

Citiverse Use Case Taxonomy: Global Insights and Implementation Pathways



Foreword

This publication was developed within the framework of the [Global Initiative on Virtual Worlds and AI – Discovering the Citiverse](#), which is a global multistakeholder platform launched by the International Telecommunication Union (ITU), the United Nations International Computing Centre (UNICC), and Digital Dubai, and supported by more than 70 international partners.

The Initiative aims to shape a future where AI-powered virtual worlds are inclusive, trusted, and interoperable. By connecting people, cities, and technologies, it empowers meaningful progress through AI-powered virtual worlds.

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Disclaimers

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations, Executive Committee members or Steering Committee members of the Initiative. The findings presented in this report are based on a comprehensive review of existing literature and voluntary written contributions submitted by a diverse range of stakeholders.

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Abbreviations and acronyms

AI	Artificial intelligence
AR	Augmented reality
GAI	Generative artificial intelligence
GenAI	Generative artificial intelligence
IoT	Internet of Things
MR	Mixed reality
SDG	Sustainable Development Goal
VR	Virtual reality
XR	Extended reality

Executive summary

The concept of virtual worlds envisions a digital, immersive layer seamlessly integrated with the physical urban ecosystem. Augmented reality (AR), virtual reality (VR), artificial intelligence (AI), metaverse platforms and digital twins collectively bridge the gap between digital and physical realms, creating interactive, data-rich environments that enhance urban planning, service delivery and citizen engagement. Building on this foundation, the innovative citiverse concept comprises interconnected, distributed virtual worlds synchronized with real-world counterparts at defined fidelities and cadences. The citiverse empowers cities to address complex challenges – from climate adaptation and infrastructure management to inclusive participation and cultural preservation – by harnessing the synergies of emerging technologies.

Under the auspices of the [Global Initiative on Virtual Worlds and AI – *Discovering the Citiverse*](#), launched at the 1st UN Virtual Worlds Day on 14 June 2024, by ITU, UNICC and Digital Dubai (with the ITU's FG-MV serving as technical anchor), this vision is evolving into a global platform for interoperable, secure and trustworthy virtual worlds. The initiative's Use Case Identification Track has curated and profiled just under 50 citiverse use cases spanning five core thematic areas: Urban Planning, Placemaking & Infrastructure; City Administration, Services & Public Participation; Economic Development, Education & Tourism; Transport & Mobility; Public Safety, Health & Disaster Resilience.

Each use case was selected based on four scoring criteria (SDG alignment, scalability, impact, feasibility), mapped to technology definitions (metaverse, digital twin, AR/VR, Internet of things (IoT), AI/generative artificial intelligence (GAI)), assigned to a maturity horizon, and risk-rated across public safety, stakeholder acceptance, data privacy, and financial/operational factors. For use cases containing examples in implementation or being piloted, these have been written up as case studies highlighting the solution approach, results and key lessons learned. This rigorous taxonomy enables cities to distinguish immediate pilots, mid-term innovation projects and long-term research areas.

Key findings

- **The citiverse enables cities to create immersive, digital representations of urban environments-bridging the physical and virtual** through technologies like the metaverse digital twins, AR/VR, AI and IoT. AI and GAI have a critical role to play within the citiverse as an enabler and accelerator. AI is increasingly serving as a foundational technology that drives innovation, enhances user experiences, and supports the creation of interactive and immersive virtual environments. As Agentic AI capabilities emerge, their impact on virtual world technologies and use cases should also be explored.
- **Citiverse use cases span five core thematic areas:** Urban Planning & Infrastructure, City Administration & Public Participation, Economic Development & Tourism, Transport & Mobility and Public Safety, Health & Disaster Resilience. Each area leverages virtual worlds to address unique challenges, from climate adaptation and circular economy to citizen engagement and emergency management.
- **The citiverse use cases mapped in the taxonomy can contribute to the achievement of a broad range of SDGs**, namely SDG1, SDG3, SDG4, SDG8, SDG9, SDG10, SDG11, SDG12, SDG13, SDG16 and SDG17.
- **The citiverse's success depends on open standards, interoperability, robust governance and security.** Collaborative, multistakeholder approaches ensure the platform remains inclusive, resilient and adaptable to evolving urban needs.

- **Cities must balance risk and opportunities when adopting citiverse use cases.** A systematic risk taxonomy-covering public safety, stakeholder acceptance, data privacy/security and financial/operational risk-enables cities to prioritize use cases that balance innovation with manageable risk. This approach supports informed decision making, ensuring that high-impact, scalable solutions are prioritized for early adoption, while more experimental or higher-risk concepts are piloted or explored further before city-wide rollout.
- **Citiverse use cases are particularly well suited to supporting the following strategic outcomes:**
 - Fostering inclusive, accessible forums for civic engagement such as virtual town halls, participatory planning and sentiment mapping-empowering citizens to co-create policy and urban spaces regardless of physical barriers.
 - Enabling data-driven, resilient and sustainable city services and infrastructure, including optimizing infrastructure, transport systems, managing resources efficiently, and model scenarios for climate resilience, disaster preparedness and operational efficiency.
 - Transforming education, vocational training, and onboarding for students and city employees. They provide safe, engaging, and personalized learning experiences, supporting life-long learning and workforce adaptability in rapidly changing economies.
 - Driving economic diversification and cultural preservation. The citiverse opens new avenues for economic growth-through virtual marketplaces, immersive tourism, digital heritage preservation and support for creative industries. These use cases promote local economic resilience, cultural continuity and global accessibility.
 - Promoting sustainability across all aspects of the city from mapping and designing with nature, facilitating circular economy and recycling through waste management and the built environment, providing educational opportunities including gamifying sustainable behaviours and modelling climate change adaptation strategies.
 - Creating hospitable worlds and creative experiences and places by creating a new medium for artistic expression, cultural participation, new public spaces and forums, personalization of experiences and community connection and wellness.

