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RESEARCH ARTICLE

Integrating Artificial Intelligence and Augmented Reality for Organisational Strategy, Change, and Innovation in Urban Governance

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Abstract

Purpose: This research examines how combining Artificial Intelligence and Augmented Reality (AI-AR) changes urban governance. By means of case studies in urban planning and emergency management, it links these changes to UN SDG 11 and measures administrative efficiency and decision-making effects.

Design/methodology/approach: The study employs a comparative multiple-case analysis in conjunction with a systematic literature review (SLR). With clear inclusion and exclusion criteria based on integrated AI-AR applications with quantifiable results pertinent to SDG 11, a PRISMA-informed screening process was implemented. Cross-context comparison was made with six consciously chosen cases.

Findings: AI-AR transforms reactive to prospective systems and emergency response from static 2D methods to immersive, participative, data-driven models in urban planning. Cases show improvements in efficiency, fewer errors, higher participation, and resource optimisation using predictive analytics and immersive overlays.

Implications: AI-AR automates analysis, lowers mistakes, democratises knowledge for people and front-line staff, and encourages inclusive, fair results. It speeds up the move to digital transformation towards people-centred, resilient governance in the face of urbanisation and climate change pressures.

Originality/value: This study bridges the gap between AI-AR applications and governance outcomes by combining theoretical perspectives, comparative case evidence, and measurable administrative outcomes, offering valuable implications for policy and sustainable urban development.

JEL Classification: H83, O3, Q55, R58

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Introduction

Cities, defined as high-density population centres with at least 50,000 inhabitants, have experienced unprecedented growth over the past several decades. In 1950, only about 20% of the global population resided in urban areas. By 2025, this proportion had increased to approximately 45% of the world's 8.2 billion people, reflecting the accelerating pace of urbanisation worldwide (United Nations, 2025). The population of cities grew faster than that of towns and rural areas between 1950 and 1970 in most regions, making cities the predominant form of settlement globally. In the last twenty-five years, the global population living in cities increased by 1.25 billion.

The number of countries and territories in which the majority of the population resided in urban areas increased from 47 to 78 between 1975 and 2000. The number of cities in the world more than doubled from 5,851 in 1975 to 12,140 by 2025.

In 2025, the world comprised more than 12,000 cities, including 33 megacities (10 million or more inhabitants), 49 large cities (5–10 million), 429 medium-sized cities (1–5 million), 1,822 small cities (250,000–1 million), and 9,807 cities with fewer than 250,000 inhabitants. The number of megacities increased markedly from 8 in 1975 to 33 in 2025 (United Nations, 2025). Table 1 presents the top ten world cities.

Table 1: Top 10 Most Populous Cities in the World

City Size Rank	City and Country	Population (millions)
1	Jakarta, Indonesia	42
2	Dhaka, Bangladesh	37
3	Tokyo (Tokyo), Japan	33
4	New Delhi, India	30
5	Shanghai, China	30
6	Guangzhou, China	28
7	Al-Qahirah (Cairo), Egypt	26
8	Manila, Philippines	25
9	Kolkata, India	23
10	Seoul, Republic of Korea	22

Note. Compiled from United Nations World Urbanisation Prospects 2025 (United Nations, 2025)

Jakarta is the most populous city, followed by Dhaka and Tokyo. However, World Population Review (2026) comes up with another list, with Tokyo at almost 36.95 million, Delhi at 35.51 million, and Shanghai at 31.04 million as the top three most populous cities.

This demographic shift strains conventional planning and governance systems beyond their capacity and raises the need for public services, energy, water, transportation, and housing (Khanal, 2024).

The urban share, including cities and semi-dense areas, is around 81%, with rural villages making up barely 19%. Driven mostly by smaller and medium-sized urban hubs in Africa and Asia, projections show that two-thirds of worldwide population growth through 2050 will occur in cities. Rapid urbanisation is placing tremendous strain on cities all over and is radically changing public-sector work processes, administrative systems, and the direction of governance work in a climate-limited, progressively digital world.

This study examines how the integration of Artificial Intelligence (AI) and Augmented Reality (AR) reshapes urban governance by enhancing administrative efficiency, decision-making, and inclusivity in urban planning and emergency management. The convergence of AI and AR represents a transformative advancement in public administration, enabling immersive, data-driven approaches to addressing the complexities of contemporary urban environments (Zuiderwijk et al., 2021). Accordingly, this study focuses on two key areas: (a) AI–AR applications in urban planning and emergency management through comparative case analysis, and (b) the measurable impact of AI-powered AR on administrative efficiency and decision-making. The integration of AI and AR is transforming urban governance by enhancing administrative efficiency, decision-making, public participation, and resilience in urban planning and emergency management. By combining AI-driven analytics with immersive AR visualisation, these technologies enable evidence-based planning, real-time situational awareness, and more inclusive governance processes while reducing administrative delays, errors, and resource inefficiencies (Wirtz et al., 2019; Zuiderwijk et al., 2021).

