

THE IMPACT OF AI AND DIGITAL TECHNOLOGIES IN PROMOTING SOCIAL INCLUSION WITHIN SMART AND SUSTAINABLE CITIES:

INTRODUCTION

Information technology is an important part in promoting social inclusion in sustainable smart cities by improving citizen engagement and participation in urban design processes (De Siqueira et al., 2022). Digital technologies empower citizens to actively contribute to the development of their environments, overcoming social barriers and supporting inclusive design for sustainable urban development patterns (van Gils & Bailey, 2023). Smart city initiatives use information and communication technologies to provide value-added services that improve citizens' quality of life, aiming to support and expand citizen participation in public management for sustainable development (Tsang, 2023). Furthermore, the integration of artificial intelligence techniques, such as case-based reasoning (CBR), into smart city planning can provide recommendations on dimensions to be adopted, promoting smarter and more sustainable cities, as well as supporting decision-makers in strategic planning (Caputo et al., 2023).

Social inclusion plays a key function in the development of sustainable smart cities by promoting citizen engagement, participatory governance and social well-being. Studies emphasise the importance of social inclusion indicators, such as citizen participation, transparency and accountability, in building citizen-centred smart cities (Alamoudi et al., 2023; Malek et al., 2021). In addition, the dimensions of social inclusion, including citizen participation and inclusion, are highlighted as essential aspects in the ethical concerns surrounding smart cities (van Gils & Bailey, 2023). Furthermore, research indicates that social factors, such as horizontal forms of social inclusion, are vital in explaining relational well-being and quality of life in the context of smart cities, emphasising the need for inclusive government policies at various levels to create sustainable well-being (Ziosi et al., 2022). Overall, promoting social inclusion not only enhances citizen empowerment and decision-making, but also contributes to the overall sustainability and well-being of smart cities.

The discussion on the importance of Information Technology (IT) and Artificial Intelligence (AI) in promoting social inclusion in sustainable smart cities is justified by several research findings. Studies highlight the importance of financial sustainability in smart city initiatives, emphasising the need for proper financial analysis for long-term planning (Puron-Cid & Gil-Garcia, 2022). Furthermore, the concept of 'green AI' is proposed as a key enabler for smart city transformations, emphasising the importance of AI systems that address issues of efficiency, sustainability and equity in urban environments (Yigitcanlar et al., 2021). Furthermore, the integration of case-based reasoning (CBR) as an AI technique in smart city planning has been shown to provide valuable recommendations for urban planners to make cities smarter and more sustainable, promoting social inclusion and improving quality of life (Anthony Jnr, 2021).

The Research Question of the study is "How do AI and digital technologies promote social inclusion in smart and sustainable cities, and what are the key challenges in ensuring equitable access and participation for all citizens?" Therefore, the aim of this essay is to explore how artificial intelligence (AI) and digital technologies contribute to social inclusion in the development of smart and sustainable cities. The study examines the mechanisms by which these technologies enhance citizen participation, improve accessibility, and support inclusive urban governance, while addressing the challenges associated with digital inequality.

This theoretical essay examines the critical function of artificial intelligence (AI) and digital technologies in fostering social inclusion within the context of smart and sustainable cities. It explores how these technologies facilitate enhanced citizen participation, improve accessibility to urban services, and promote inclusive governance. Integrating AI into urban planning, cities can develop smarter infrastructure that responds more effectively to the needs of diverse populations, including marginalized groups. The essay discusses various digital tools, such as case-based reasoning (CBR) systems and smart city platforms, which enable citizens to actively engage in decision-making processes and urban design. It also addresses how AI can optimize public services and urban mobility, contributing to higher quality of life and sustainability.

However, the essay also acknowledges the challenges posed by digital inequality, such as the exclusion of certain groups due to lack of digital literacy or access to technology. Synthesizing key literature and recent research findings, the essay provides an understanding of the opportunities and obstacles in leveraging AI and digital technologies for social inclusion in cities. It calls attention to the need for inclusive and ethical deployment of these technologies to ensure equitable urban development, fostering both social well-being and sustainable growth.