Next steps

The use case taxonomy presented here is a snapshot of current innovation, as well as a foundation for future collaboration. As cities continue to scale and expand initiatives, and experiment with pilot projects and sandbox environments, this living resource will continue to evolve. Ultimately, the citiverse is not a fixed destination – it’s a journey of collective innovation, iterative learning and shared urban futures. By identifying, analysing and amplifying promising use cases, this report contributes to shaping that journey.

The use case identification track’s work will feed into several other tracks in the Global Initiative on Virtual Worlds and AI.

This report is part of a series produced under the Use Case Identification Track of the Global Initiative on Virtual Worlds and AI – Discovering the Citiverse. To ensure accessibility for different audiences, the Citiverse Use Case Taxonomy has been presented as one overarching report and five thematic reports.

This Global Insights and Implementation Pathways report provides the overarching framework. It includes the executive summary, introduction, methodology, overall taxonomy, conclusion, and references. It is complemented by the five thematic reports, which present sector-specific insights and detailed use cases in the areas of Urban Planning, Placemaking and Infrastructure; City Administration, Services and Public Participation; Economic Development, Education and Tourism; Transport and Mobility; and Public Safety, Health and Disaster Resilience.

Together, these reports form a comprehensive reference designed to inform policymakers, industry leaders, city officials, and other stakeholders on the opportunities and pathways for Citiiverse implementation.





1 Introduction

1.1 Introducing the Global Initiative on Virtual Worlds and AI: Discovering the Citiverse

Cities around the globe are undergoing a profound transformation. Emerging technologies are reshaping how urban environments are designed, managed and experienced. Cities are leveraging these technologies to help them address and manage societies' most pressing challenges, from climate change through to urban inequality, traffic congestion and air pollution. Virtual worlds are an important component of this urban digital transformation. For example, IDC predicts that, "by 2027, 40 per cent of states, provinces and large cities will deploy spatial computing to create immerse 3D models and digital twins to support environmental and urban planning and emergency management."¹

The concept of virtual worlds envisions a digital, immersive layer seamlessly integrated with the physical urban ecosystem. In this context, the gap between the digital and physical worlds can be bridged with the help of emerging technologies such as augmented reality (AR), virtual reality (VR), artificial intelligence (AI), metaverse and digital twin, which can create a parallel digital world that interacts with and enhances the urban landscape.

As virtual worlds continue to evolve, an innovative concept known as the "**citiverse**" has emerged. A citiverse can comprise a series of interconnected distributed virtual worlds representing their physical counterparts, and synchronized at a specified frequency and fidelity in order to address the necessities and aspirations of cities and their inhabitants. AI has a critical role to play within the citiverse as an enabler and accelerator. As noted by the IEEE, "AI is acting as a catalyst driving innovation, enhancing user experiences and powering highly interactive and immersive environments within this virtual realm."² Furthermore, the ITU FGMV-22 highlights the potential impact of generative AI (GAI) on the metaverse:

"As the technology continues to evolve, there is an increasing demand for generative artificial intelligence (GAI) technology in the metaverse. GAI is crucial for creating immersive and interactive experiences in the metaverse. It has numerous capabilities in metaverse applications and services, from creating personalized avatars and environments to generating more immersive and personalized services. These capabilities can enrich the content of metaverse in more forms and significantly enhance the user experience within the metaverse, providing a more engaging and immersive environment." ITU FGMV-22, 12/2023

Under the auspices of the **Global Initiative on Virtual Worlds and AI - Discovering the Citiverse**, this vision is gaining momentum. The International Telecommunication Union (ITU) established the Focus Group on metaverse (FG-MV) in December 2022. Following a contribution from Digital Dubai, Global Initiative on Virtual Worlds - Discovering the Citiverse (henceforth "the Initiative") was established and launched by ITU, UNICC and Digital Dubai on 14 June 2024, during the 1st UN Virtual Worlds Day. This mission is underpinned by the first resolution on the metaverse within the UN system, [ITU-T Resolution 105 "Promoting and strengthening metaverse standardization"](#), approved in October 2024.

The initiative serves as a global platform that aims at fostering open, interoperable and innovative virtual worlds that can be used safely and with confidence by people, businesses and public services. The core objectives are outlined below in Figure 1. Stakeholders of the

initiative include, *inter alia*, cities, governments, city organizations, NGOs, industry, UN entities and academia.

