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Original Article

Ethical Challenges of AI Integration in Architecture and Built Environment

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Abstract

Artificial intelligence is transforming the way cities operate by increasing efficiency and sustainability. Smart cities use artificial intelligence (AI) to optimize traffic flow, reduce energy usage, and improve public services. AI-powered systems process massive volumes of data in real time to improve urban planning and resource allocation. However, there are certain obstacles, such as data protection, ethical considerations, and the potential of employment displacement. This study investigates how AI contributes to smart cities and the limitations that must be overcome. Understanding these aspects enables urban planners to develop AI-powered solutions that promote sustainable and equitable city growth.

Keywords: Artificial Intelligence (AI), Smart Cities, Urban Resilience, Architecture, Sustainability, Urban Planning.

Introduction

The idea of cities that are smart is developing as new technology in urban infrastructure becomes available. Modern technology is becoming an important instrument for creating the future of cities as they address difficulties such as resource management, environmental protection and rapid population grows. These technologies improve how cities operate by making them more efficient and sustainable while providing new ways to solve common urban issues. As cities around the world grow larger more are adopting smart systems to improve services such as transportation energy use and waste management.

Beyond basic automation, artificial intelligence (AI) contributes to smart cities by enabling autonomous resource management, real-time decision-making, and predictive analysis, all of which lead to more sustainable urban development. As cities try to minimize their carbon footprints and become more resilient to climate change, artificial intelligence provides innovative solutions to enhance energy efficiency, reduce waste and improve people overall quality of life (Balcı et al., 2025). For example, AI may evaluate enormous volumes of data from sensors implanted in the urban fabric to optimize traffic flow, monitor air quality and control energy usage which is lowering cities' environmental impact (Khan et al., 2023).

Generative AI is rapidly evolving toward next-generation AI applications centered around autonomous adaptation and creativity. (Mahmoud & Mohammadabadi, 2025) outlines an evolutionary strategy for AI systems in city planning around self-generating architectural forms, infrastructure predictive maintenance, and adaptive urban mobility options. This strategy powered by generative AI reinforces the ability of smart cities to maximize spatial arrangement, reduce carbon emissions, and enhance urban habitability through dynamically learned adaptation to real-time environmental dynamics.

However, despite its potential, using AI in smart cities presents problems. One of the main challenges is the ethical implications of AI, particularly in terms of privacy and data security. As AI systems collect and analyze vast volumes of personal data, protecting people' privacy becomes increasingly important (Muralidhara Rao et al., 2022). Furthermore, the dependence on AI raises worries about technological unemployment and the demand for a competent workforce to operate and maintain these systems (Yigitcanlar & Cugurullo, 2020).

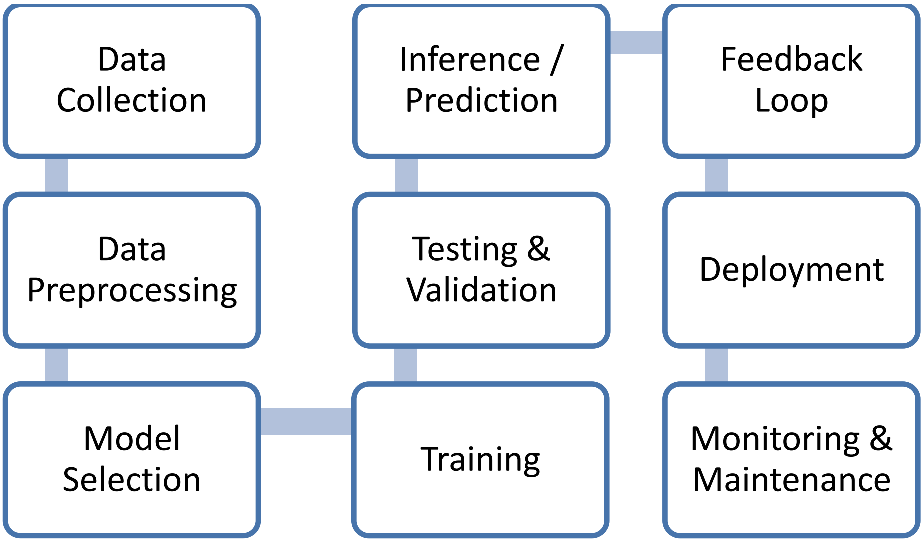

Figure 1 Overview of AI Workflow. Source: Author.

Figure 1. A simplified overview of the AI workflow, illustrating the key stages from data collection and preprocessing to model training, testing, inference, deployment, and ongoing maintenance.

