive urban ecosystems stands as a key governance challenge for the current decade.

Conclusion

The concept of a "citiverse" – an urban ecosystem powered by artificial intelligence – should not be viewed as a single technological platform, but rather as a long-term development trajectory for cities. It serves as a framework for enhancing urban management, planning, operations, and civic engagement. The true value of this approach lies not in the mere accumulation of digital tools, but in the opportunities they create to deliver outcomes that are meaningful to residents. Consequently, the central question for cities is how these technologies can be transformed into practical instruments that foster greater sustainability, inclusivity, public trust, and social value.

This transition is anchored in several fundamental areas of development:

- Ensuring the interconnected and coordinated functioning of urban services.
- Implementing proactive management methods and intelligent decision-making processes.
- Establishing capabilities for system-level modeling, testing, and planning – enabling the analysis of various scenarios, the comparison of potential courses of action, and the assessment of risks before they are implemented in the physical urban environment.
- Developing scalable, resilient, real-time urban systems that leverage cloud computing, edge computing, and advanced communication channels.
- Creating a secure, safe, and inclusive digital environment, alongside open urban systems capable of interacting effectively with one another.

Cities should approach the development of an AI-powered "citiverse" with both ambition and pragmatism. It is not necessary to immediately build a comprehensive "digital twin" or launch a large-scale, all-encompassing AI implementation program. Instead, the focus should be on clearly defining priorities, identifying the most impactful use cases, and gradually building capacity – all while remaining mindful of local realities. An "AI-enabled urban universe" is not a ready-made model that can simply be copied; rather, it is a path that each city must forge for itself, based on its own unique needs and development trajectory.

Cities should not wait for ideal conditions to begin taking action. By engaging with a broad community of practitioners and participating in various initiatives [2], cities gain access to collective knowledge, opportunities for collaboration, and expert guidance for experimentation. In this way, an "AI-enabled urban universe" can become a practical tool for building a more efficient, inclusive, and sustainable urban future. Delaying the adoption of innovations leads to technological dependency, "brain drain," a loss of economic competitiveness, and an inability to attract the industries and talent of the future.

The central governance question of this decade is not whether to create future-ready cities, but rather who will lead the process [4-7].

Abbreviations and acronyms

AI	Artificial Intelligence
API / APIs	Application Programming Interface(s)
AR	Augmented Reality
BID	Biometrically Inferred Data
CIN	Carteira de Identidade Nacional (National Identity Card, Portugal)
CIO / CIOs	Chief Information Officer(s)
DIDs	Decentralized Identifiers
EDIC	European Digital Infrastructure Consortium
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
GOV.UK	Government of the United Kingdom
IGO	Intergovernmental Organization
IoT	Internet of Things
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
MIMs	Minimal Interoperability Mechanisms
RDG	Responsible Data Governance
SSI	Self-sovereign Identity
XR	Extended Reality

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