Figure 1: Objectives of the Global Initiative on Global Worlds and AI

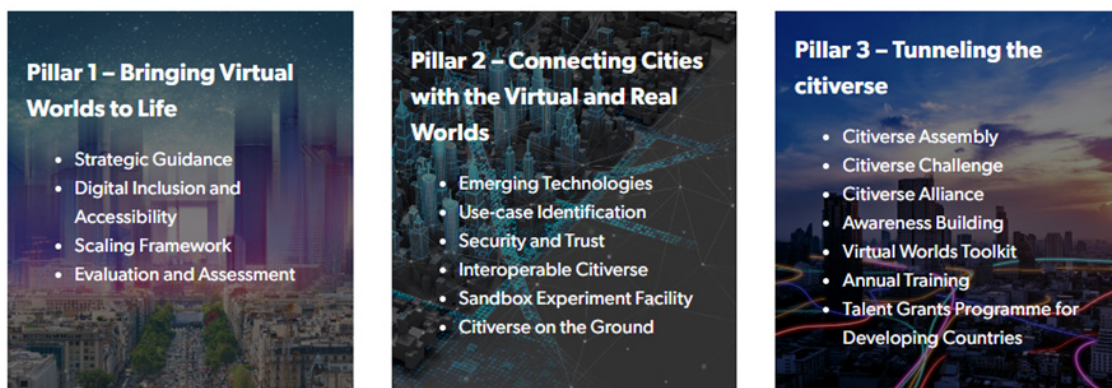


Source: Global Initiative on Virtual Worlds and AI

1.2 Introducing the Use Case Identification Track

The Initiative advances its mission through three strategic pillars, each supported by dedicated tracks that tackle the most pressing opportunities and challenges in AI-powered virtual worlds. (See Figure 2)

Figure 2: Initiative pillars and related tracks



Source: Global Initiative on Virtual Worlds and AI

This report is a deliverable under the “Use Case Identification Track” under pillar 2. Pillar 2, connecting cities with virtual and real worlds, focuses on the operational aspects of the citiverse such as the integration of emerging technologies, key uses cases and best practices and providing the environment, tools and events for city experimentation.

The use-case identification track focuses on the collection and curation of new use cases pertaining to virtual worlds, including the adoption of digital technologies such as AI, VR, AR, digital twins and AI cities. The track brings together insights on the expected opportunities, risks and maturity horizons associated with the use cases identified. The track has two core outputs:

- (1) Citiverse Use Case Taxonomy Overview – a PowerPoint presentation that provides a library of citiverse use cases
- (2) Citiverse Use Case Taxonomy: Global Insights and Implementation Pathways and its thematic reports – these reports which act as a companion to the taxonomy and provide a more detailed overview of the use cases presented.

1.3 Introducing the use case taxonomy

These reports present the first **Citiverse Use Case Taxonomy**, capturing more than 50 use cases across the following thematic areas:

- **Urban planning, placemaking and infrastructure:** This thematic area is focused on leveraging virtual worlds to transform the way we create liveable places and transform the built environment around in cities and includes topics such as placemaking and liveable spaces and urban infrastructure engineering.
- **City administration services and public participation:** This thematic area is focused on leveraging virtual worlds to transform city governance, enhance public services, and foster meaningful citizen engagement and includes topics such as public service delivery, sustainable city operations and citizen participation and co-creation.
- **Economic development, education and tourism:** This thematic area is focused on leveraging virtual worlds to provide immersive and personalised education, drive sustainable economic development in cities and promote sustainable tourism and includes topics such as the blue economy, circular economy and vocational training.
- **Transport and mobility:** This thematic area is focused on leveraging virtual worlds to transform the way people and goods move through cities and includes topics such as public transportation, active transportation and micromobility.
- **Public safety, health and disaster resilience:** This thematic area is focused on leveraging virtual worlds to strengthen public safety, health and disaster resilience and includes topics such as first responder training, health crisis management and climatic resilience.

The use cases have been curated by an international working group of experts spanning academia, city representatives, NGOs, SME and industry stakeholders following a set methodology elaborated in chapter 2. More than a catalogue of technological applications, the taxonomy offers a structured lens through which to assess the **opportunities, risks and maturity levels** associated with emerging solutions. It will help cities to identify the use cases that are in operation now and for which they can draw lessons learned from implementations in other cities, those that are currently being piloted and they should consider incorporating into their innovation pipeline and those that are still in discovery phase which point to a vision of how cities and citizens will use virtual worlds in the future.

The Use Case Taxonomy seeks to:

- Curate innovations that leverage technologies such as AI, AR/VR, digital twins, IoT and the metaverse.
- Highlight the myriad opportunities virtual worlds present for city leaders and stakeholders across diverse domains.

- Highlight international examples of best practice which with cities can draw inspiration and key lessons.
- Encourage conversation on the potential challenges and risks linked to implementation of virtual world initiatives.
- Provide a basis from which the other tracks in the Initiative to develop, for example, the emerging technologies track, security and trust track, and digital inclusion and accessibility track.