Despite these challenges the application of AI in smart cities has a useful future. The continuous development of AI technologies such as blockchain and machine learning is enabling smarter, more sustainable cities (Mrabet & Sliti, 2024). As AI systems advance, they will have a substantial impact on the future of urban life by improving the livability, efficiency, and environmental friendliness of cities. By employing AI to improve urban operations and reduce environmental impact, cities may play a big part in advancing sustainability in the twenty-first century (Zafar, 2024).

In conclusion, the development of artificial intelligence will determine how smart cities develop in the future. Opportunities for more sustainable cities arise as AI's capacity to alter urban environments advances. To guarantee that the benefits are shared equally among all citizens of cities, it is imperative to address the ethical and social issues surrounding AI (Bibri et al., 2023).

1. The Importance of AI in Sustainable Urban Development

Cities can expand more intelligently and sustainably with the aid of artificial intelligence. Cities become more ecologically friendly and efficient as a result. AI is capable of processing large amounts of data rapidly. This aids city planners in making better choices that enhance people's quality of life. By better controlling the usage of electricity, AI also contributes to energy conservation. Smart networks ensure that energy is used where it is most required and is not wasted (Babu et al., 2023). AI can enhance transportation as well. It improves the efficiency of public transportation and aids in traffic flow regulation (Zafar, 2024). AI helps monitor air quality, manage waste and reduce pollution when combined with smart technologies like the Internet of Things (Herath & Mittal, 2022). Cities may expand using AI while conserving resources and preserving the environment.

Architecture has perpetually been a reflection of human ambitions and culture, and the preservation of ancient monuments is fundamental to maintaining such connections. (Roya Nazari Najafabadi et al., 2024) underscore the importance of ecological restoration in maintaining the structural and cultural integrity of such sites as the Chogha Zanbil ziggurat. According to their study, ecological restoration enhances the integration of historic buildings with the environment while maintaining their architectural, cultural, and religious significance. AI helps preserve cultural monuments by analyzing structural integrity, predicting deterioration, automating restoration processes, and enhancing conservsation efforts with data.

ChronoGAN, a time-series generation model, enhances this predictive power of AI in city planning by simulating traffic patterns, energy consumption, and weather fluctuations. By integrating temporal interdependencies into the produced data, ChronoGAN enhances long-term forecasting performance of crucial critical smart city services, such as energy optimization and disaster preparedness (EskandariNasab et al., 2024). This simulation-based approach with AI resolves uncertainty and promotes more sustainable and resilient cities.

The integration of AI and big data financial technologies is improving urban economic resource distribution. Based on consumption patterns analysis, AI-based financial models guide investment, optimize municipal budgeting, and facilitate financial inclusion in underbanked urban communities (Pazouki, Behdad, et al., 2025).

Artificial intelligence applications in green architecture range from energy efficiency to carbon reduction throughout the building's life cycle. (Wang et al., 2024) present a life cycle assessment (LCA) technique for comparing the carbon footprint of buildings based on design, material consumption during construction, and energy use. The comprehensive approach enables urban planners to implement AI-based carbon accounting and design low-carbon cities that meet global sustainability criteria.

The integration of dual RIS-supported WSNs enhances energy efficiency in smart cities. With fuzzy deep reinforcement learning, the networks streamline data transmission, reduce latency, and optimize overall QoS. The innovation cuts energy consumption noticeably while maintaining secure data exchange between interconnected systems, a necessity for scalable smart infrastructure in cities (Khatami et al., 2025). As cities transition towards sustainability, such adaptive WSNs offer vital pathways to achieving more sustainable and low-energy urban systems.

The inclusion of new technologies is a vital component in the evolution of smart cities. One example of this technology is Radio Frequency Identification (RFID) which enhances the operations of the supply chain with increased efficiency and lower costs. (Saremi et al., 2013) assert that the implementation of RFID in Malaysia has improved real-time location tracking and inventory management. The use of RFID within smart cities can incorporate resources and logistics and make the city even smarter.

Artificial intelligence (AI)-based multi-criteria decision-making (MCDM) models are revolutionizing the digital economy as well as urban governance. (Entezami et al., 2025) point towards the ability of AI to evaluate economic, environmental, and social criteria to guide urban development policies. This AI-based system allows city planners to make data-informed decisions, identify sustainable investments, and ensure equitable access to urban resources, thus fostering more resilient and inclusive urban environments.

Intelligent freight transport is essential in enabling smart cities to realize supply chain efficiency and reduced carbon footprints. (Espahbod, 2020) emphasizes the potential of AI and IoT in the governance of intelligent freight systems by augmenting real-time routing, load optimization, and delivery productivity. With this integration, fuel consumption decreases and traffic congestion eases, resulting in a more sustainable and resilient urban supply chain network, which plays a significant role in meeting growing urban populations' demands.