Despite increasing applications of AI and AR in smart cities, existing research has largely examined these technologies independently or focused on technical implementation, with limited attention to their measurable administrative outcomes and implications for governance. This study addresses this gap by synthesising recent empirical evidence and comparative case studies to examine how AI–AR integration improves governance performance, including administrative efficiency, decision quality, resource allocation, and citizen participation. It further extends existing digital governance frameworks by demonstrating how AI–AR supports sustainable and inclusive urban governance aligned with the United Nations Sustainable Development Goal 11 (Sustainable Cities and Communities), while providing evidence-based insights to guide policymakers and public administrators in the responsible adoption of AI-enabled immersive technologies.

Research Methods

This study adopts a SLR combined with a comparative multiple case analysis to examine how AI–AR integration reshapes urban governance processes. Guided by the established systematic review protocols of Webster and Watson (2002) and Tranfield et al. (2003), the study ensures analytical rigour, transparency, and reproducibility. A systematic search was conducted across major academic databases, including Scopus, Web of Science, IEEE Xplore, and Google Scholar, using carefully constructed Boolean search strings combining terms related to “AI”, “AR”, and “urban governance”. The review was restricted to peer-reviewed publications and high-quality institutional reports published between 2023 and 2025, with additional insights drawn from global policy sources such as the OECD and the United Nations to ensure both academic and policy relevance.

A PRISMA-informed screening process was employed to systematically identify, filter, and select relevant studies, ensuring methodological transparency and minimising selection bias. Explicit inclusion and exclusion criteria were applied, focusing on studies that demonstrate integrated AI–AR applications within urban governance contexts, particularly those aligned with SDG 11 objectives. To complement the literature review, a purposive sampling strategy was used to select six illustrative case studies representing diverse governance and technological contexts, including initiatives from Singapore, Helsinki, Dubai, FEMA, Tokyo, and the Netherlands. Cases were selected based on demonstrated AI–AR integration, availability of measurable outcomes (e.g., efficiency gains, participation rates), and relevance to urban planning and emergency management, thereby enabling robust comparative insights across varying institutional and socio-technical environments.

Data extraction was conducted using a structured framework capturing key dimensions such as AI capabilities, AR functionalities, governance domains, performance outcomes, and ethical considerations. The analysis followed a two-stage approach, combining thematic analysis with cross-case comparative evaluation to identify recurring patterns and divergences across contexts. An analytical lens encompassing technological capability, governance transformation, and societal impact was applied to develop an integrative understanding of AI–AR-enabled governance. To enhance validity, the study employed data triangulation across multiple sources and cross-case validation, while explicitly acknowledging limitations such as reliance on secondary data and potential publication bias. Ethical considerations, including algorithmic bias, data privacy, and digital inequality, were critically incorporated into the analysis.

Theoretical Underpinning and Conceptual Foundations

This study is grounded in three interconnected theoretical lenses that explain why and how AI-AR influences urban governance: Urban Governance Theory, AI Governance, and Responsible Innovation.

According to Urban Governance Theory, governance is a multi-actor, networked process negotiating resources, power, and sustainability, including government, private sector, and civil society (Pierre, 1999; Baud et al., 2021). Emphasising participation and flexibility in complicated urban systems, it transforms from hierarchical administration to cooperative partnerships.

Using participatory planning, AI-AR translates this by means of immersive platforms for stakeholder co-creation, bridging theory to practice via increased inclusion and shared decision-making in dynamic urban surroundings.

OECD AI Principles and NIST AI Risk Management Framework, among others, emphasise human supervision, accountability, justice, and transparency in AI implementation. This perspective helps to eliminate dangers such as bias in prediction models in metropolitan settings and encourages trustworthy systems.

By integrating the analytic capability of AI with the intuitive interfaces of AR, AI-AR guarantees governance stays human-centred. (Real-time overlays with intelligible predictions in emergency response).

According to Yigitcanlar et al. (2021), responsible innovation emphasises inclusive, responsive, reflective, and anticipatory processes to align innovation with societal value. It requires balancing benefits (efficiency, resilience) with risks (privacy, equity) for AI-AR. In practice, ethical audits, inclusive design, and iterative pilots stressing SDG 11 results, like fair access in various urban contexts, help to achieve this.

Together, these theories → frameworks → practice by placing AI-AR as a tool for networked, responsible, and ethically based urban governance. AI drives predictive intelligence while AR enables immersive participation, and responsible mechanisms guarantee fair translation into resilient cities.

Findings

AI-AR Applications in Urban Planning

Traditional urban planning depended on static two-dimensional images, which frequently resulted in misinterpretations and projects detached from real-world processes. Fostering data-driven and inclusive design, AI-AR integration lets immersive, participatory procedures overlay virtual models over actual settings

Longer iterations, planner-to-policymaker-and-community miscommunications, and designs failing to consider dynamic urban realities such as population flows, microclimates, or social behaviours often result from these traditional instruments.

Stakeholders may see, interact with, and collectively modify ideas using these technologies, which superimpose virtual models on real locations. Actual events in Singapore, Helsinki, Dubai, FEMA, Tokyo, and the Netherlands show how practical applications encourage resilience and public involvement.

Integration of AI and AR fundamentally upsets this model, allowing for a change to immersive, data-enriched, participatory activities that link theoretical planning with experience and promote inclusive design approaches.