The use case taxonomy presented here is a **snapshot** of current innovation and a **foundation** for future collaboration. As cities continue to scale and expand initiatives, and experiment with pilot projects and sandbox environments, this living resource will continue to evolve. Ultimately, the citiverse is not a fixed destination – it's a journey of **collective innovation, iterative learning** and **shared urban futures**. By identifying, analysing and amplifying promising use cases, this report contributes to shaping that journey.

2 Methodology for developing the use case taxonomy

The development of the Citiverse Use Case Taxonomy followed a structured, multiphase methodology designed to ensure that the use cases identified are diverse, representative and practically relevant for cities exploring the potential of virtual world technologies. The methodology combined literature analysis, expert input, stakeholder contributions, and horizon scanning to curate and classify use cases across key thematic areas. This process was guided by the overarching objective of identifying use cases that demonstrate meaningful applications of technologies such as AI, XR, digital twins and the metaverse to support urban innovation.

2.1 Criteria for prioritising use cases

The initial phase of the Use Case Taxonomy work track focused on collecting a broad range of use cases for each thematic area from various sources, including:

- **Desk-based research** involving academic literature, industry white papers and smart city project repositories.
- **Stakeholder contributions** from members of the Use Case Identification Track and broader Global Initiative on Virtual Worlds community.

A long list was created of use cases spanning the five thematic areas. In order to create a short list for each of the thematic areas of approximately 10 use cases, the use cases were then assessed by the working group using four core criteria validated by the broader Global Initiative on Virtual Worlds Community: alignment with SDGs, scalability, impact and feasibility (See Table 1 below). Each expert scored each of the five criteria from 1–10. Those with the highest scores were then integrated into a short list for each thematic group; consideration was also given to ensure a diverse range of case studies with coverage across key topics. It's these use cases that are presented within the Citiverse Use Case Taxonomy. The Taxonomy is not intended to be an exhaustive resource; there are myriad additional virtual world use cases that can and are being implemented in cities globally.

Table 1: Citiverse Use Case Scoring Criteria

Scoring Criteria	Key Questions
1. Alignment with SDGs	To what extent does this use case contribute to one or more SDG targets?
2. Scalability	How relevant is this use case for multiple cities and how easily can it be replicated and scaled?
3. Impact	How impactful will the case study be for social, economic and environmental outcomes?
4. Feasibility	What are the long-term maintenance and resource requirements? What is the time to value?

2.2 Use case profiling

For each use case a use case profile has been created drawing together core information such as, *inter alia*, a use case description, case study and horizon mapping. The following section of the methodology elaborates the methodology for: (i) horizon mapping (ii) risk mapping and (iii) technology mapping.

2.2.1 Use case horizon mapping

To illustrate the maturity and temporal applicability of use cases, each was assigned to one of three **horizons**. The horizon stages and definitions have been drawn from IDC's methodology for horizon mapping³ and validated by the Use Case Identification Track working group of experts.

- **Horizon 1:** Solutions that are mature and currently being deployed in real-world settings.
- **Horizon 2:** Emerging use cases with demonstrated pilots or early-stage implementations.
- **Horizon 3:** Conceptual or experimental use cases that show significant long-term potential but are not yet operational. For these horizons, case studies have not been included as they are in the "discovery" phase.

This mapping allows cities to distinguish between near-term implementation opportunities, those that should be in their innovation and piloting pipeline, and forward-looking innovations that require further research and indicate how virtual worlds may evolve within urban spheres in the future.

2.2.2 Use case risk mapping

Each use case was also evaluated against four risk dimensions to help cities assess implementation challenges and mitigation needs:

- **Public safety:** Evaluates how a use case may impact the physical and digital safety of individuals and communities. It considers unintentional harms and the misuse of technology that could threaten public well-being.
- **Stakeholder acceptance:** Reflects the expected level of endorsement or opposition from key stakeholders, including city officials, community members and private partners, taking into account cultural values, political contexts and potential equity concerns.
- **Data privacy and security:** Assesses the sensitivity and volume of personal or sensitive data involved in a use case, as well as the robustness of governance, encryption and

compliance mechanisms in place to safeguard it from misuse, breaches, or unauthorized access.

- **Financial and operational risk:** Captures the potential economic and logistical challenges associated with implementing the use case, including high upfront costs, complex procurement or regulatory hurdles, ongoing maintenance requirements and the need for cross-departmental coordination or new workforce capabilities.

Risk levels were classified as low, medium, or high, based on available evidence and expert judgment. This analysis provides cities with foresight in key challenges to address before deployment.

2.2.3 Use case technology mapping

Key technologies were also selected for each use case. A pre-defined list was created from which to select relevant technologies (list and definitions provided in Table 2 below). This list is not intended to be extensive but was selected by the expert group based on the technologies most pertinent across Virtual World use cases. This list may evolve based on the work of the Emerging Technology Track and can be integrated into future iterations of the Citiverse Use Case Taxonomy.

