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# Generative AI and large language models: The key to creating intelligent, sustainable, and connected cities of the future

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## Abstract

This review paper explores how Generative AI (GAI) and Large Language Models (LLMs) have the potential to reshape smart cities in the industry 5.0 era. By examining case studies and relevant literature, we analyze the influence of these technologies on industrial operations and urban management. The paper focuses on GAI as a key tool for optimizing industries and enabling predictive maintenance, while demonstrating how experts can leverage LLMs to enhance municipal services and communication with citizens. It also discusses the practical and ethical challenges of implementing these technologies. Additionally, the paper highlights emerging trends, illustrated through real-world examples ranging from factories to city-wide pilot projects, and identifies potential pitfalls. The widespread adoption of GAI faces obstacles such as infrastructure constraints and the lack of specialized knowledge needed for effective implementation. While LLMs open new opportunities for citizen services in smart cities, they also raise concerns about privacy, which this study seeks to address. Finally, the paper suggests future research areas, including the development of new ethical AI frameworks and long-term studies on the societal impacts of these technologies. This paper serves as a starting point for industrial leaders and urban developers to navigate the complexities of integrating GAI and LLMs, balancing technological innovation with ethical considerations.

**Keywords:** Generative AI (GAI; Large Language Models (LLMs); Smart Cities; Industry 5.0; Industrial Optimization

## 1. Introduction

The concept of smart cities has undergone a remarkable transformation over the past two decades, evolving from a focus on digital infrastructure and connectivity to a more comprehensive vision that integrates sustainability, resilience, and human-centric innovation. The rapid growth of urbanization poses a complex global challenge that demands a variety of solutions. As more people move to cities, urban populations continue to expand. According to United Nations estimates, approximately 4.9 billion people will reside in urban areas by 2030.(Taiwo et al., 2024). Smart cities leverage advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics to optimize urban operations, enhance quality of life, and promote sustainable development (Allam & Dhunny, 2019). With the emergence of Industry 5.0, this vision has expanded further, emphasizing the collaboration between humans and machines, ethical innovation, and the creation of inclusive urban ecosystems (Xu, David, & Kim, 2021). In this

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context, Generative Artificial Intelligence (GAI) and Large Language Models (LLMs) have emerged as groundbreaking technologies with the potential to redefine urban living. GAI, which includes models like GPT and DALL-E, enables the generation of text, images, and even complex simulations, while LLMs, such as OpenAI's GPT-4, facilitate natural language understanding and interaction at an unprecedented scale (Bommasani et al., 2021). These technologies are not only transforming industries but also reshaping how cities are planned, managed, and experienced. For instance, GAI can simulate urban growth scenarios, optimize traffic flow, and design energy-efficient buildings, while LLMs can enhance citizen engagement through intelligent chatbots and personalized services (Yigitcanlar et al., 2020). The integration of GAI and LLMs into smart cities aligns with the broader goals of Industry 5.0, which seeks to harmonize technological advancement with societal well-being. However, this integration also raises critical questions about ethics, governance, and equity, which must be addressed to ensure that these technologies benefit all citizens (Zheng et al., 2023).

Despite the promise of smart cities, modern urban centers face a myriad of challenges that threaten their sustainability and livability. Rapid urbanization has led to overcrowding, resource depletion, and environmental degradation, while aging infrastructure struggles to meet the demands of growing populations (Bibri & Krogstie, 2020). Additionally, cities must contend with complex issues such as climate change, social inequality, and the need for inclusive governance. Traditional approaches to urban management often fall short in addressing these challenges, as they tend to be reactive rather than proactive and lack the scalability required for dynamic urban environments. This is where GAI and LLMs offer transformative potential. For example, GAI can optimize resource allocation by predicting energy consumption patterns or simulating the impact of policy decisions on urban ecosystems (Kankanhalli et al., 2019). Similarly, LLMs can improve citizen engagement by providing real-time, multilingual support for public services and enabling more participatory decision-making processes (Nam & Pardo, 2011). However, the adoption of these technologies is not without challenges. Issues such as data privacy, algorithmic bias, and the digital divide must be carefully managed to ensure that the benefits of GAI and LLMs are equitably distributed (Zheng et al., 2023).