Artificial intelligence ability to enhance architectural applications also appears in urban planning and campus planning. Deep learning models, for instance, have exhibited a high ability to classify architectural images accurately, which is crucial in record keeping of historical buildings, monitoring renovations, and improving the mapping of cities. (Karkehabadi & Sadeghmalakabadi, 2024) researched to demonstrate how AI could analyze architectural trends in the UC Davis campus to identify spatial inefficiencies and optimize pedestrian paths. The technology allows city planners to create more pedestrian-friendly, resource-efficient spaces through an understanding of real-time information regarding infrastructure usage.

Technology improves resource management, supports environmental protection and energy efficiency which all contribute to sustainable urban growth. (Talebian et al., 2025) explain that smart building systems can lower energy consumption by optimizing heating and cooling functions. These systems adjust energy use based on occupancy and external conditions by collecting and analyzing real-time data from various sensors. This process maintains indoor comfort while reducing carbon emissions and preventing energy waste. By increasing building efficiency and minimizing resource use, technology plays an important role in advancing sustainable urban development (Talebian et al., 2025).

1. Challenges Cities Face

Cities face substantial challenges that restrict their ability to develop in a way that is beneficial. Population increase is one issue. Each day, more individuals relocate to urban areas. According to (Leal Filho et al., 2024), this raises the demand for a place to live and essential services. Cities must grow while providing for the needs of their citizens. Climate change is another issue. Extreme weather events as heat waves, storms and floods occur in many cities. (NASA's Scientific Visualization Studio, 2025) reports that the global temperature has risen by 1.28 °C and 2.3 °F (Fig2). Cities can become more resilient to catastrophes by using AI to better foresee these occurrences (Bibri et al., 2023). Resource management is another issue that cities face. Living sustainably is made more difficult by issues with water shortages and overuse of energy.

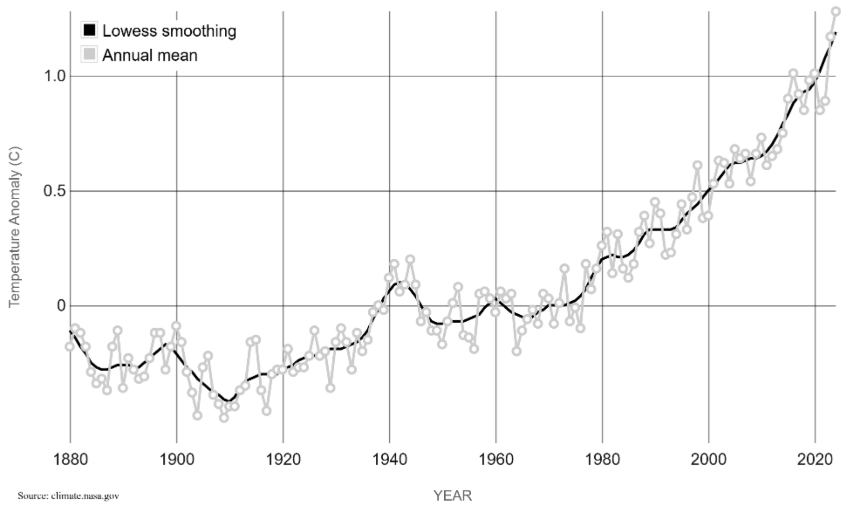

Figure 2, Climate Change Over Years. Source: (NASA's Scientific Visualization Studio, 2025)

Figure 1 shows global temperature rise of 1.28 °C (2.3 °F) as reported by NASA's Scientific Visualization Studio (2025).

Urban planners are increasingly faced with ensuring soil stability in infrastructure development, especially in fine-grained soil. A comparative study by (Barati-Nia et al., 2025) of the efficiency of SHANSEP and recompression methods in improving soil resistance to cyclic stress conditions is presented. Results suggest how sustainable urban infrastructure development may be facilitated through the guarantee that foundations are stable even under extreme climate or seismic activity.

Volatility in truckload spot markets of transportation creates inefficiencies that burden urban freight logistics. (Haughton et al., 2022) analyze the "price of anarchy" effect, where decentralized carrier decision-making produces non-optimal outcomes. This refers to the need for AI-driven coordination in urban logistics where centralized platforms could optimize delivery efficiency, make prices stable, and reduce avoidable emissions from inefficient route planning and redundant truckloads.