RATIONALE AND DISCUSSION

Information technology (IT) plays a necessary part in promoting social inclusion within smart and sustainable cities by enhancing citizen participation, improving access to services, and fostering community engagement. Smart city initiatives leverage IT to create platforms that facilitate real-time connectivity and interaction among citizens, businesses, and government entities, thereby building social capital and enabling more inclusive urban environments (Anttiroiko et al., 2014). For instance, digital urban platforms allow citizens to vote on urban initiatives and collaborate on problem-solving, which empowers them to actively participate in city management and decision-making processes (Ziosi et al., 2022). This participatory approach is essential for ensuring that diverse urban populations, including marginalized groups, are included in the development and implementation of smart city solutions. Moreover, IT enables the creation of networked infrastructures that support social, cultural, and urban development, which are fundamental components of a smart city (Ziosi et al., 2022).

The integration of IT in urban planning, through tools like City Digital Twins (CDTs), further enhances citizen involvement by providing intuitive visualization features that make complex data more accessible and understandable to the public (Haraguchi et al., 2024). This not only improves transparency and accountability but also ensures that urban planning processes are more responsive to the needs and concerns of all citizens, regardless of their socio-economic status (Haraguchi et al., 2024). Additionally, IT-driven smart city solutions can address issues of inequality and discrimination by ensuring that public services are accessible to various urban residents, thereby promoting social inclusion and equity (Ziosi et al., 2022). However, challenges remain, such as the need to effectively incorporate digitally invisible populations, like undocumented individuals, into these systems to prevent their exclusion from the benefits of smart city initiatives (Haraguchi et al., 2024). Overall, IT is a powerful enabler of social inclusion in smart cities, as it not only facilitates the integration of diverse stakeholders into urban governance but also supports the development of sustainable and resilient urban communities.

Digital technologies have the potential to empower individuals by enhancing accessibility and participation, although they also present challenges that need to be addressed to overcome barriers effectively. In the context of smart cities, digital technologies can transform urban environments to be more digitally friendly, potentially improving individual lives, social wellbeing, and environmental conditions. However, these technologies can also exacerbate existing inequalities if not implemented with careful consideration of ethical, social, and legal

implications (Ziosi et al., 2022). For instance, the digitization of government services can inadvertently create new inequities if certain groups lack the digital literacy or access needed to benefit from these services (Ziosi et al., 2022). Moreover, digital twin technology, while offering innovative solutions, may fail to incorporate digitally invisible populations, such as undocumented individuals or the homeless, thus excluding them from the benefits of digital advancements (Haraguchi et al., 2024). This exclusion highlights the importance of ensuring that digital technologies are inclusive and consider the diverse needs of all citizens. Additionally, smart cities aim to promote inclusive growth by integrating urban policies with smart technologies, thereby providing easier access to services and infrastructure for all citizens, including those with disabilities and senior citizens (Sidani et al., 2022). Nevertheless, the success of these initiatives depends on overcoming challenges related to digital literacy and ensuring equitable access to technology. While digital technologies offer significant opportunities for empowerment, they must be designed and implemented with a focus on inclusivity and equity to truly overcome barriers and empower all individuals.

Leveraging smart technology for sustainable urban development offers numerous benefits, as listed on Table 1. Smart cities utilize information and communication technologies (ICT) to enhance the quality of life, efficiency of urban operations, and competitiveness while ensuring sustainability across economic, social, environmental, and cultural dimensions (Sidani et al., 2022). The integration of smart technologies, such as smart grids, meters, and buildings, can significantly improve energy efficiency, reduce environmental pollution, and promote a shift towards renewable energy sources, thereby contributing to environmental sustainability (Ziosi et al., 2022). Additionally, smart city initiatives can mitigate the adverse effects of urbanization, such as pollution and resource depletion, by implementing efficient transport systems and smart energy solutions (Ziosi et al., 2022). The use of smart computing technologies in city infrastructure, including transportation and utilities, enhances interconnectedness and efficiency, which are important for sustainable urban development (Sidani et al., 2022). Moreover, smart technologies can facilitate active mobility through smartphone applications that promote walking and cycling, thus reducing reliance on motorized vehicles and contributing to healthier lifestyles and reduced pollution (Papageorgiou et al., 2024). The strategic use of digital twin technology (CDT) in urban planning can also enhance public participation and understanding, fostering a bottom-up approach that improves governance and accountability in smart city initiatives (Haraguchi et al., 2024).