Table 2: Citiverse Use Case Taxonomy mapping

Technology	Definition	Reference
Metaverse	An integrative ecosystem of virtual worlds offering immersive experiences to users, that modify pre-existing and create new value from economic, environmental, social and cultural perspectives. NOTE – A metaverse can be virtual, augmented, representative of, or associated with, the physical world.	FGMV-20
Digital twin	A digital twin network is a digital representation of an object of interest.	ITU-T Y.4600
Augmented reality (AR)	An environment containing real and virtual sensory components. The augmented reality continuum runs from virtual content that is clearly overlaid on a real environment (assisted reality) to virtual content that is seamlessly integrated and interacts with a real environment (mixed reality).	ITU-T P.1320
Virtual reality (VR)	An environment that is fully generated by digital means. To qualify as virtual reality, the virtual environment should differ from the local environment.	ITU-T P.1320
Mixed reality (MR)	An environment containing real and virtual components that are seamlessly integrated and interact with each other in a natural way (one end of the augmented reality continuum).	ITU-T P.1320
Internet of Things (IoT)	A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.	TU-T Y.4000

Table 2: Citiverse Use Case Taxonomy mapping (continued)

Technology	Definition	Reference
Artificial intelligence (AI)	Computerized system that uses cognition to understand information and solve problems.	ITU-T M.3080
Generative AI (GAI)	GAI refers to a broad field of research and development that focuses on creating intelligent systems that can generate new, original content such as images, videos, music, text and even entire conversations. These systems use machine learning algorithms to learn patterns and structures within the data they are trained on and then use this knowledge to generate new content that resembles the original data, but is not necessarily identical to it.	FGMV-22

2.3 Validation and peer review

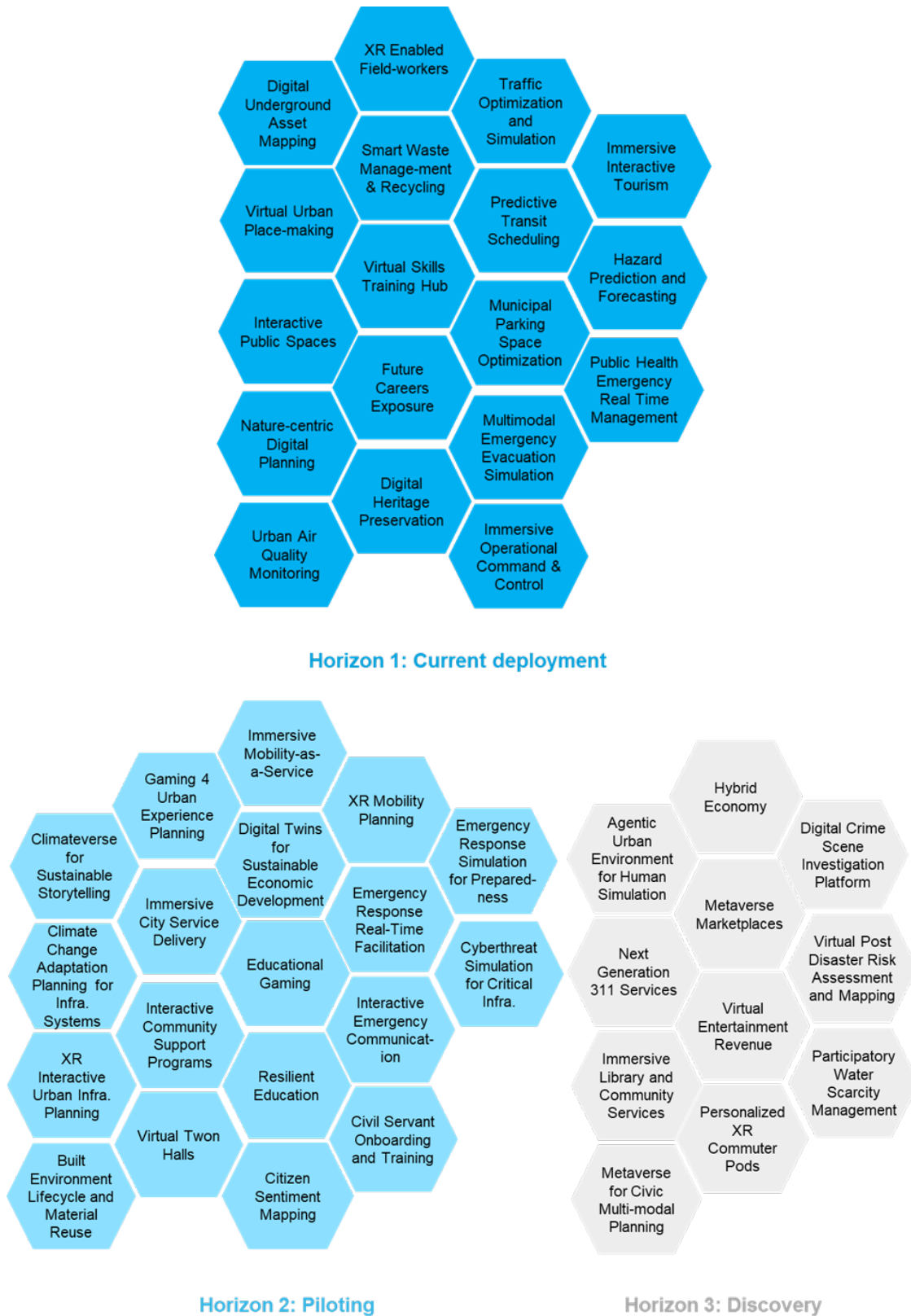
Draft use cases and thematic analyses were reviewed by a working group of experts from the Global Initiative on Virtual Worlds and AI, including representatives from academia, city representatives, multilateral organizations and industry. The taxonomy reflects their feedback.