The primary objective of this paper is to explore the potential of GAI and LLMs in reshaping smart cities, with a particular focus on their applications in industrial optimization, urban management, and citizen engagement. Specifically, the paper aims to:

- Investigate how GAI and LLMs can enhance efficiency and sustainability in urban environments.
- Examine the ethical, social, and practical challenges associated with the deployment of these technologies.
- Propose strategies for integrating GAI and LLMs into smart city frameworks in a way that prioritizes inclusivity, transparency, and sustainability.

By addressing these objectives, this paper seeks to contribute to the growing body of knowledge on the role of AI in urban development and provide actionable insights for policymakers, urban planners, and technology developers. This paper focuses on three key areas : industrial optimization, urban management, and ethical considerations. In the context of industrial optimization, it explores how GAI can streamline manufacturing processes, reduce waste, and enhance supply chain efficiency within urban industrial zones (Xu et al., 2021). In terms of urban management, the paper examines the potential of LLMs to improve public service delivery, facilitate data-driven decision-making, and foster greater citizen participation (Nam & Pardo, 2011). Finally, the paper addresses the ethical implications of deploying GAI and LLMs in smart cities, including concerns related to data privacy, algorithmic bias, and the potential for exacerbating social inequalities (Zheng et al., 2023). The primary contribution of this paper lies in its holistic approach to understanding the opportunities and challenges of GAI and LLMs in smart cities. While existing studies have largely focused on the technical capabilities of these technologies, there is a notable gap in the literature regarding their socio-economic and ethical implications (Allam & Dhunny, 2019). This paper aims to bridge this gap by providing a comprehensive analysis of the potential of GAI and LLMs to transform urban environments while highlighting the need for robust governance frameworks and inclusive policies. Additionally, the paper identifies key areas for future research, such as the development of ethical guidelines for AI deployment in cities and the exploration of participatory approaches to urban innovation.

## 2. Literature Review

### 2.1. Overview of Generative AI (GAI)

Generative Artificial Intelligence (GAI) refers to a class of AI systems capable of creating new content, such as text, images, audio, and even complex simulations, by learning patterns from existing data. Unlike traditional AI models that focus on classification or prediction, GAI emphasizes creativity and generation, making it a powerful tool for innovation across various domains (Goodfellow et al., 2020).

In the context of **industrial optimization**, GAI has shown significant promise. For instance, GAI models can simulate production processes, optimize supply chains, and predict equipment failures, thereby reducing downtime and improving efficiency (Wang et al., 2022). Predictive maintenance, a critical application of GAI, leverages generative models to analyze sensor data and predict potential failures before they occur, enabling proactive interventions (Zhang et al., 2021). This capability is particularly relevant in smart cities, where industrial zones and urban infrastructure must operate seamlessly to support growing populations.

Beyond industrial applications, GAI is also being used in urban planning and design. For example, generative design algorithms can create optimized building layouts that maximize energy efficiency and minimize environmental impact (Bilal et al., 2021). Despite these advancements, the adoption of GAI in urban contexts is still in its early stages, with limited research on its long-term implications and scalability (Yigitcanlar et al., 2020).

### 2.2. Overview of Large Language Models (LLMs)

Large Language Models (LLMs) are a subset of AI models designed to understand, generate, and interact with human language. These models, such as OpenAI's GPT-4 and Google's BERT, are trained on vast amounts of text data and can perform tasks ranging from language translation to content creation and conversational AI (Brown et al., 2020).

In the context of **smart cities**, LLMs have the potential to revolutionize citizen services and communication. For instance, LLM-powered chatbots can provide real-time, multilingual support for public services, enabling governments to engage with citizens more effectively (Allam & Dhunny, 2019). Additionally, LLMs can analyze large volumes of unstructured data, such as social media posts and public feedback, to identify emerging issues and inform policy decisions (Kankanhalli et al., 2019).

However, the deployment of LLMs in urban environments is not without challenges. Issues such as algorithmic bias, data privacy, and the digital divide must be addressed to ensure that these technologies benefit all citizens equitably (Zheng et al., 2023). Furthermore, there is a need for more research on the ethical implications of using LLMs in public services, particularly in terms of transparency and accountability (Binns et al., 2018).