Conceptual Foundations

AI–AR-enabled urban planning integrates predictive analytics with immersive visualisation to support evidence-based, participatory, and sustainable decision-making. Building on digital twin technologies, AI analyses geospatial, demographic, and environmental data to generate predictive models and design alternatives, while AR employs Simultaneous Localisation and Mapping (SLAM) algorithms to deliver context-aware, real-time visualisations and intuitive user interaction (Abdeen & Sepasgozar, 2022). Grounded in data-driven governance, algorithmic urbanism, participatory GIS, and universal design principles, AI–AR expands citizen participation by enabling stakeholders to visualise, evaluate, and co-create urban development scenarios regardless of technical expertise (Raymond et al., 2025). Practical applications, including Virtual Singapore, Helsinki's Augmented Urbans, and Dubai's AI Advisor, demonstrate improvements in planning efficiency, public engagement, and evidence-based decision-making, while FEMA's AR-enabled disaster simulations highlight the technology's potential for emergency preparedness. Despite these advances, challenges related to algorithmic bias, data interoperability, computational infrastructure, privacy, and equitable access remain critical considerations for the responsible adoption of AI–AR in urban governance.

Case Studies

This section presents three representative case studies illustrating how the integration of AI and AR enhances inclusive, resilient, and data-driven urban governance.

Case Study 1: Virtual Singapore: Virtual Singapore, the nation's digital twin platform, exemplifies AI–AR-enabled urban planning by allowing planners to overlay real-time visualisations, such as flood-risk maps and green infrastructure scenarios, onto physical environments to support evidence-based planning and decision-making (Lei et al., 2024).AI algorithms processed past climate information and population forecasts in pilots for districts to create AR versions of neighbourhood designs, shortening planning cycles. Collected via AR annotations, citizen input guided changes that increased involvement over conventional techniques.

One of the most sophisticated national-scale implementations of a digital twin incorporating AI and AR features for urban planning is Singapore's Virtual Singapore. Originally designed as a collaborative platform by the National Research Foundation and Singapore Land Authority. It produces a high-resolution, semantically rich 3D model of the whole island-state with real-time and historical information on buildings, infrastructure, geography, population mobility, environmental circumstances, and utilities (Lei et al., 2024).

Predictive simulations in the twin, powered by AI techniques, simulate scenarios including traffic demand under fresh building, microclimate influences from high-rise additions, urban heat island reduction, solar panel optimisation, or traffic demand under new construction

AI processes real-time inputs, like satellite imagery, IoT sensor data, and mobility patterns, to forecast outcomes like traffic congestion, energy consumption, or heat island effects. Logistics and climate adaptation have recently shown scalability in expansions.

These methods not only let Singapore rapidly adjust to changes in daily life but also improve data-driven decision-making in all kinds of sectors, hence demonstrating how Singapore uses AI to create responsive, smooth urban environments while also raising serious concerns about surveillance, privacy, and behavioural control in a well-coordinated, state-managed model.

By linking systems across more than 70 government entities to provide citizen services, healthcare, transportation, and municipal operations, Singapore's Smart Nation best shows governance-centric AI implementation.

By integrating subjective visual perceptions and public feedback into scenario simulation, perception-powered digital twins further support human-centred planning (Luo et al., 2025). Community participation models in digital twins also enable broader stakeholder input through virtual environments (Abdeen & Sepasgozar, 2022). Accelerated decision-making via fast scenario iteration, decreased reliance on expensive physical models, and increased cross-agency cooperation via a shared, authoritative data platform are among the obvious administrative advantages.

Enhancements by 2024–2025 included multilingual virtual assistants learning from interactions and adaptive AI chatbots increasing accessibility and real-time service delivery efficiency. Singapore has emerged as a leader in digital governance thanks to this comprehensive strategy, which has robust infrastructure enabling inter-agency collaboration, cybersecurity, and moral supervision. These enhancements reflect evolving paradigms in public administration where AI fosters intelligent, responsive governance systems (Zhu et al., 2025). Citizen involvement rises when citizens investigate ideas online, providing comments that guide sustainable development consistent with Singapore's Smart Nation vision.

This case highlights how AI-AR helps connect technical expertise with public opinion and turns theoretical concepts into real-life experiences. As AI anomaly detection flagged zoning conflicts, administrative teams noted decreases in revision cycles. Although integration presents problems like keeping data fresh and ensuring privacy protection, the platform shows how AI-AR changes planning from passive to proactive and inclusive.

Case Study 2 – Helsinki's AR-Enhanced Participatory Planning: Another case is Helsinki's AR-enhanced participatory planning, where residents use AR tools to walk through AI-simulated worlds, seeing traffic flows, energy-efficient buildings, and biodiversity effects superimposed on the actual environment (Kyttä et al., 2023).

Helsinki has led AR-enhanced participative planning, especially through initiatives like Summer Streets, which temporarily transform residential streets into pedestrian-priority zones complete with more greenery, seating, and public amenities during warmer months.

Helsinki's AI-enhanced weather and energy forecasting tools have significantly boosted prediction accuracy, supporting proactive urban zoning and resource planning. In emergencies, AR's contextualisation appears to boost responder confidence, as shown in recent prehospital care studies, building confidence through real-time guidance. AI-driven administrative dashboards speed up approvals and help to combine siloed data.

Earlier pilots in the Kallio area are built upon in recent versions that use AR technologies to involve citizens in co-designing these changes (Kyttä et al, 2023). Participants see suggested modifications superimposed on real streets using mobile AR software.