3 Overall citiverse use case taxonomy

This chapter presents the Citiverse Use Case Taxonomy. It provides an overview of just under 50 case studies spanning five key themes pertinent to city governments and stakeholders. This taxonomy is intended to be a living catalogue that can be updated and iterated to reflect fast moving technological advances and city innovations.

While each thematic report offers a deep dive into specific domains, the overarching taxonomy allows policymakers and practitioners to see the bigger picture, showing how urban planning connects with mobility, how public participation supports resilience, and how education and economic development link to infrastructure innovation. For details of each thematic area, please refer to the five thematic reports.

Figure 3: Overall use case overview and horizon mapping



Source: Citiverse Use Case Taxonomy: Global Insights and Implementation Pathways, 2025

4 Conclusion

4.1 Key takeaways

1) Virtual worlds as urban transformation catalysts

The citiverse enables cities to create immersive, digital representations of urban environments – bridging the physical and virtual through technologies like the metaverse, digital twins, AR/VR, AI, and IoT. AI and generative AI are increasingly serving as a foundational technology that drives innovation, enhances user experiences, and supports the creation of interactive and immersive virtual environments. As Agentic AI capabilities emerge, their impact on virtual world technologies and use cases should also be explored.

The research demonstrates that virtual worlds are not merely technological novelties but fundamental infrastructure for 21st-century urban governance. Cities implementing these technologies report measurable improvements: Seoul's digital twin traffic management system achieved 20 per cent faster emergency response times, Helsinki's Virtual Helsinki attracted more than 1 million viewers during COVID-19 lockdowns, and the UK's National Underground Asset Register now provides data from 267 asset owners representing over 40 per cent of the national infrastructure community. These outcomes validate virtual worlds as essential tools for addressing complex urban challenges at scale.

2) Comprehensive thematic coverage across urban domains

Citiverse use cases span five core thematic areas: Urban Planning & Infrastructure, City Administration & Public Participation, Economic Development & Tourism, Transport & Mobility, and Public Safety, Health & Disaster Resilience. Each area leverages virtual worlds to address unique challenges, from climate adaptation and circular economy initiatives to citizen engagement and emergency management. The taxonomy reveals remarkable breadth, encompassing everything from underground asset mapping and virtual skills training to immersive cultural experiences and disaster response coordination.

The cross-cutting nature of these applications demonstrates virtual worlds' versatility as problem-solving platforms. For instance, digital twins serve urban planners for infrastructure visualization, emergency responders for disaster simulation, and citizens for immersive education and cultural experiences.

3) Alignment with global sustainability goals

The citiverse use cases mapped in the Taxonomy contribute to achievement of a broad range of SDGs, namely SDG1 (No Poverty), SDG3 (Good Health and Well-being), SDG4 (Quality education), SDG8 (Decent Work and Economic Growth), SDG9 (Industry, Innovation and Infrastructure), SDG10 (Reduced Inequalities), SDG11 (Sustainable Cities and Communities), SDG12 (Responsible Consumption and Production), SDG13 (Climate Action), SDG16 (Peace, Justice and Strong Institutions), and SDG17 (Partnerships for the Goals). This alignment positions virtual world investments as contributions to global sustainability commitments rather than isolated technology projects.

Case studies reveal specific pathways to SDG achievement: virtual skills training hubs directly address unemployment and inequality (SDGs 1, 8, 10), immersive educational platforms improve access to quality learning (SDG 4), and digital twin climate modelling supports environmental

action (SDG 13). The TRACE Centre in Scotland exemplifies this integration, training workers for green energy jobs while supporting just transitions from high-carbon industries, simultaneously addressing employment, education, and climate goals.

4) Risk-informed decision making for urban innovation

Cities must balance risk and opportunities when adopting citiverse use cases. A systematic risk taxonomy – covering public safety, stakeholder acceptance, data privacy/security, and financial/operational risk – enables cities to prioritize use cases that balance innovation with manageable risk. This approach supports informed decision making, ensuring that high-impact, scalable solutions are prioritized for early adoption, while more experimental or higher-risk concepts are piloted or explored further before city-wide rollout.

The research reveals that most public safety risks are low to medium, with virtual environments often enhancing rather than compromising safety through improved training, simulation, and coordination capabilities. However, data privacy and cybersecurity risks require sustained attention, particularly for applications handling sensitive infrastructure, personal, or financial data.