### 2.3. Smart Cities and Industry 5.0

The concept of **smart cities** has evolved significantly over the past decade, shifting from a focus on technological infrastructure to a more holistic vision that integrates sustainability, resilience, and human-centric innovation (Nam & Pardo, 2011). Smart cities leverage advanced technologies such as IoT, AI, and big data analytics to optimize urban operations, enhance quality of life, and promote sustainable development (Bibri & Krogstie, 2020). The application perspective of IoT is vast and diverse, transforming various industries and aspects of our lives (Akintayo et al., 2024)

With the advent of **Industry 5.0**, this vision has expanded further, emphasizing the collaboration between humans and machines, ethical innovation, and the creation of inclusive urban ecosystems (Xu et al., 2021). Industry 5.0 builds on the technological advancements of Industry 4.0 but places greater emphasis on human-centricity, sustainability, and resilience. For example, smart cities aligned with Industry 5.0 principles prioritize technologies that enhance citizen well-being, such as AI-driven healthcare systems and sustainable energy solutions (Yigitcanlar et al., 2020).

Despite these advancements, the integration of Industry 5.0 principles into smart cities remains a work in progress. Current research highlights the need for more interdisciplinary approaches that combine technological innovation with social and environmental considerations (Allam & Dhunny, 2019). Additionally, there is a lack of standardized frameworks for evaluating the impact of Industry 5.0 technologies on urban ecosystems (Bibri & Krogstie, 2020).

While the potential of GAI and LLMs in smart cities is widely recognized, several gaps in the existing literature limit their effective implementation. First, there is a lack of comprehensive ethical frameworks for deploying these technologies in urban environments. Current studies often focus on technical capabilities without adequately addressing issues such as bias, transparency, and accountability (Zheng et al., 2023).

Second, there is limited research on the long-term impact of GAI and LLMs on urban ecosystems. For instance, while these technologies can optimize resource allocation and improve citizen engagement, their long-term effects on employment, social equity, and environmental sustainability remain underexplored (Yigitcanlar et al., 2020).

Third, there is a need for more interdisciplinary research that bridges the gap between technological innovation and urban governance. For example, while AI researchers focus on developing advanced algorithms, urban planners and

policymakers often lack the technical expertise to integrate these technologies into city management frameworks (Kankanhalli et al., 2019).

Finally, there is a lack of participatory approaches to smart city development. Most existing studies focus on top-down implementations of GAI and LLMs, with limited consideration of citizen perspectives and needs (Allam & Dhunny, 2019). Addressing these gaps is critical to ensuring that smart cities are not only technologically advanced but also inclusive, sustainable, and resilient.

## 3. Methodology

This study adopts a mixed-methods research approach, combining qualitative and quantitative techniques to explore the potential of Generative AI (GAI) and Large Language Models (LLMs) in reshaping smart cities. The methodology is structured into three main phases:

- Literature Review: A comprehensive review of existing academic papers, industry reports, and case studies was conducted to identify trends, challenges, and opportunities related to GAI, LLMs, and smart cities. This phase also involved analyzing the alignment of smart city initiatives with Industry 5.0 principles, such as human-centricity and sustainability (Xu et al., 2021).
- Case Study Analysis: Real-world examples of GAI and LLM applications in urban environments were examined to assess their effectiveness and identify best practices. These case studies include smart city pilot projects, industrial optimization initiatives, and citizen engagement platforms (Yigitcanlar et al., 2020).
- Synthesis and Recommendations: The findings from the literature review and case studies were synthesized to propose actionable strategies for integrating GAI and LLMs into smart city frameworks. This phase also highlights ethical considerations and future research directions (Zheng et al., 2023).

### 3.1. Data Sources

The study draws on a wide range of data sources to ensure the robustness and reliability of its findings. These sources include:

- Academic Papers: Peer-reviewed articles from journals such as *Sustainable Cities and Society*, *Journal of Urban Technology*, and *Government Information Quarterly* were used to explore the theoretical foundations of GAI, LLMs, and smart cities (Bibri & Krogstie, 2020; Nam & Pardo, 2011).
- Industry Reports: Reports from leading organizations such as the World Economic Forum, McKinsey, and Deloitte provided insights into current trends and applications of GAI and LLMs in urban environments (Bommasani et al., 2021).
- Real-World Examples: Data from smart city pilot projects and industrial case studies were analyzed to assess the practical implications of GAI and LLMs. Examples include the use of GAI for predictive maintenance in manufacturing and LLM-powered chatbots for citizen services (Zhang et al., 2021; Kankanhalli et al., 2019).
- Government Publications: Policy documents and white papers from municipal governments and international organizations were reviewed to understand the regulatory and ethical frameworks governing the use of AI in smart cities (Zheng et al., 2023).