Real-world settings show virtual plants, benches, play spaces, or traffic calming devices, which let users stroll around suggested layouts and offer comments via interactive annotations or game-based features.

Integrating with participatory GIS systems and SoftGIS captures place-based preferences, thereby giving top priority to community input on walkability, safety, and liveability. This method promotes inclusivity by involving many different groups, such as kids and neighbourhood businesses, in significant ways that regular meetings sometimes miss. Faster consensus-building, less opposition via early visualisation, and cost-effective temporary implementations guided by virtual testing are among administrative efficiency improvements.

Recent pilots with AI-driven 3D visualisation tools (such as UrbanistAI) in Helsinki's Summer Streets workshops demonstrate how generative visuals accelerate dialogue and consensus in participatory redesign (Larsen, 2024). VR/AR prototypes in Helsinki's participatory policy-making processes further strengthen citizen co-creation and policy visualisation (Shakibamanesh et al., 2025). Good resident and corporate input from pilots justifies continuation since AR shows its part in democratising urban design and matching Helsinki's people-first planning approach.

Case Study 3 – Dubai's AI Advisor for Density Planning: Dubai employs an AI-driven advisor system that marks a global first in generative AI for urban planning. This helps Dubai's goal of a cognitive, data-driven city by combining with more general smart projects like Dubai Pulse and digital twins for a single urban monitoring mechanism.

Administrative effects include cost savings from virtual optimisation, simplified approvals via predictive validation, and better alignment with long-term objectives such as lower vehicle dependency and improved livability.

Though the advisor demonstrates AI-AR's ability to fairly and effectively handle sophisticated development, challenges include scalability across mega-projects and making sure inclusivity in high-density areas.

This approach aligns with AI applications in high-density and tall-building development in Dubai, where predictive analytics optimise zoning and sustainability metrics (Emad, 2025). Global digital-twin perspectives highlight Dubai's integration of AI for smart-city density optimisation and resource balancing (Alvi et al., 2025).

Comprehensive urban digital-twin reviews confirm that Dubai's projects achieve similar efficiency gains to Singapore's through AI-driven scenario testing (Mazzetto, 2024).

Synthesis of Urban Planning Cases: Convergent strengths of AI-AR in urban planning are shown in the three cases: Singapore's complete digital twin, Helsinki's community-focused augmented reality involvement, and Dubai's density-optimised AI guidance.

Common components include immersive visualisation for stakeholder buy-in, predictive analytics for risk-informed decisions, and efficiency gains via virtual iteration. The following Table 2 gives the comparative analysis of the case studies.

Table 2: Comparative Analysis of AI-AR in Urban Planning Cases

Case Study	Key AI-AR Feature	Efficiency and Decision-Making Impact	Inclusivity and Participation Benefits
Singapore's Virtual Singapore	National-scale digital twin with AI simulations and AR overlays	Rapid scenario testing; reduced physical prototyping and approval cycles	Shared platform for cross-agency and citizen exploration
Helsinki's AR-Enhanced Planning	Mobile AR for street redesign visualisation and participatory GIS	Faster consensus; lower consultation costs	Gamified, accessible input from diverse residents (e.g., increased participation in underrepresented groups)
Dubai's AI Advisor	ML-optimised density models with AR walkthroughs	Streamlined approvals; predictive resource balancing	Stakeholder immersion in high-density proposals

Note. Compiled by Author

Singapore excels in scalability at national level, Helsinki in community-driven processes, and Dubai in generative optimisation for density. Common benefits include reduced planning cycles and enhanced decision quality through immersive feedback. Differences highlight contextual adaptability: centralised infrastructure supports broad twins (Singapore), while mobile tools boost local participation (Helsinki).

Together, these cases demonstrate a transition from two-dimensional abstraction to interesting, inclusive approaches that improve administrative efficiency, decision quality, and equality. They emphasise how promising AI-AR is for advancing sustainable urbanism.

The transition to immersive approaches also supports AI-driven urban intelligence for generative design and decision support (Bittencourt & Faccioni Filho, 2026).

AI-AR Applications in Emergency Management

Traditionally, emergency management has operated reactively, focusing on post-event damage assessment, resource mobilisation under uncertainty, and coordination amid fragmented information. In contrast, the integration of AI-AR enables real-time situational awareness, supporting faster, more informed decision-making and shifting emergency response from reactive operations to proactive risk management (Ameen & Qadir, 2025). This section presents three case studies demonstrating how AI–AR enhances emergency management through predictive analytics, real-time visualisation, and dynamic resource allocation. By analysing historical and real-time data, AI identifies potential secondary hazards and optimises response strategies, while AR delivers contextual information to responders in the field. These capabilities are particularly valuable in densely populated urban areas vulnerable to cascading disasters, such as earthquakes, floods, and wildfires, where timely decisions are critical to reducing operational delays, resource inefficiencies, and risks to responders and affected communities. The integration of AI-AR enhances anticipatory resilience by enabling organisations to forecast potential threats, simulate alternative scenarios, provide employees with experiential training, and deliver real-time contextual insights during operations.