Furthermore, smart city policies emphasize social inclusion and the creation of public value through creative collaboration and coordination, which are essential for sustainable urban environments (Anttiroiko et al., 2014). By addressing the challenges of urbanization with innovative solutions, smart technologies not only improve the sustainability and resilience of urban communities but also support economic growth and social well-being (Anttiroiko et al., 2014; Ziosi et al., 2022). Nonetheless, it is important to balance technological advancements with considerations of social and environmental impacts to ensure that smart city projects prioritize sustainability challenges effectively (Ziosi et al., 2022). Overall, the integration of smart technologies in urban development holds the potential to transform cities into more sustainable, efficient, and inclusive environments, addressing both current and future urban challenges.

Table 1 provides an overview of the key benefits offered by smart technology for sustainable urban development, supported by insights from relevant academic sources. The table highlights various aspects, such as energy efficiency, public participation, and social inclusion, demonstrating how smart cities can foster not only technological advancement but also social equity and environmental responsibility.

Table 1: Benefits offered by smart technology for sustainable urban development

<i>Benefit;</i>	<i>Description;</i>	<i>Source</i>
<i>Improved Quality of Life and Urban Efficiency</i>	Smart cities leverage ICT to enhance residents' quality of life, increase the efficiency of urban operations, and boost competitiveness while ensuring sustainability across economic, social, environmental, and cultural dimensions.	Sidani et al., 2022
<i>Enhanced Energy Efficiency and Environmental Sustainability</i>	The integration of smart grids, meters, and buildings improves energy efficiency, reduces pollution, and promotes renewable energy sources, contributing to environmental sustainability.	Ziosi et al., 2022
<i>Mitigation of Urbanization Challenges</i>	Smart city initiatives help mitigate the negative effects of urbanization, such as pollution and resource depletion, through efficient transport systems and smart energy solutions.	Ziosi et al., 2022
<i>Increased Interconnectedness and Infrastructure Efficiency</i>	Smart computing technologies improve the interconnectedness and efficiency of city infrastructure, including transportation and utilities, which are critical for sustainable urban development.	Sidani et al., 2022
<i>Promotion of Active Mobility and Reduced Pollution</i>	Smartphone applications that promote walking and cycling reduce reliance on motorized vehicles, contributing to healthier lifestyles and reduced pollution.	Papageorgiou et al., 2024
<i>Enhanced Public Participation through Digital Twin Technology</i>	The use of digital twin technology (CDT) in urban planning facilitates public participation and understanding, fostering a bottom-up approach that improves governance and accountability.	Haraguchi et al., 2024
<i>Social Inclusion and Public Value Creation</i>	Smart city policies emphasize social inclusion and the creation of public value through collaboration and coordination, essential for fostering sustainable urban environments.	Anttiroiko et al., 2014
<i>Economic Growth and Social Well-Being</i>	By addressing urbanization challenges with innovative solutions, smart technologies support the sustainability and resilience of urban communities, while promoting economic growth and social well-being.	Anttiroiko et al., 2014; Ziosi et al., 2022
<i>Balanced Technological Advancements with Social and Environmental Considerations</i>	It is important to balance technological progress with considerations of social and environmental impacts to ensure that smart city projects effectively prioritize sustainability challenges.	Ziosi et al., 2022