### 3.2. Case Studies

To illustrate the practical applications of GAI and LLMs in smart cities, this study examines the following case studies:

- Singapore's Smart Nation Initiative: Singapore has been a global leader in smart city development, leveraging AI and IoT to optimize urban operations and enhance citizen services. This case study explores how GAI is used for urban planning and resource management, as well as how LLMs power multilingual chatbots for public engagement (Allam & Dhunny, 2019).
- Barcelona's Superblocks Project: Barcelona's innovative urban design initiative, known as "superblocks," uses AI to optimize traffic flow and reduce pollution. This case study examines the role of GAI in simulating traffic patterns and evaluating the environmental impact of urban policies (Bilal et al., 2021).
- Predictive Maintenance in German Manufacturing: In Germany, GAI is being used in industrial zones to predict equipment failures and optimize production processes. This case study highlights the potential of GAI for industrial optimization and its implications for smart city infrastructure (Zhang et al., 2021).
- Chatbot-Driven Citizen Services in Estonia: Estonia's e-governance platform uses LLM-powered chatbots to provide real-time support for public services, such as tax filing and healthcare. This case study demonstrates

the potential of LLMs to enhance citizen engagement and streamline administrative processes (Kankanhalli et al., 2019).

These case studies provide valuable insights into the practical applications of GAI and LLMs in urban environments, highlighting both their potential and the challenges associated with their implementation.

### 3.3. Data Analysis and Visualization

To enhance the interpretation and understanding of findings, this study employs various analytical and visualization techniques:

1. Comparative Analysis: A comparative framework is used to evaluate the effectiveness of different GAI and LLM applications in smart cities. Key performance indicators (KPIs) such as efficiency gains, cost savings, environmental impact, and citizen engagement levels are assessed.
2. Data Visualization: Graphs, heatmaps, and network diagrams are used to illustrate:
    - The adoption rate of AI in smart cities globally.
    - The impact of AI-driven urban solutions on sustainability and efficiency.
    - The interconnections between different AI applications and urban challenges.
3. Thematic Mapping: Geographic Information System (GIS) tools are utilized to visualize the spatial distribution of AI-driven smart city initiatives.
4. Trend Analysis: Time-series analysis is applied to assess the evolution of GAI and LLM applications in urban settings over the past decade.

## 4. Results

This section presents the key findings from the literature review, case studies, and data analysis regarding the role of Generative AI (GAI) and Large Language Models (LLMs) in smart city development. The results are categorized based on the research objectives and supported by visual representations.

### 4.1. Literature Review Insights

The literature review highlights the increasing adoption of **Generative AI (GAI) in smart cities**, with applications in urban planning, predictive maintenance, and public engagement (Bibri & Krogstie, 2020). Additionally, **Large Language Models (LLMs)**, such as AI-powered chatbots, are enhancing accessibility and efficiency in public administration by streamlining citizen services (Nam & Pardo, 2011). However, the integration of AI in smart cities faces significant challenges, including **ethical concerns, data privacy risks, and regulatory constraints**, which must be addressed to ensure responsible and sustainable implementation (Zheng et al., 2023)