Theoretical and Conceptual Foundations of AI–AR in Emergency Management

The integration of AI-AR provides a conceptual foundation for transitioning emergency management from reactive response to proactive risk mitigation and adaptive recovery. AI enhances emergency preparedness by integrating multi-source data, including IoT sensors, satellite imagery, weather forecasts, historical incident records, and social media feeds, to predict hazards, optimise resource allocation, and model cascading disaster impacts with greater accuracy. Complementing these capabilities, AR delivers AI-generated insights through immersive, real-time visualisations, enabling responders to identify hazard zones, evacuation routes, critical infrastructure, and structural vulnerabilities in the field. Together, AI and AR improve situational awareness, reduce cognitive burden, and strengthen inter-agency coordination and decision-making in high-pressure environments (Ameen & Qadir, 2025). In addition, AR-based simulations facilitate realistic training for complex emergency scenarios, enhancing preparedness without exposing responders to physical risk.

Grounded in resilience and anticipatory governance frameworks, AI–AR supports inclusive disaster management by incorporating vulnerable populations into predictive modelling and decision-making processes (Saengtabtim et al., 2025; Zhu et al., 2025). Despite its transformative potential, successful implementation depends on addressing challenges related to data quality, interoperability, algorithmic bias, privacy, and human oversight to ensure transparent, equitable, and trustworthy emergency management systems.

Case Study 1: FEMA's AI-AR Disaster Applications: The U.S. Federal Emergency Management Agency (FEMA) increasingly incorporates AI for predictive analytics and decision support across disaster phases, preparedness, response, recovery, and mitigation, while AR enhances training and operational visualisation (FEMA, 2025).

AI systems predict effects by processing geospatial and vulnerability data, for example, by combining social vulnerability indices with meteorological patterns for resource pre-positioning or damage estimation post-event.

AR improves this by training programmes that overlay virtual hazards (e.g., smoke, fire, structural collapse) onto actual environments, thereby enabling first responders to practice in well-known situations with simulated threats. Integrating with geographic platforms fosters cooperative collaboration.

Administrative effects comprise accelerated situational awareness, lower training expenses through repeatable virtual drills, and enhanced equity through vulnerability-focused forecasts. Integration issues remain in ethical governance and employment adoption.

Integrated digital-twin and AR frameworks also support humanitarian logistics and urban disaster response, directly applicable to FEMA's predictive and training operations (Abrishami & Jayaram, 2025).

Case Study 2 – Tokyo's Post-Earthquake AR Headset Drills: Tokyo is situated in one of the world's most seismically active regions, making disaster preparedness a national priority. Building on Japan's well-established disaster management culture, the city has integrated AI and AR into earthquake preparedness programs to enhance the capabilities of both emergency responders and the public (Fan et al., 2021). Using AR headsets, participants engage in highly immersive post-earthquake simulations where they encounter virtual injured victims, collapsed structures, debris fields, and realistic aftershocks while performing search-and-rescue operations, evacuation coordination, and triage. AI continuously analyses participant performance and dynamically adjusts the simulation by introducing variables such as crowd panic, infrastructure failures, blocked evacuation routes, and increasing levels of complexity, thereby creating adaptive and personalised training experiences.

During post-earthquake preparedness exercises, AI integrates seismic sensor data with real-time mobility information to generate AR overlays that display safe evacuation routes, assembly points, and hazard zones. Field evaluations have shown that these AI-enhanced AR simulations reduce evacuation times and improve decision-making under emergency conditions. Additionally, AR-based haptic feedback provides users with realistic sensory cues, further strengthening situational awareness and procedural learning. AI also streamlines post-exercise evaluation by automatically analysing event logs and participant performance, significantly reducing debriefing time while enabling more comprehensive performance assessments. These capabilities demonstrate how the integration of AI and AR can strengthen disaster preparedness and potentially save lives in earthquake-prone environments.

The adoption of AI-integrated AR training offers several operational and administrative benefits, including accelerated skill acquisition, enhanced inter-agency coordination, improved emergency preparedness through repeated risk-free practice, reduced dependence on costly physical training infrastructures, and scalable training for diverse stakeholder groups. Comparable AR-based substitutional reality simulators developed in Japan likewise provide immersive, location-specific earthquake preparedness experiences that enhance procedural memory without exposing participants to physical danger (Ishihara et al., 2024). By cultivating contextual awareness, rapid decision-making, and muscle memory before disasters occur, Tokyo's AI-enabled AR strategy exemplifies a proactive and resilient approach to emergency management that reduces uncertainty and strengthens community preparedness.

Case Study 3 – Netherlands' EU Horizon AR Flood Control System*:* The Netherlands has adopted AI-integrated AR systems to strengthen flood preparedness and response through several EU-supported initiatives (Ameen & Qadir, 2025). By combining AI-driven hydrological modelling with drone imagery and real-time environmental data, these systems forecast water levels, identify breach risks, and predict inundation patterns. AR headsets and tablet-based applications enable emergency responders and planners to visualise flood maps, evacuation routes, infrastructure vulnerabilities, and adaptive barriers directly within real-world environments, improving situational awareness and decision-making.

AI supports proactive resource deployment and enhances coordination by integrating cross-agency data through shared dashboards, while AR provides immersive visualisation for planning and response. Field applications have demonstrated improved hazard prediction, faster coordination, and more efficient emergency logistics. In addition, AI automates data analysis and post-event assessment, reducing administrative workload and supporting timely operational decisions (Symeonidis et al., 2023).