2. Purpose and Scope of This Article

The goal of this study is to investigate the role of artificial intelligence in the development of smart cities. It aims to reveal the advantages of AI in urban administration such as traffic optimization reduced energy usage and improved public services. The report also discusses the ethical issues and concerns involved with AI implementation such as data security and employment loss. By tackling these concerns the research provides insights on how AI might be integrated into urban planning to produce more sustainable and efficient communities.

Table 1: Applications of AI in Smart Cities

Application	Description
Traffic Management	AI analyzes traffic data to reduce congestion and optimize routes
Energy Efficiency	AI monitors power usage and optimizes distribution
Waste Management	AI predicts waste collection schedules and improves recycling rates
Public Safety	AI enhances surveillance and emergency response times

3. Challenges and Ethical Considerations

The use of artificial intelligence in smart cities raises several ethical problems and barriers to achieving sustainable urban development. Concerns about data security and privacy, bias in decisions, job ramifications and unequal access to digital services are just a few of these challenges.

Walkability is one of the most important aspects of sustainable urban planning, particularly where cities are densely populated. Walkability corridor studies, for example, for Saadatabad Square in Tehran, demonstrate the usefulness of AI-based applications for assessing pedestrian comfort and safety. (Oskooie et al., 2023) describe the capability of AI to optimize corridor designs based on pedestrian density, air quality, and accessibility considerations. This data-driven approach minimizes city traffic and ensures equitable distribution of public space in line with the principles of inclusive and ethical urban development.

AI plays a vital role in mitigation of urban freight logistics inefficiencies. (Espahbod, 2024) points towards the dynamics of trucking freight spot markets, and it demonstrates how AI-based logistics can reduce redundancies on routes, streamline delivery schedules, and reduce carbon footprint through maximizing real-time load distribution and preventing empty miles.

AI-based FinTech models are a cause for concern in city economies, particularly with regards to data privacy and algorithmic transparency. (Pazouki, Metamax, et al., 2025) emphasize the need for fair regulation of AI in order to prevent discriminatory outcomes and encourage ethical practices in finance systems within smart cities.

Decentralized multi-agent learning introduces novel communication efficiency problems, particularly in urban complex systems. A workload-balancing approach by (Sajjadi Mohammadabadi, Yang, et al., 2024) optimizes task distribution among AI agents, minimizing network congestion and speeding up task execution in smart city applications. The model promotes equitable resource allocation and addresses ethical concerns related to AI bias, system overload, and data access in urban governance.

Artificial intelligence has a double-edged contribution towards financial market stability, with its effects on sustainable growth and speculative bubbles. While AI becomes more integrated into urban economies, discrimination between authentic value creation in markets and harmful hype is necessary to prevent economic fluctuations. Financial regulation through AI can analyze prospective speculative patterns and alleviate associated risks, enhancing economic resilience in intelligent cities (Ahmadirad, 2024a).

Driven by AI smart cities must provide data security and privacy. People provide sensors and digital technologies with a vast amount of data. When data is accessed or exploited, poor data management can lead to privacy violations and cybersecurity breaches (Muralidhara Rao et al., 2022). Enacting rigorous data protection legislation and supporting moral values are critical for maintaining public trust and avoiding the exploitation of personal information.

Resilient supply chain management raises urban logistics ethical issues. (Entezami & Havaeji, 2023) articulate the intricate balance between time-to-market performance and reducing environmental risk for green drug supply chains. Artificial intelligence-based logistic optimization can soften this balance through route-optimized delivery, greenhouse gas emission reduction, and compliance with environmental regulations. Ethical questions are raised when speed is prioritized over sustainability and open AI programming is required to balance both intentions.

Another key difficulty with AI-based urban decision-making is bias and fairness. AI systems commonly rely on historical data, which can be suggestive of current social inequalities. If these systems are not adequately developed, they may produce biased results in sectors such as housing, public services, and law enforcement (Yigitcanlar & Cugurullo, 2020). To avoid these issues, cities must create transparent AI algorithms and fairness checks that ensure all residents are treated fairly (Cugurullo, 2020).

AI can also help cities adapt to climate change by directing the creation of resilient infrastructure. Innovative technologies, such as amphibious house, offer an ongoing approach to flood risk mitigation (Naseri et al., 2024). These buildings float on rising water levels which is keeping people safe from flooding. Artificial intelligence contributes to this effort by evaluating environmental data to forecast flooding patterns and assist the construction of such structures. When AI and sustainable design are linked, urban resilience increases while disaster risk decreases.

Job loss and workforce changes are growing concerns as AI automates urban services. Although AI increases efficiency it may also replace workers in sectors like transportation administration and customer support (Mrabet & Sliti, 2024). Cities need to create training and education programs to help workers shift to new jobs in an AI-driven economy (Khan et al., 2023).