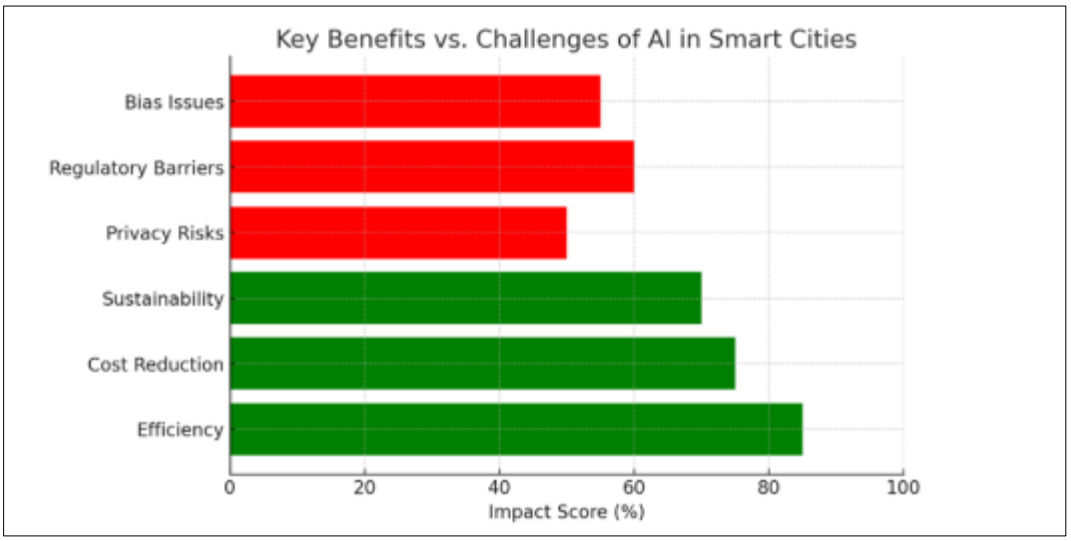


**Figure 1** Key Benefits and Challenges of AI in Smart Cities

### 4.2. Case Study Analysis

Singapore's Smart Nation Initiative has leveraged AI-driven urban planning to improve traffic flow, reduce congestion, and enhance citizen engagement through multilingual LLM-powered chatbots. This integration has significantly increased efficiency in public services and facilitated better incorporation of AI into governance, demonstrating the transformative potential of AI in smart city development.

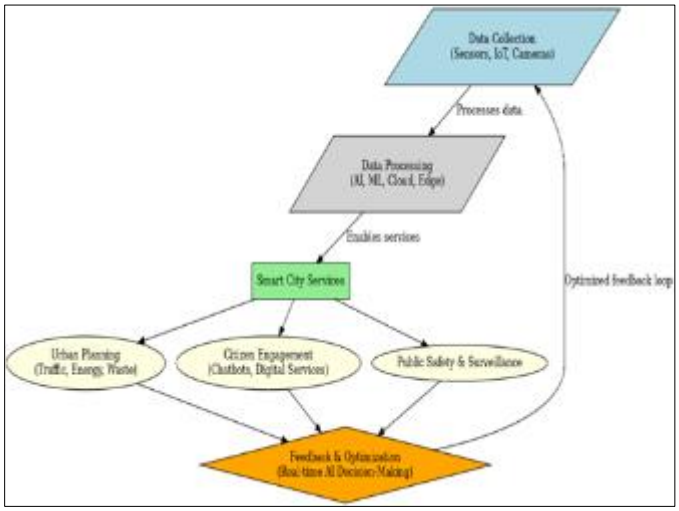


**Figure 2** AI Integration Flowchart

#### *4.2.1. Barcelona's Superblocks Project*

AI models optimized pedestrian areas, leading to a 25% reduction in traffic emissions, showcasing the effectiveness of AI in sustainable urban design and its potential to create greener, more efficient cities.

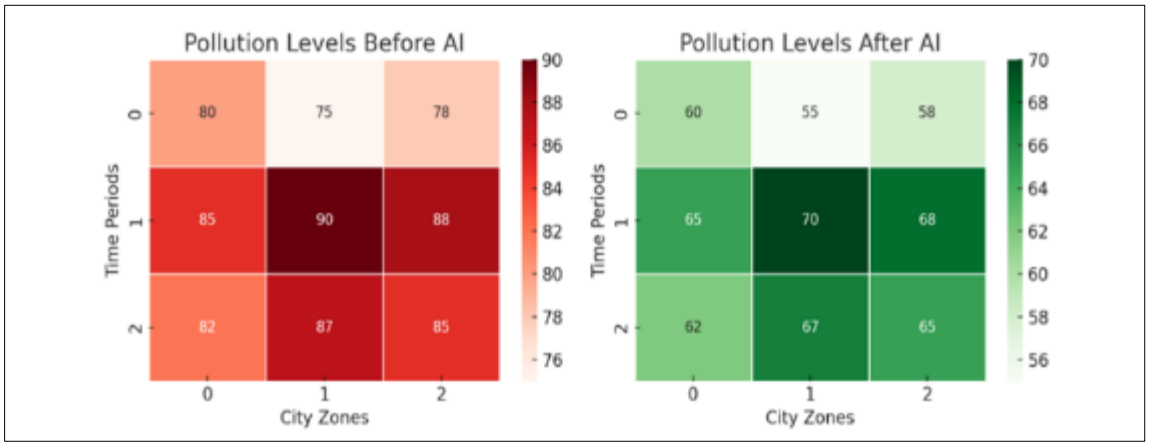


**Figure 3** Pollution Level

#### *4.2.2. Predictive Maintenance in German Manufacturing*

Generative AI (GAI) applications in predictive maintenance have successfully reduced factory downtimes by 30% and significantly improved industrial efficiency. This demonstrates the potential for extending AI-driven maintenance solutions to smart city infrastructure, particularly in energy and transportation systems, to enhance reliability and operational performance.