5) Critical success factors for implementation

Key success factors and lessons learned for citiverse initiatives can be drawn from across the case studies highlighted within this report, including, *inter alia*:

Establish open standards and interoperability: Successful citiverse implementations hinge on defining and adopting common data models, APIs, and semantic frameworks that enable seamless data exchange across platforms. The UK's NUAR project demonstrated the power of a shared international underground-asset data model (MUDDI) in uniting 267 asset owners and multiple agencies under one digital twin. By aligning on open standards early, cities avoid data silos, accelerate solution replication, and reduce vendor lock-in. ITU-T Study Group 20 "Internet of Things, digital twins and smart sustainable cities and communities" is developing international standards on the Citiverse, which serve as a global platform to promote interoperability, trust, and scalability across city, industry, and government implementations⁴.

Build Robust, adaptive governance frameworks: Beyond technology, governance structures must evolve to manage roles, responsibilities and risk over time. Digital twins in Copenhagen's Street Lab thrive because city agencies, private operators, and academic partners collaborate, sharing decision rights and data stewardship duties. Establishing clear governance policies – covering data ownership, quality assurance, and change management – ensures sustainability.

Foster multistakeholder collaboration and engagement: No single organization can master the citiverse alone. Seoul's Metaverse Seoul succeeded by co-creating with community groups, technology firms and civil society. Early engagement builds trust, surfaces hidden requirements, and secures buy-in from end users. [Global Initiative on Virtual Worlds and AI - Discovering the Citiverse](#) provides a multistakeholder platform to connect governments, cities, industry, and academia in shaping interoperable, human-centric virtual worlds.

Sequence deployment with phased, incremental pilots: Phased rollouts mitigate risk and build momentum. The UK's CReDo project began with targeted flood-impact pilots before expanding to multi-infrastructure resilience planning. Starting with small, well-scoped use cases yields quick wins, validates concepts, and fosters stakeholder confidence.

Balance technical infrastructure with organizational change management: Technologies such as digital twins and immersive XR platforms can require significant infrastructure investments – 3D modelling, cloud services, sensor networks – but technology alone does not guarantee impact. Nottingham City Council's digital twin integrated dedicated organizational change teams that guided developers, planners, and the public through new workflows. Dedicated change-management resources – training, communication plans, and feedback channels – are as critical as servers and software.

Prioritize security, privacy, and trust by design: Several citiverse use cases highlighted in this taxonomy integrate personal, infrastructure, and IoT data. Embedding security and privacy at every layer – network segmentation, end-to-end encryption, consented data sharing, and role-based access controls – ensures resilience against breaches.

Invest in continuous monitoring and evaluation: Iterative improvement depends on real-time performance data and structured assessments. Seoul's traffic digital twin reduced emergency response times by 20 per cent by continuously refining AI models based on live sensor feedback.

Cultivate an inclusive, accessible design ethos: While virtual worlds can democratize participation, they risk excluding those with low digital literacy, limited device access, people with visual impairments and neurodivergence. Implementing universal design principles – support for multiple input modalities, low-bandwidth modes, multilingual interfaces – among other design considerations can help to ameliorate these challenges.



6) Citiverse and AI initiatives are particularly well suited for achieving the following strategic outcomes:

Foster inclusive, accessible forums for civic engagement such as virtual town halls, and participatory planning – empowering citizens to co-create policy and urban spaces regardless of physical barriers. Virtual environments can democratize participation by removing geographic, temporal, and accessibility constraints that traditionally exclude vulnerable populations from urban planning processes. Seoul's Metaverse Seoul platform and Barcelona's citizen sentiment mapping initiatives demonstrate how digital platforms can amplify previously marginalized voices in municipal decision making. However, citiverse applications can also create new accessibility challenges. The Digital Inclusion and Accessibility Track of the Global Initiative on Virtual Worlds and AI is creating guidance to support cities and other stakeholders to address these challenges and promote an inclusive by design approach.

Enable data-driven, resilient and sustainable city services and infrastructure including optimizing infrastructure, transport systems, managing resources efficiently, and modelling scenarios for climate resilience, disaster preparedness, and operational efficiency. Digital twins and AI-powered analytics transform reactive maintenance into predictive management, reducing costs while improving service reliability.

Climate adaptation emerges as a critical application area, with digital twins enabling cities to model flooding scenarios, optimize green infrastructure placement, and coordinate multiagency responses to extreme weather events. The UK's CReDo project showcases how cross-sector data sharing through digital twins improves collective resilience against climate risks, while supporting more efficient capital investment decisions.

Revolutionize education, vocational training, and onboarding for students and city employees through safe, engaging, and personalized learning experiences, supporting lifelong learning and workforce adaptability in rapidly changing economies. The TRACE Center's success in training more than 1 200 workers for green energy careers demonstrates virtual worlds' potential for large-scale workforce transformation.

Immersive educational platforms prove particularly effective for complex, high-risk, or expensive-to-access learning environments. These applications support formal education systems and continuous professional development across municipal workforces.

Drive economic diversification and cultural preservation as the citiverse opens new avenues for economic growth through virtual marketplaces, immersive tourism, digital heritage preservation, and support for creative industries. These use cases promote local economic resilience, cultural continuity, and global accessibility while reducing environmental impacts associated with physical tourism and commerce.

