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Generative AI for Smart City Management: A Review of Large Language Models, Synthetic Data, Scenario Simulation and Urban Digital Twins

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Abstract—Rapid urbanization places pressure on traffic, energy, water, waste, environment and public services, and traditional city management often struggles with congestion, pollution and inefficient use of resources. Generative Artificial Intelligence (GenAI), comprising models that create text, images, time series and simulations, offers new tools for city administrators, planners and citizens. This paper reviews the application of GenAI to smart city management. It examines foundation models and large language models that provide conversational access to city data and assist with reports and citizen services; generative models that synthesize realistic sensor data and future scenarios; graph-based spatio-temporal models for traffic forecasting that feed generative planning; and urban digital twins in which generated scenarios can be tested before decisions are made. Applications in traffic, energy, environmental monitoring, waste management, public safety and urban planning are discussed. A five-layer architecture integrating IoT data, a city data platform, predictive and generative AI, a digital twin and stakeholder interfaces is proposed, with research gaps, objectives, a comparison of AI roles and challenges including hallucination, bias, data governance, privacy and accountability. The review concludes that GenAI can make city management more efficient and participatory when grounded in reliable data and human oversight.

Index Terms—Generative AI, smart city, large language models, urban digital twin, traffic forecasting, synthetic data, IoT, urban planning

I. INTRODUCTION

More than half of the world's people live in cities, and Indian cities are growing rapidly. City administrators must manage traffic, power, water, sanitation, air quality and public safety with limited budgets, while responding to millions of citizens. Smart city programmes have deployed sensors, cameras and control centres, producing large amounts of data that are not always turned into timely decisions.Batty *et al.* [1] described a vision of smart cities in which data and computation support planning and operations. Generative AI adds a new layer: language models that let officials and citizens query complex data in plain language, and generative models that create plausible scenarios and synthetic data for planning. Bommasani *et al.* [2] discussed the opportunities and risks of such foundation models.This paper reviews generative AI for smart city management and proposes an integrated architecture.

II. BACKGROUND AND RELATED WORK

1. Generative Ai Families

Fig. 1 summarizes GenAI families relevant to cities: large language models for text and dialogue [3], generative adversarial networks [4] and diffusion models [5] for images and data, and generative time-series models for sensor streams.

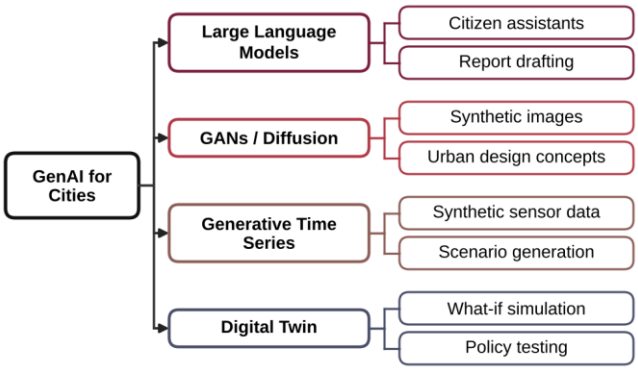


Fig. 1. Generative AI families and smart city uses.

2. Urban Digital Twins

A city digital twin is a virtual replica of urban infrastructure updated with live data. Shahat *et al.* [6] reviewed city digital twins and their potential for simulation, planning and citizen engagement.

3. Review Of Related Studies

Zanella *et al.* [7] described an urban IoT architecture supporting services such as traffic, lighting and environmental monitoring, and Zheng *et al.* [8] presented urban computing methods that analyse heterogeneous city data.

For traffic, Li *et al.* [9] modelled traffic as a diffusion process on a road graph with the DCRNN, and Wu *et al.* [10]

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proposed Graph WaveNet, which learns hidden spatial dependencies. Jiang and Luo [11] surveyed graph neural networks for traffic forecasting. These predictive models provide the base on which generative planning tools can build.

For synthetic data, Yoon *et al.* [12] introduced TimeGAN, which generates realistic multivariate time series while preserving temporal dynamics, useful for creating training data or privacy-safe sharing of sensor data.

Large language models trained with instruction tuning [13] can answer questions and draft documents, and retrieval-augmented generation [14] grounds answers in city records, reducing hallucination. Bommasani *et al.* [2] cautioned that foundation models can propagate biases and errors at scale. Table I summarizes these works.

TABLE I Summary of Literature Survey

Ref.	Method	Key Findings	Limitations
[1]	Smart city vision	Data-driven urban planning	Conceptual
[7]	Urban IoT architecture	Deployed city services	No generative AI
[9]	Diffusion convolutional RNN	Accurate traffic forecasting	Fixed road graph
[10]	Graph WaveNet	Learns hidden spatial links	Data hungry
[12]	TimeGAN	Realistic synthetic time series	Training instability
[6]	City digital twin review	Simulation and planning potential	Implementation cost
[14]	Retrieval-augmented generation	Grounded answers	Retrieval quality
[2]	Foundation model analysis	Opportunities and risks	General scope

III. RESEARCH GAP AND OBJECTIVES

1. Identified Research Gaps

- GenAI applications for cities are mostly prototypes with little field evaluation.
- LLMs can hallucinate facts about city services or regulations.
- Generated scenarios may not respect physical and legal constraints.
- City data are fragmented across departments, limiting grounding.
- Accountability for AI-assisted decisions in public administration is unclear.