Source: developed by the authors

Research papers provided offer insights into the development of Smart Pedestrian applications, emphasizing the importance of optimized walking routes, accessibility, and social inclusion in urban environments. The study from Nicosia, Cyprus (Papageorgiou et al., 2024), highlights the necessity of addressing infrastructural deficiencies and enhancing pedestrian safety to encourage walking and the adoption of Smart Pedestrian applications. It suggests using technologies like Geographic Information Systems (GIS) and real-time data integration to dynamically map and update pedestrian pathways, ensuring the shortest, safest, and most convenient routes are available to users (Papageorgiou et al., 2024). This approach not only optimizes walking routes but also enhances accessibility by considering various factors such as path distance, surface conditions, and congestion. Furthermore, the research underscores the socioeconomic factors, such as income and education, in influencing walkability, suggesting that more educated individuals are likely to appreciate the benefits of walking, which can be integrated into the design of pedestrian applications to promote inclusivity (Papageorgiou et al., 2024).

Promoting social inclusion for deaf and hearing-impaired Individuals, ICOM Libras represents a significant step forward in using information technologies to promote social inclusion for deaf and hearing-impaired individuals. By providing real-time, remote translation services, the platform addresses a critical communication barrier and enhances the accessibility of services across various sectors. Its role in supporting legal and ethical obligations for accessibility further highlights its importance in fostering inclusive environments (ICOM Libras, 2024). As technology continues to evolve, platforms like ICOM will be fundamental in ensuring that people with disabilities are fully integrated into society, with equal access to communication and opportunities. Despite its benefits, ICOM and similar platforms must continuously address challenges related to digital access and inclusion. While ICOM provides a solution for communication barriers, it relies on the availability of internet access and compatible devices. For some institutions, especially in regions with limited digital infrastructure, ensuring that both deaf and hearing participants have the necessary technology may be challenging. However, the platform's flexibility in device usage mitigates this issue to some extent, allowing for wider accessibility.

The concept of social inclusion is further explored in the context of smart cities, where citizen participation and equitable access to urban services are essential. The papers discuss the importance of involving a diverse range of urban residents in the planning and implementation of smart city initiatives, ensuring that marginalized groups are not excluded from the benefits of such technologies (Haraguchi et al., 2024; Ziosi et al., 2022). This is particularly relevant for Smart Pedestrian applications, which must be designed to cater to the needs of all citizens, regardless of their economic status, gender, or other demographic factors. The integration of advanced technologies, such as augmented reality, is proposed to enhance user engagement and provide immersive navigational cues, further supporting accessibility and inclusivity in urban environments (Papageorgiou et al., 2024). Additionally, the papers highlight the potential of smart city technologies to facilitate more responsive and participatory urban governance, which can lead to more inclusive and effective urban planning and service delivery (Anttiroiko et al., 2014). Overall, the research emphasizes a holistic approach to developing Smart Pedestrian applications, focusing on optimizing walking routes, enhancing accessibility, and ensuring social inclusion to improve urban mobility and quality of life.

CONCLUSION

This theoretical essay has highlighted the significant potential of AI and digital technologies in promoting social inclusion within smart and sustainable cities. The integration of AI-driven systems, such as case-based reasoning (CBR) and smart city platforms, can enhance citizen participation, improve accessibility to public services, and support more inclusive urban governance. These technologies offer opportunities for more efficient urban planning, greater transparency, and the empowerment of marginalized groups, contributing to a more equitable and sustainable urban environment. However, the study identifies several limitations. First, the theoretical nature of the essay means that it lacks empirical evidence to validate the proposed impacts of AI and digital technologies on social inclusion. Second, digital inequality remains a critical challenge, as certain populations may be excluded from the benefits of these innovations due to limited access to technology or insufficient digital literacy. Additionally, the ethical implications of AI in urban development, such as privacy concerns and potential biases in algorithmic decision-making, require further exploration.

For future research, empirical studies are needed to assess the real-world impacts of AI and digital technologies on social inclusion in various urban settings. Investigating how different cities address digital inequality and the role of participatory governance in overcoming these challenges could provide valuable insights. Moreover, research should focus on

developing frameworks that balance technological advancement with ethical considerations, ensuring that smart city initiatives prioritize social equity and sustainability in practice.

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