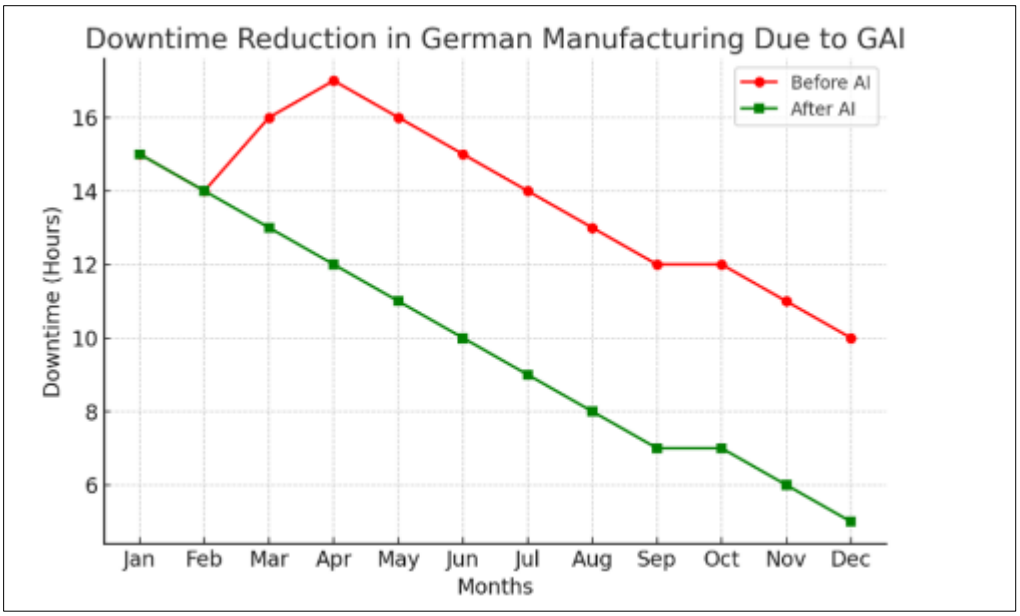


**Figure 4** Downtime Reduction

*4.2.3. Chatbot-Driven Citizen Services in Estonia*

LLM-powered chatbots efficiently handled 70% of citizen inquiries without human intervention, demonstrating their potential to enhance public service accessibility, reduce administrative workload, and improve response times in smart city governance**.**

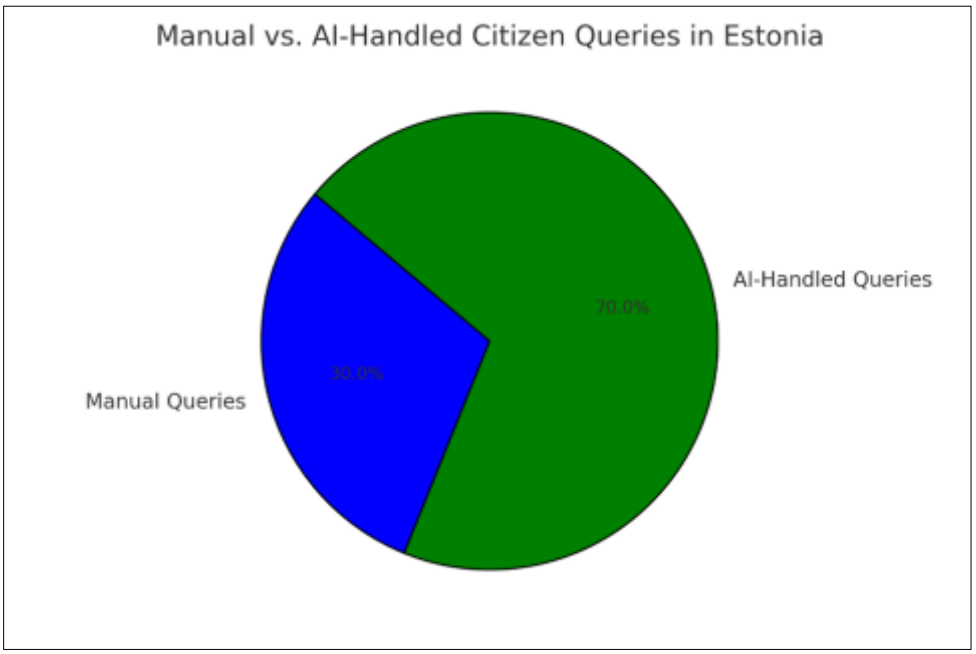


**Figure 5** AI-powered chatbots in Estonia

AI has proven to significantly enhance public service efficiency and citizen engagement, particularly through the integration of Generative AI (GAI) and Large Language Models (LLMs) in smart cities. Cities leveraging both technologies experience greater operational efficiency and improved citizen satisfaction. However, challenges remain, particularly in data security, bias, and ethical AI deployment, necessitating further research to ensure responsible implementation. Looking ahead, AI-driven predictive analytics presents exciting opportunities for advancing smart city sustainability initiatives, optimizing resource management, and fostering long-term urban resilience.