Virtual tourism platforms demonstrate particular promise for cultural sites facing overtourism pressures or climate threats. Digital heritage preservation projects create permanent records of vulnerable sites, while generating new revenue streams through virtual experiences. The Global Digital Heritage initiative and various virtual museum experiences show how cities can simultaneously preserve cultural assets and expand global access to local heritage, creating sustainable tourism models that benefit communities without overwhelming physical infrastructure.

Promote sustainability across all aspects of the city from mapping and designing with nature, facilitating circular economy and recycling through waste management and the built environment, providing educational opportunities including gamifying sustainable behaviours and modelling climate change adaptation strategies. Virtual worlds enable comprehensive sustainability integration by making complex environmental data accessible to citizens, supporting behaviour change through gamification, and optimizing resource use through predictive modelling.

Educational gaming platforms like Scubaverse demonstrate how immersive experiences can build environmental awareness and drive behaviour change at scale. Digital twins support circular economy initiatives by tracking material flows, optimizing waste collection routes, and enabling collaborative planning for resource efficiency.

Create hospitable worlds and creative experiences and places by establishing new mediums for artistic expression, cultural participation, innovative public spaces and forums, personalization of experiences and community connection and wellness. Virtual worlds expand the concept of public space beyond physical boundaries, creating inclusive environments where diverse communities can gather, create, and celebrate regardless of geographic or economic constraints.

Arts and cultural programming in virtual environments enable new forms of creative expression, while preserving traditional cultural practices. Virtual Helsinki's integration of live music performances with interactive city exploration and Burning Man's virtual placemaking experiments demonstrate how digital environments can augment rather than replace physical cultural experiences, creating hybrid models that expand access while maintaining authentic community connections.

7) Future-oriented urban innovation

The taxonomy reveals that virtual worlds are transitioning from experimental technologies to essential urban infrastructure. Looking forward, the convergence of virtual worlds with emerging technologies like advanced AI, and quantum computing will enable even more sophisticated applications. Cities must begin building foundational capabilities now – including data governance frameworks, digital literacy programmes, and cross-sector partnerships – to capitalize on future opportunities while ensuring equitable access to virtual world benefits across all community members.

4.2 Next steps

Going forward, the Use Case Identification Track's comprehensive taxonomy of citiverse applications will directly inform ongoing tracks under the Global Virtual Worlds and AI Initiative, for example:

- The taxonomy will directly inform the **Emerging Technologies Track** by highlighting priority areas for technology maturation and integration paths for AI, GAI, XR, digital twins, and IoT.
- Insights on risk profiles, stakeholder dynamics, and governance models from the Use Case Identification Track will feed into the **Security and Trust Track**, enabling development of tailored guidelines and trust mechanisms – ensuring that virtual world deployments uphold user safety, data integrity, and regulatory compliance.

- Case studies, success factors, and lessons learned distilled by the Use Case Identification Track will power the **Awareness-Building Track's** outreach, stakeholder education, and capacity-building programmes.
- Insights on the use cases that the citiverse can and is being applied to will inform the Digital **Inclusion and Accessibility Track's** work on ensuring that the right questions are asked in terms of digital skills, visual impairment and neuro-divergence.
- Findings from the taxonomy will provide an evidence-based foundation for the Strategic Guidance Track, supporting the development of high-level recommendations and policy frameworks that help governments, cities, and industry align virtual world adoption with broader sustainable development and digital transformation agendas.



About the Global Initiative on Virtual Worlds and AI - Discovering the Citiverse

Launched by ITU, UNICC, and Digital Dubai, the [Global Initiative on Virtual Worlds and AI - Discovering the Citiverse](https://www.itu.int/metaverse/virtual-worlds/) is a multistakeholder platform dedicated to shaping the next generation of AI-powered virtual worlds⁵.

These immersive digital environments are transforming how people live, learn, govern, and interact. The Initiative ensures that AI-powered virtual worlds evolve in ways that are inclusive, interoperable, and human-centric – and that they help deliver on the Pact for the Future and its Global Digital Compact.

Serving as a neutral and action-oriented platform, the Initiative brings together cities, governments, UN agencies, private sector companies, academia, and civil society to collaboratively shape the responsible development and deployment of these technologies.

The Initiative advances its mission through three strategic pillars, each supported by dedicated tracks that address the most urgent challenges and promising opportunities in AI-powered virtual worlds. This comprehensive structure enables the Initiative to deliver both high-level global guidance and practical implementation in cities worldwide.

The Initiative is supported by over 70 international partners.

For more information, please visit: <https://www.itu.int/metaverse/virtual-worlds/>.

Meet the Champions

Champions are entities that demonstrate leadership by providing financial contributions in support of the Initiative. This may include funding for events, challenges, research outputs, communication activities, trainings, travel grants, or other related efforts.



Meet the Founding Partners

Founding Partners are the organizations that launched the Initiative. They serve as the core convening entities and contribute to shaping its long-term vision. The Founding Partners are:



Meet the Supporters

Supporters are organizations that have expressed endorsement of the Initiative and actively participate in its activities. This includes, but is not limited to, participation in tracks, contribution of use cases, co-organization of events, provision of expertise, or public advocacy of the Initiative.





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