The digital gap exacerbates inequalities in smart city services. AI-powered systems rely on digital infrastructure, which is not necessarily accessible to everyone. Underserved populations may struggle to obtain basic services such as healthcare, education, and transportation (Bibri et al., 2023). Without inclusive policies, these people may fall behind. Governments and city planners must close this gap by increasing internet access and ensuring that AI technologies serve all residents equitably (Rieder et al., 2022).

Table 2: Challenges of AI Implementation

Challenge	Description
Data Privacy	Risk of unauthorized access to sensitive information
Ethical Concerns	AI bias and its impact on decision-making
High Costs	Expensive implementation and maintenance
Workforce Displacement	Automation replacing traditional jobs

Addressing these challenges requires a balanced approach that integrates ethical considerations, policy regulations, and technological advancements. Without proactive measures, AI-driven smart cities risk deepening social inequalities rather than fostering sustainable and inclusive urban environments.

4. Future Trends and Innovations

The future smart city will be shaped by current advancements in AI and its integration with other emerging technologies. Several important trends and innovations will greatly affect urban development sustainability and efficiency.

AI-driven digital twins are increasingly being used in urban planning. The virtual representations emulate physical urban infrastructure with real-time information from IoT sensors and AI modeling. Digital twins help city planners model various scenarios and predict outcomes in terms of infrastructure sustainability and disaster response (Xu et al., 2024). Cities can streamline resource planning, traffic management, and resilience to climate change through the use of such models (Alnaser et al., 2024).

Interactive design-of-experiments (DoE) in artificial intelligence (AI) optimizes complex urban systems by optimizing cooling efficiency in smart buildings. By capturing various design parameters, the AI-driven DoE technique optimizes system versatility and energy efficiency in real-world implementation, thus contributing to sustainable smart city infrastructure (Splechtna et al., 2024).

Digital marketing is transforming citizen engagement in smart cities with data-driven approaches. (Saremi et al., 2024) propose a framework under which customer engagement and knowledge management enhance marketing effectiveness. This approach allows municipalities to provide personalized urban services, improve communication, and increase public engagement. Integration of digital marketing with smart city initiatives guarantees that the development of technology keeps pace with citizens' expectations, with urban governance becoming responsive and effective.

AI is transforming financial operations in intelligent cities by integrating digital technologies that enhance fraud detection, credit scoring, and automated asset management. The transformation optimizes financial service delivery, increases efficiency, and enhances financial infrastructure resilience (Pazouki, Jamshidi, et al., 2025).

Generative AI is also proving to be a revolutionary instrument in the creation of smart grid communication. Distributed learning frameworks facilitated by generative AI can help improve data transmission, fault detection, and energy efficiency in smart grids, as noted by (Sajjadi Mohammadabadi, Entezami, et al., 2024). With this technology, cities can reduce power outages, improve grid resilience, and optimize energy usage, thus making AI-driven grids an extremely critical component of sustainable urban infrastructure in the future.

Federated learning (FL) is transforming smart city data sharing with accelerated decentralized learning in heterogeneous environments. Dynamic tiering improves communication efficiency and reduces training latencies in smart city IoT networks. This enables the easier integration of autonomous devices, real-time data analysis, and faster decision-making without compromising privacy (Mahmoud Sajjadi Mohammadabadi et al., 2025). By reducing latency, FL speeds up resilience and responsiveness in city services, from transport to energy management.

Decentralized management of energy is emerging as one of the new trends in urban sustainability. (Hashemi et al., 2016) suggest strong model predictive control (MPC) for energy hubs that maximizes use of renewable and conventional energy sources in smart cities. By decentralizing control systems, city planners will be able to have more resilient, dynamic, and energy-efficient infrastructure, which is needed to maintain stability in the energy supply and lower carbon emissions during peak demand.

AI is also being combined with IoT blockchain and 5G networks to create more integrated city ecosystems. IoT sensors collect and transmit massive amounts of data which is analyzed by AI to optimize city services such as waste management energy supply and security surveillance (Khan et al., 2023). Blockchain technology ensures data integrity and transparency while 5G ensures faster and more reliable communication between smart city components (Bibri et al., 2023). These technologies are also facilitating more intelligent and responsive urban systems through their integration (Babu et al., 2023).