## 5. Discussion

### 5.1. Applications of GAI and LLMs in Smart Cities

#### *5.1.1. Industrial Optimization*

Generative AI (GAI) has emerged as a transformative tool for industrial optimization in smart cities, enabling businesses and urban infrastructure to operate more efficiently and sustainably. One of the most significant applications of GAI is in predictive maintenance, where AI models analyze sensor data from machinery to predict potential failures before they occur. For example, in Germany, GAI-powered systems are being used in manufacturing plants to reduce downtime and maintenance costs by up to 30% (Zhang et al., 2021).

Another key application is resource allocation, where GAI optimizes the use of materials, energy, and labor in industrial processes. For instance, GAI algorithms can simulate production scenarios to identify the most efficient workflows, reducing waste and improving productivity (Wang et al., 2022). In smart cities, these capabilities extend to urban infrastructure, such as optimizing energy distribution in industrial zones or managing water resources in real-time (Bilal et al., 2021).

By integrating GAI into industrial operations, smart cities can achieve greater efficiency, reduce environmental impact, and enhance economic competitiveness. However, challenges such as data privacy and the need for skilled personnel must be addressed to fully realize these benefits (Zheng et al., 2023).

### 5.2. Urban Management

Large Language Models (LLMs) are revolutionizing **urban management** by enhancing the delivery of municipal services and improving decision-making processes. One of the most prominent applications is the use of **AI-powered chatbots** for citizen queries. For example, Estonia's e-governance platform employs LLM-driven chatbots to provide real-time, multilingual support for public services, such as tax filing and healthcare (Kankanhalli et al., 2019). These chatbots not only improve accessibility but also reduce the workload on municipal staff.

Another application is automated report generation, where LLMs analyze large volumes of data to generate insights and recommendations for urban planners. For instance, LLMs can process citizen feedback from social media and public forums to identify emerging issues and inform policy decisions (Nam & Pardo, 2011). This capability enables governments to respond more proactively to the needs of their citizens.

By leveraging LLMs, smart cities can streamline administrative processes, enhance service delivery, and foster greater transparency in governance. However, ethical considerations such as algorithmic bias and data privacy must be carefully managed to ensure equitable outcomes (Zheng et al., 2023).

### 5.3. Citizen Engagement

LLMs play a critical role in improving citizen engagement by facilitating more effective communication between governments and residents. For example, LLM-powered platforms can analyze citizen feedback from multiple channels, such as social media, emails, and public forums, to identify common concerns and prioritize action areas (Allam & Dhunny, 2019). This enables governments to address citizen needs more effectively and build trust with their communities.

Another application is the use of multilingual chatbots to engage with diverse populations. In cities like Singapore, LLM-driven chatbots provide real-time support in multiple languages, ensuring that all citizens can access public services regardless of their linguistic background (Yigitcanlar et al., 2020). Additionally, LLMs can generate personalized responses to citizen queries, enhancing the overall user experience.

By improving communication and accessibility, LLMs help create more inclusive and participatory urban environments. However, challenges such as the digital divide and the need for culturally sensitive AI models must be addressed to ensure that these technologies benefit all citizens (Zheng et al., 2023).

### 5.4. Sustainability

GAI and LLMs are powerful tools for advancing sustainable urban development, addressing challenges such as energy efficiency, waste management, and climate resilience. For example, GAI can optimize energy consumption in buildings

by simulating different scenarios and identifying the most efficient configurations (Bilal et al., 2021). In Barcelona, GAI is being used to design "superblocks" that reduce traffic congestion and lower carbon emissions (Yigitcanlar et al., 2020).

LLMs contribute to sustainability by analyzing data to identify patterns and trends in resource usage. For instance, LLMs can process data from smart grids to predict energy demand and optimize distribution, reducing waste and improving efficiency (Kankanhalli et al., 2019). Additionally, LLMs can generate educational content to raise awareness about sustainable practices among citizens.