The integration of AI and AR enhances preparedness through realistic scenario planning, strengthens inter-agency collaboration, and reduces uncertainty during flood emergencies. AR-based visualisation also facilitates stakeholder engagement by making complex flood risks easier to understand, while AI-driven predictions help minimise unnecessary evacuations and optimise resource allocation. Similar mixed-reality and tablet-based AR applications have further improved public preparedness and emergency response capabilities in flood-prone regions (Terfurth, 2026). Despite ongoing challenges related to data integration and accessibility, the Netherlands demonstrates how AI-enabled AR can support scalable, anticipatory, and climate-resilient flood management.

Synthesis of Emergency Management Cases: The cases of FEMA, Tokyo, and the Netherlands all point to the role that AI-AR plays in moving emergency management towards anticipation and resiliency. Predictive ability comes from AI; AR gives contextual, immersive delivery. Table 3 gives a summary of the emergency management cases addressed.

Table 3: Summary of Emergency Management Cases Addressed

Case Study	Key AI-AR Feature	Primary Resilience Impact	Administrative Benefit
FEMA's AI-AR Disaster Applications	Predictive analytics with AR training overlays	Faster situational awareness; reduced training risk	Cost-effective drills; equitable resource forecasting
Tokyo's AR Headset Drills	Personalised post-earthquake simulations via headsets	Muscle memory for chaotic scenarios	Scalable, repeatable training; quicker coordination
Netherlands' EU Horizon AR Flood	AI flood modelling with AR landscape overlays	Proactive inundation mitigation	Optimised response; cross-sector visualisation

Note. Compiled by the author

Taken together, these illustrate how effectively individuals may make choices when they have adequate preparation, can predict the future, and can obtain instantaneous assistance. Good data governance, inclusive design, and ongoing assessment will help to maximise advantages in a period of growing risks. Success depends on these things.

Thematic Framework for AI-AR in Urban Planning

Four fundamentals, linked themes, comprise a thematic structure as outlined below:

- Immersive Visualisation: AR overlays abstract data and real-life experience.
- Predictive Analytics: AI-driven scenario modelling
- Participatory Co-Creation (democratised input)
- Resilient Adaptation (integration of equity and climate).

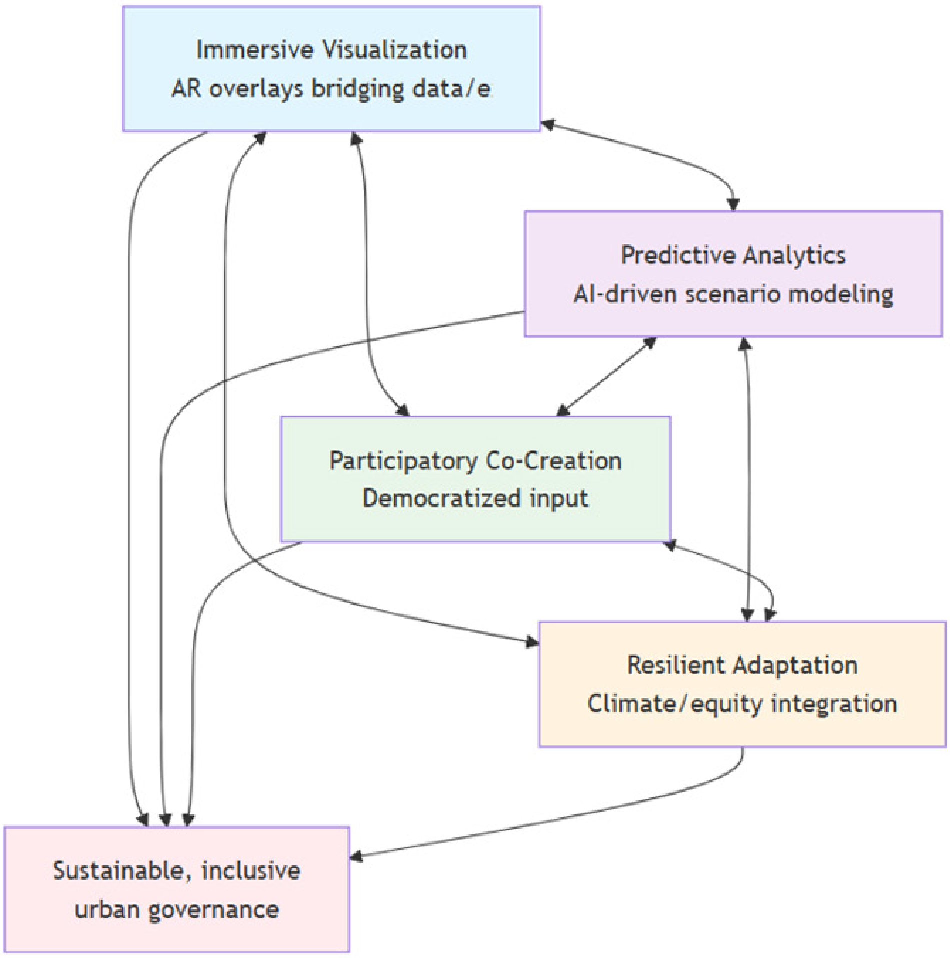

Figure 1: Thematic Framework for AI-AR in Urban Planning

Through the synthesis of several examples, one can see how AI-AR changes planning philosophies towards anticipatory, equitable systems. Interconnections increase effects. Predictive AI drives AR visuals that increase resilience and participation. This structure combines ideas while also recognising contextual differences.