Silicon Valley's technological advancements, inspired by venture capital investment, have accelerated innovations in AI technologies that strengthen world financial markets. Such innovations constitute the financial leg of smart cities by enhancing streams of investment, enabling AI-based wealth management, and increasing urban economic forecasting (Ahmadirad, 2024b). Through sustainable innovation systems, city planners can offer long-term financial growth, improved urban living, and an enhanced digital economy.

With the development of technology of AI, its application in cultural and city beauty is being expanded. Generative AI and machine learning processes inspired by Zen art and visual images have opened a new path for city planning. (Panahi et al., 2018) describe cities can recreate natural artistic process to create a harmonious city view that combines ancient beauty with modern functionality. With the integration of aesthetic algorithms with urban planning, AI transforms cities into more vibrant, good-looking and people friendly places.

Satellite synchronization based on artificial intelligence (AI)-based control systems offers new avenues for city surveillance and disaster mitigation. The recent development of integral terminal sliding mode controllers provides the capability to stabilize chaotic leader-follower satellites' angular velocities to enable precise city air quality, water system, and traffic surveillance (Azadmanesh et al., 2024). The AI-based synchronization approach enhances the accuracy of real-time information, which is essential for smart city sustainable urban planning and crisis management.

The use of AI to revolutionize city planning and design extends beyond the mere automation of processes to more innovative applications like predictive analytics and real-time resource management. (Naseri, 2024a) believes that AI can crunch massive amounts of data gleaned from sensors embedded in urban infrastructure to allow cities to manage energy consumption, regulate mobility, and optimize waste management in real time. Apart from improving urban operations' output, artificial intelligence technologies help to lower the whole environmental effect of cities. Urban designers may create a more transparent and sustainable urban environment by means of the integration of artificial intelligence and newly developed technologies such the Internet of Things (IoT) and blockchain (Naseri, 2024a).

Table 3: Future Trends in AI for Smart Cities

Trend	Impact
Digital Twins	Virtual city models for better planning
AI in Governance	Data-driven decision-making
AI-Blockchain Integration	Secure and transparent data management

AI-enabled mobility solutions are transforming transport in smart cities. Intelligent public transport autonomous cars and AI-driven traffic management are increasing efficiency and reducing congestion (Yigitcanlar & Cugurullo, 2020). Predictive analysis and AI-driven traffic signals are optimizing urban mobility by reducing journey time and minimizing carbon emissions (Bibri et al., 2023). AI-enabled smart public transport systems introduce passenger demand management improve scheduling and increase commuter satisfaction (Cugurullo, 2020).

Another groundbreaking use is the application of generative AI in urban modeling and design. Generative AI uses machine learning to create the most optimized building layouts urban areas and green infrastructure alternatives (Rieder et al., 2022). Real-time data can be used by AI to offer adaptive urban design that maximizes efficiency environmental sustainability and habitability (Naseri, 2024b). These AI-designed models can be utilized by architects and planners to scan through various design options and choose the most promising ones for use in future developments (Bibri et al., 2023).

Transport equity is increasing in importance as cities become more intelligent. A general model developed by (Halimi et al., 2025) quantifies transport equity based on disparities in urban ground transport access. AI can trace underprivileged areas and propose fair public transportation expansions, where poor neighborhoods have better access to city services. The innovation does not merely encourage mobility but also transportation planning inclusivity.

Cities have to embrace adaptive governance systems and legislative policies to guarantee ethical implementation of such AI-driven trends rising in them. The effectiveness of embedding these technologies into current urban surroundings while resolving any hazards and guaranteeing inclusion will determine the direction of smart cities. By means of efficient use of artificial intelligence, smart cities may achieve equilibrium between technological progress and sustainable development, thereby fostering effective resilient and inclusive cities for all.

2. Conclusion

The future success of smart cities depends on how much artificial intelligence is integrated into cities to promote efficiency sustainability and livability. AI can transform cities by optimizing transportation improving energy usage and responsiveness of public services. However, cities must address the ethical issues that come with AI like data privacy job displacement and the digital divide. To create truly intelligent and inclusive cities policymakers urban planners and tech developers must work together so that AI benefits all citizens equally. The future requires responsible AI governance investment in digital infrastructure and continued innovation to align technological progress with social responsibility. Since cities continue to evolve AI will continue to be a leading driving force of change shaping urban areas that are more adaptive resilient and sustainable for future generations.