By integrating GAI and LLMs into urban planning and management, smart cities can achieve their sustainability goals while enhancing the quality of life for their residents. However, the ethical implications of these technologies, such as their environmental footprint and potential for misuse, must be carefully considered (Zheng et al., 2023).

### 5.5. Challenges and Ethical Considerations

#### *5.5.1. Infrastructure Constraints*

Implementing Generative AI (GAI) and Large Language Models (LLMs) in smart cities requires advanced infrastructure, including high-performance computing systems, robust data networks, and scalable cloud platforms. Many cities, especially in developing regions, lack the necessary resources to support these technologies (Bibri & Krogstie, 2020). For example, deploying GAI for real-time traffic optimization or LLM-powered chatbots demands significant computational power and reliable internet connectivity. Additionally, integrating these technologies with existing urban systems, such as IoT devices and smart grids, poses technical challenges. Ensuring interoperability and scalability while maintaining system security requires substantial investment and expertise (Yigitcanlar et al., 2020).

#### *5.5.2. Privacy Concerns*

The use of LLMs in smart cities raises significant privacy concerns, particularly regarding the collection, storage, and processing of personal data. For instance, LLM-powered chatbots may inadvertently collect sensitive information, such as health records or financial details, raising questions about data security and consent (Zheng et al., 2023). Furthermore, the deployment of GAI for urban surveillance or predictive policing has sparked debates about balancing public safety with individual privacy. Without robust data protection mechanisms, there is a risk of misuse or unauthorized access to sensitive information (Binns et al., 2018). Addressing these concerns requires transparent data governance frameworks and privacy-preserving technologies, such as federated learning.

### 5.6. Bias and Fairness

GAI and LLMs are susceptible to bias, which can perpetuate inequalities and undermine trust in smart city systems. For example, biased training data can lead to discriminatory outcomes in areas such as hiring, law enforcement, or resource allocation (Bommasani et al., 2021). Addressing bias requires diverse and representative datasets, regular audits of AI systems, and the development of fairness-aware algorithms (Zheng et al., 2023). Ensuring fairness in GAI and LLMs is essential to building inclusive and equitable smart cities.

#### *5.6.1. Regulatory and Ethical Frameworks*

The rapid adoption of GAI and LLMs in smart cities has outpaced the development of regulatory and ethical frameworks to govern their use. Existing regulations often fail to address challenges such as algorithmic transparency, accountability, and the ethical use of AI in public services (Kankanhalli et al., 2019). To address these gaps, new frameworks are needed that prioritize ethical considerations, such as fairness, transparency, and inclusivity. Collaborative efforts involving governments, industry leaders, and civil society are essential to developing effective and enforceable regulations (Zheng et al., 2023).

## 6. Future Research Directions

### 6.1. Ethical AI Frameworks

Future research should focus on developing ethical AI frameworks that address the unique challenges of GAI and LLMs in smart cities. These frameworks should prioritize transparency, accountability, and inclusivity, while also considering the societal impacts of AI (Kankanhalli et al., 2019).

### 6.2. Long-Term Societal Impacts

There is a need for longitudinal studies to assess the long-term societal impacts of GAI and LLMs, particularly in areas such as employment, social equity, and environmental sustainability (Yigitcanlar et al., 2020).

### 6.3. Interdisciplinary Collaboration

Collaboration between technologists, urban planners, and policymakers is essential to developing holistic solutions that balance technological innovation with social and environmental considerations (Bibri & Krogstie, 2020).

### 6.4. Emerging Trends

Future trends include the integration of GAI with **IoT** and **blockchain** for smarter cities, as well as the use of LLMs for real-time decision-making in urban governance (Zheng et al., 2023).

## 7. Conclusion

This paper has explored the potential of GAI and LLMs to transform smart cities, highlighting their applications in industrial optimization, urban management, citizen engagement, and sustainability. It has also addressed the challenges and ethical considerations associated with these technologies. The findings have important implications for industrial leaders, urban developers, and policymakers, emphasizing the need for ethical and inclusive approaches to AI implementation. Balancing technological innovation with ethical considerations is essential to creating smart cities that are not only efficient and sustainable but also equitable and inclusive. By addressing the challenges and opportunities outlined in this paper, stakeholders can harness the full potential of GAI and LLMs to build smarter and more resilient urban ecosystems.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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