Quantifiable Impacts on Administrative Efficiency and Decision-Making

The fusion of AI with AR transforms public administration from labour-intensive, reactive processes to simplified, predictive ones in urban design and emergency response, showing quantifiable improvements in administrative procedures.

These tools automate repetitive chores, speed up data processing, allow for virtual testing, and give engrossing insights that improve speed and accuracy. Broader research and case implementations provide empirical evidence showing qualitative improvements in decision quality and scalability together with time and cost reductions.

Broader research and case implementations provide empirical evidence showing qualitative improvements in decision quality and scalability together with time and cost reductions. Though problems like integration obstacles, ethical concerns, and work readiness still exist, net effects favour significant efficiency increases when systems are carefully applied.

Operational Efficiency: Time and Cost Reductions

AI-AR improves operational efficiency by reducing planning time, lowering costs, and optimising resource utilisation. In urban planning, AI-driven predictive models and AR visualisation enable planners to evaluate multiple development scenarios without relying on repeated physical models or extensive site visits. For example, Singapore's *Virtual Singapore* digital twin facilitates rapid scenario testing and stakeholder engagement, reducing planning iterations and development costs (Lei et al., 2024). Similarly, Helsinki employs mobile AR applications to support public participation, streamlining consultation processes and reducing administrative delays associated with design revisions (Kyttä et al., 2023). Dubai further enhances planning efficiency through AI-assisted density optimisation and AR-based project visualisation, enabling faster approvals and more informed planning decisions.

In emergency management, AI-AR technologies enhance operational performance by improving preparedness, accelerating response, and optimising resource deployment. Tokyo's AI-enabled AR training simulations reduce the need for resource-intensive physical exercises while improving emergency readiness through immersive and repeatable training (Fan et al., 2021). Likewise, AI-supported disaster management systems facilitate rapid situational awareness, efficient resource allocation, and timely decision-making during emergencies. These applications collectively reduce operational costs, improve administrative efficiency, and allow organisations to focus resources on strategic activities rather than routine operational tasks.

Decision-Making: From Reactive to Predictive

AI-AR transforms public sector decision-making from reactive responses to proactive and evidence-based planning. AI analyses large volumes of geospatial, environmental, and socio-economic data to predict future conditions, while AR presents these insights through intuitive and immersive visualisations that improve understanding among planners, decision-makers, and stakeholders. This integration supports rapid scenario evaluation, real-time data interpretation, and more accurate planning decisions (Othengrafen et al., 2025).

Applications such as Singapore's *Virtual Singapore* enable planners to evaluate urban density, climate adaptation, and infrastructure resilience before implementation, reducing the need for costly modifications. In disaster management, AI forecasts potential hazards while AR visualises evacuation routes, risk zones, and emergency response strategies in real time. For example, AI-supported flood prediction systems in the Netherlands combine predictive modelling with AR visualisation to support timely evacuation planning and infrastructure protection (Ameen & Qadir, 2025). Similarly, AI-enhanced emergency simulations in Tokyo strengthen anticipatory decision-making by exposing responders to dynamic disaster scenarios before real events occur (Fan et al., 2021). Collectively, these technologies improve decision accuracy, reduce uncertainty, and support more resilient governance.

Scalability, ROI, and Challenges

The scalability of AI-AR depends on robust digital infrastructure, high-quality data, institutional capacity, and effective governance. Successful implementations such as Singapore's national digital twin demonstrate the potential for AI-AR platforms to operate across multiple government agencies, while EU-supported initiatives illustrate their applicability across regions and sectors. The financial benefits of AI-AR arise from reduced planning costs, improved productivity, more efficient resource allocation, and the prevention of costly infrastructure failures and disaster impacts (Janssen & Kuk, 2024).

Despite these advantages, several challenges remain. Data interoperability, data quality, privacy and cybersecurity concerns, algorithmic bias, workforce capability, and high implementation costs continue to limit widespread adoption (Sanchez, 2025; Vatamanu & Dinu, 2025). Addressing these challenges requires strong governance frameworks, transparent AI systems, workforce development, and phased implementation strategies. When supported by appropriate policies and institutional readiness, AI-AR offers a scalable and sustainable approach to improving administrative performance, strengthening resilience, and enhancing evidence-based governance.

Table 4: Benefits of AI-AR

Impact Category	Key Metrics (Approximate Ranges from Cases and Studies)	Urban Planning Examples	Emergency Management Examples	Primary Challenges
Time Reductions	Reductions in cycles/processes	Scenario testing (Singapore); consultations (Helsinki)	Damage assessment (FEMA); training (Tokyo)	Data latency; integration delays
Cost Savings	Savings in prototyping/training/resource use	Virtual models (Dubai/Singapore)	Predictive staging; virtual drills	Initial setup; maintenance
Decision Quality	Improvement in accuracy/foresight	Predictive simulations + AR reviews	Hazard forecasting + overlays	Bias; explainability
ROI Timeline	Realisation for targeted applications	Efficiency in approvals	Reduced response costs	Measurement; scalability hurdles
Scalability Factors	Infrastructure, data governance, training	National twins to local apps	Agency-wide to cross-border systems	Legacy systems; equity access

Note: Compiled by the author

While demanding proactive management of ethical and technical challenges, AI-AR drives quantifiable administrative enhancements like time and cost efficiencies, predictive decision superiority, and scalable resilience. These findings position AI-AR as a cornerstone of modern, sustainable public administration, enabling intelligent, data-driven, and resilient governance (Dcruz et al., 2025; Elshater & Abusaada, 2025).