Bibliography

1. Ahmadirad, Z. (2024a). Evaluating the Influence of AI on Market Values in Finance: Distinguishing Between Authentic Growth and Speculative Hype. *International Journal of Advanced Research in Humanities and Law*, *1*(2),50–57. https://doi.org/10.63053/IJREL.11
2. Ahmadirad, Z. (2024b). The Beneficial Role of Silicon Valley's Technological Innovations and Venture Capital in Strengthening Global Financial Markets. *International Journal of Modern Achievement in Science, Engineering and Technology*, *1*(3), 9–17. https://doi.org/10.63053/IJSET.40
3. Alnaser, A. A., Maxi, M., & Elmousalami, H. (2024). AI-Powered Digital Twins and Internet of Things for Smart Cities and Sustainable Building Environment. *Applied Sciences 2024, Vol. 14, Page 12056*, *14*(24), 12056. https://doi.org/10.3390/APP142412056
4. Azadmanesh, M., Roshanian, J., Georgiev, K., Todrov, M., & Hassanalian, M. (2024). Synchronization of angular velocities of chaotic leader-follower satellites using a novel integral terminal sliding mode controller. *Aerospace Science and Technology*, *150*, 109211. https://doi.org/10.1016/J.AST.2024.109211
5. Babu, V. V., Preetha Roselyn, J., & Sundaravadivel, P. (2023). Multi-objective genetic algorithm based energy management system considering optimal utilization of grid and degradation of battery storage in microgrid. *Energy Reports*, *9*, 5992–6005. https://doi.org/10.1016/J.EGYR.2023.05.067
6. Balcı, O., Almohammad, D., Kılıç, C., & Singh, R. (2025). Harnessing Emerging Technologies for Green Sustainability: Innovations, Challenges, and Future Pathways. *Climate Change Management*, *Part F106*, 209–225. https://doi.org/10.1007/978-3-031-832 50-5_13
7. Barati-Nia, A., Earl Parrott, A., Sorenson, K., Moug, D. M., & Khosravifar, A. (2025). Comparing Cyclic Direct Simple Shear Behavior of Fine-Grained Soil Prepared with SHANSEP or Recompression Approaches. *Geotechnical Frontiers 2025*, 419–429. https://doi.org/10.1061/9780784485996.040
8. Bibri, S. E., Alexandre, A., Sharifi, A., & Krogstie, J. (2023). Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies and solutions: an integrated approach to an extensive literature review. *Energy Informatics 2023 6:1*, *6*(1), 1–39. https://doi.org/10.1186/S42162-023-00259-2
9. Cugurullo, F. (2020). Urban Artificial Intelligence: From Automation to Autonomy in the Smart City. *Frontiers in Sustainable Cities*, *2*, 494301. https://doi.org/10.3389/FRSC.2020.00038/BIBTEX
10. Entezami, M., Basirat, S., Moghaddami, B., Bazmandeh, D., & Charkhian, D. (2025). Examining the Importance of AI-Based Criteria in the Development of the Digital Economy: A Multi-Criteria Decision-Making Approach. *Journal of Soft Computing and*