2. Objectives Of The Review

- To review generative AI families and their relevance to cities.
- To examine applications in traffic, energy, environment, safety, planning and citizen services.
- To propose an integrated GenAI smart city architecture with a digital twin.
- To compare predictive and generative AI roles.
- To discuss risks and governance requirements.

I. Design of the Proposed System

The architecture is shown in Fig. 2.

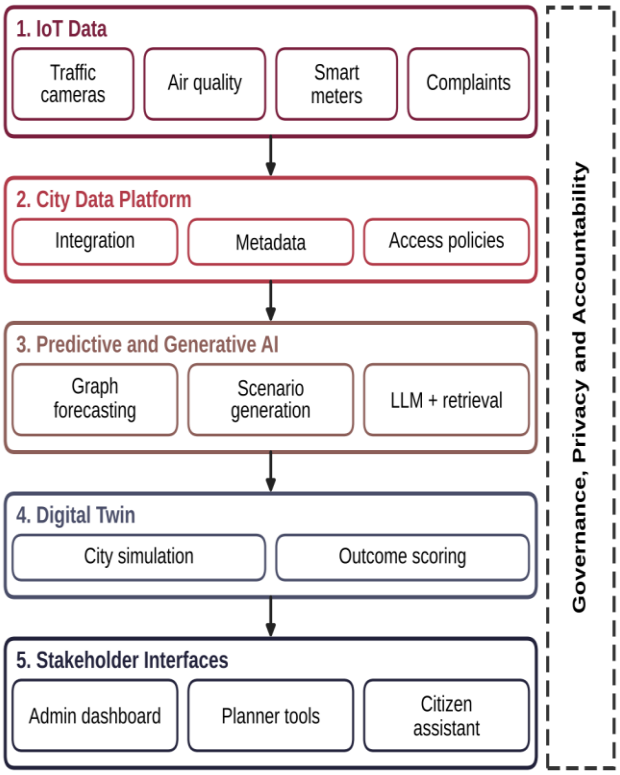


Fig. 2. Proposed generative AI smart city management architecture.

3. Iot Data Layer

Traffic cameras, air-quality monitors, smart meters, waste-bin sensors and citizen complaints provide data.

4. City Data Platform Layer

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Data are cleaned, integrated and stored with metadata and access policies, creating a single source of truth.

5. Predictive And Generative Ai Layer
Graph models forecast traffic and demand; generative models create synthetic data and future scenarios; an LLM with retrieval answers queries and drafts reports.

6. Digital Twin Layer
Scenarios such as a new bus route, a road closure or a heatwave are simulated in the city twin to evaluate outcomes before implementation.

7. Stakeholder Interface Layer
Administrators use dashboards and conversational assistants, planners compare scenarios, and citizens access services in their own language.

8. Methodology
Fig. 3 outlines the decision workflow. A graph forecasting model predicts future traffic X_{t+1} from past observations and the road graph G:

$$\hat{X}_{t+1} = f_\theta(X_{t-k} \ldots X_t, G) \quad (1)$$

and generated scenarios are scored by the digital twin on objectives such as travel time, emissions and cost before being proposed to officials.

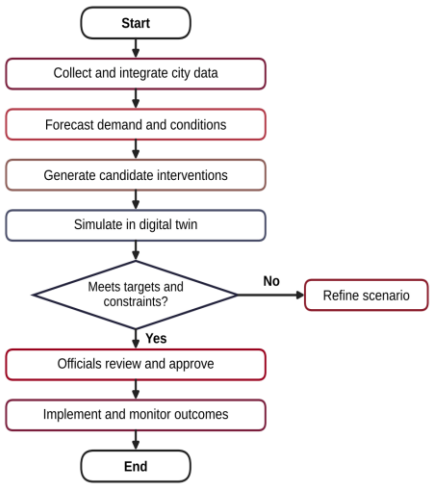


Fig. 3. GenAI-assisted city decision workflow.

IV. DISCUSSION AND COMPARISON

Table II compares AI roles in city management. Predictive models forecast what will happen, generative models create alternatives and synthetic data, LLMs make data accessible, and digital twins test consequences.

TABLE II Comparison of AI Roles in City Management

AI Role	Question Answered	Example
Predictive models	What will happen?	Traffic and demand forecasts
Generative models	What could we do?	Alternative routes, synthetic data
LLM assistants	What does the data say?	Plain-language queries, reports
Digital twin	What if we do it?	Simulated policy outcomes

V. CHALLENGES AND FUTURE DIRECTIONS

Table III summarizes challenges. Future directions include multilingual citizen assistants, generative design of urban layouts with sustainability constraints, privacy-preserving synthetic data sharing and governance frameworks for AI in public administration.

TABLE III Challenges and Mitigation

Challenge	Mitigation
Hallucination	Retrieval grounding; human verification
Unrealistic scenarios	Constraint checks in digital twin
Fragmented data	Integrated city data platform
Privacy	Synthetic data; anonymization
Accountability	Human approval; audit trails

VI. CONCLUSIONS

Generative AI can help cities move from reacting to problems toward anticipating and planning for them. The reviewed literature shows mature IoT and urban computing foundations, accurate graph-based forecasting and generative models capable of synthesizing data and scenarios. Combined with digital twins and grounded language assistants, GenAI can improve efficiency, sustainability and citizen engagement, provided outputs are verified and decisions remain accountable to people.

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