DISCUSSION

Taken together, the case studies examined in this paper, including urban planning initiatives in Singapore, Helsinki, and Dubai, emergency management practices in FEMA operations, Tokyo's earthquake preparedness, and the Netherlands' flood management systems, demonstrate the transformative potential of integrating AI-AR. In urban planning, AI enables predictive analysis and optimisation of complex systems, such as urban density, infrastructure, and environmental impacts, while AR enhances stakeholder engagement through immersive visualisation, facilitating more informed, inclusive, and efficient planning processes. Singapore's Virtual Singapore digital twin illustrates data-driven foresight at the national level, AR-enhanced Summer Streets initiatives of Helsinki highlight inclusivity led by the community, and Dubai's AI Advisor exemplifies efficient management of high-density growth.

In emergency management, the emphasis shifts to anticipatory resilience. AI predicts hazards and optimises resources, while AR delivers real-time geospatial overlays and immersive training to reduce chaos. Predictive models from FEMA and AR-supported drills improve operational readiness; Tokyo's headset simulations increase procedural knowledge for seismic events; and the Netherlands' systems proactively model and illustrate flood dynamics.

Across both domains, common benefits include substantial improvements in operational efficiency through virtual simulations and predictive analytics, enhanced decision-making supported by immersive visualisations, and greater equity achieved through participatory planning and vulnerability-informed approaches. Among the measurable benefits are decreases in planning or response cycles, cost savings from avoided physical trials or over-allocation, and changes from reactive to proactive frameworks. These results support broader trends towards resilient administration and algorithmic urbanisation, connecting conceptual bases with practical application (Bittencourt & Faccioni Filho, 2026; Leal-Filho et al., 2024).

These changes demonstrate how AI-AR transforms the public sector working system to a more adaptive, inclusive, and sustainable one, striking a compromise between efficiency and human-centred government (Fistola, 2025).

The results show how participatory AR improves multi-actor cooperation (Urban Governance Theory), therefore supporting the theoretical viewpoints of AI-AR's transformative impact in urban governance. Transparent AI interfaces (AI Governance) help to encourage accountability. Balancing the benefits and challenges of AI-AR is essential for fostering responsible and ethical innovation. The research gap can be closed by providing empirical grounding for past theoretical assertions, inclusiveness, measurable effects, efficiency increases, and error reductions.

Conclusion and Implications

This research shows how incorporating AI-AR fuels inclusive participation, predictive decision-making, and efficiency in urban administration. Its main contribution is a thematic framework, theoretical bridging for actual-world use, and a comparative evidence base.

AI-assisted reality has significant repercussions for an intelligent, sustainable urban future going forward. As climate concerns grow and cities develop, AI-AR will probably scale more and greatly impact the future of labour in public administration. AI-AR is expected to transform administrative roles from routine, repetitive tasks to strategic facilitation, continuous learning, and collaborative human–AI decision-making, thereby fostering more resilient and sustainable governance systems (Gupta & Degbelo, 2023).

Emergency management will see AI-AR develop towards autonomous early-warning systems as predictive models feed straight into AR-guided field activities and citizen warnings. It will redefine the role of the public administration, shifting from administrative gatekeepers to facilitators of data-driven, inclusive processes. It accelerates SDG 11 progress through resilient, equitable cities.

However, implications are not without risks. It can create ethical dilemmas and widen the digital divide when access is not equitable. Balancing innovation with governance that prioritises inclusivity, transparency, and human-centred design is the only solution.

To properly realise the promise of AI-AR, the following are the recommendations:

- Start with targeted pilots to build evidence. Refine integrations and scale gradually.
- To ensure equitable outcomes and public trust, develop clear policies on algorithmic transparency, bias audits, data privacy, and accessibility standards.
- Design tools with diverse user testing and incorporate vulnerability indices in predictions. Provide low-tech alternatives to bridge digital divides.
- Have regular assessments of ROI, efficiency, and impact using consistent measures to help improve deployments by means of measurement and iteration.
- Collaborate across government, academia, industry, and communities, leveraging models.
- Prioritise training programmes for planners and responders in AI literacy,

AI-AR, in the end, is more than just a technological advancement. It inspires a re-evaluation of urban design, management, and conservation, and of the very nature of public-sector work in an era of digital transformation and sustainability imperatives.

These technologies provide paths to more intelligent, fairer urban futures from two-dimensional abstractions to immersive realities; from reactive reactions to anticipatory resiliency; and from traditional administrative routines to digitally augmented, human-centric, and sustainable work systems in governance.

Likewise, future studies should empirically examine the long-term organisational and societal impacts of AI-AR adoption across diverse urban governance contexts using quantitative, qualitative, or mixed-method approaches. Further research should also investigate the governance, ethical, and institutional factors that influence the successful implementation and scalability of AI-AR technologies in achieving sustainable and resilient cities.

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Conflict of Interest

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