Decision Analytics, *3*(1), 72–95. https://doi.org/ 10.31181/JSCDA31202555
11. Entezami, M., & Havaeji, H. (2023). Green Drug Supply Chain Investigation by Time-Market Balance and Risk. *World Journal of Engineering and Technology*, *11*(03), 611–631. https://doi.org/10.4236/WJET.2023.113042
12. EskandariNasab, M., Hamdi, S. M., & Boubrahimi, S. F. (2024). *ChronoGAN: Supervised and Embedded Generative Adversarial Networks for Time Series Generation*. https://arxiv.org/abs/2409.14013v1
13. Espahbod, S. (2020). Intelligent Freight Transportation and Supply Chain Drivers: A Literature Survey. *Uncertainty and Operations Research*, 49–56. https://doi.org/10.1007/978-981-15-5720-0_6
14. Espahbod, S. (2024). Market Information, Human Behaviour, and Policy: Dissecting the Trucking Freight Spot Markets in Three Essays. *Theses and Dissertations (Comprehensive)*. https://scholars.wlu.ca/etd/2606
15. Halimi, Z., SafariTaherkhani, M., & Cui, Q. (2025). A Generalized Framework for Assessing Equity in Ground Transportation Infrastructure: Exploratory Study. *Journal of Management in Engineering*, *41*(2). https://doi.org/10.1061/JMENEA.MEENG-6336
16. Hashemi, Z., Ramezani, A., & Moghaddam, M. P. (2016). Energy hub management by using decentralized robust model predictive control. *2016 4th International Conference on Control, Instrumentation, and Automation, ICCIA 2016*, 105–110. https://doi.org/10.1109/ICCIAUTOM.2016.7483144
17. Haughton, M., Rostami, B., & Espahbod, S. (2022). The price of anarchy in truckload transportation spot markets. *EURO Journal on Transportation and Logistics*, *11*, 100071. https://doi.org/10.1016/J.EJTL.2022.100071
18. Herath, H. M. K. K. M. B., & Mittal, M. (2022). Adoption of artificial intelligence in smart cities: A comprehensive review. *International Journal of Information Management Data Insights*, *2*(1), 100076. https://doi.org/10.1016/J.JJIMEI.2022.100076
19. Karkehabadi, A., & Sadeghmalakabadi, S. (2024). Evaluating Deep Learning Models for Architectural Image Classification: A Case Study on the UC Davis Campus. *2024 IEEE 8th International Conference on Information and Communication Technology (CICT)*, 1–6. https://doi.org/10.1109/CICT64037.2024.10899686
20. Khan, M. A., Saleh, A. M., Waseem, M., & Sajjad, I. A. (2023). Artificial Intelligence Enabled Demand Response: Prospects and Challenges in Smart Grid Environment. *IEEE Access*, *11*, 1477–1505. https://doi.org/10.1109/ACCESS.2022.3231444
21. Khatami, S. S., Shoeibi, M., Salehi, R., & Kaveh, M. (2025). Energy-Efficient and Secure Double RIS-Aided Wireless Sensor Networks: A QoS-Aware Fuzzy Deep Reinforcement Learning Approach. *Journal of Sensor and Actuator Networks 2025, Vol. 14, Page 18*, *14*(1), 18. https://doi.org/10.3390/JSAN14010018
22. Leal Filho, W., Mbah, M. F., Dinis, M. A. P., Trevisan, L. V., de Lange, D., Mishra, A., Rebelatto, B., Ben Hassen, T., & Aina, Y. A. (2024). The role of artificial intelligence in the implementation of the UN Sustainable Development Goal 11: Fostering sustainable cities and communities. *Cities*, *150*, 105021. https://doi.org/10.1016/J.CITIES.2024.105021
23. Mahmoud, S., & Mohammadabadi, S. (2025). *From Generative AI to Innovative AI: An Evolutionary Roadmap*. https://arxiv.org/abs/2503.11419v1
24. Mahmoud Sajjadi Mohammadabadi, S., Zawad, S., Yan, F., & Yang, L. (2025). Speed Up Federated Learning in Heterogeneous Environments: A Dynamic Tiering Approach. *IEEE Internet of Things Journal*, *12*(5), 5026–5035. https://doi.org/10.1109/JIOT.2024.3487473
25. Mrabet, M., & Sliti, M. (2024). Integrating machine learning for the sustainable development of smart cities. *Frontiers in Sustainable Cities*, *6*, 1449404. https://doi.org/10.3389/FRSC.2024.1449404/BIBTEX
26. Muralidhara Rao, P., Al-Turjman, F., & Deebak, B. D. (2022). Smart grid metering: security, privacy, and open challenges. *Sustainable Networks in Smart Grid*, 255–272. https://doi.org/10.1016/B978-0-323-85626-3.00009-0
27. NASA's Scientific Visualization Studio. (2025). *Global Temperature | Vital Signs – Climate Change: Vital Signs of the Planet*.

https://climate.nasa.gov/vital-signs/global-temperature/?intent=121

28. Naseri, S. (2024a). AI in Architecture and Urban Design and Planning: Case studies on three AI applications. *Https:// Gsconlin epress .Com/*, *21(02)*, 565–577. https://doi.org/ https://doi.org/10.30574/gscarr.2024.21.2.0463
29. Naseri, S. (2024b). AI in Architecture and Urban Design and Planning: Case studies on three AI applications. *Https://Gsconlinepress.Com/Journals/Gscarr/Sites/Default/Files/GSCARR-2024-0463.Pdf*, *21*(2), 565–577. https://doi.org/10.30574/GSCARR.2024.21.2.0463
30. Naseri, S., Eshraghi, S., & Talebian, | Shima. (2024). "Innovative Sustainable Architecture A Lesson Learned from Amphibious House in the UK". *Current Opinion*, *4*(4), 766–777. https://doi.org/10.52845/CURRENTOPINION.V4I4.318
31. Oskooie, S., Civil, S. N.-J. of S. A. and, & 2023, undefined. (2023). An Assessment of the Walkability of Square Corridors in Developing Countries: a Case Study of Saadatabad, Tehran, Iran. *Ceeol.ComSFE Oskooie, S NorouziJournal of Sustainable Architecture and Civil Engineering, 2023 •ceeol.Com*, *1*(32), 77–91. https://doi.org/ 10.5755/j01.sace.32.1.31992
32. Panahi, S., Cheraghifar, F., & Talebian, S. (2018). An Investigation on Painting and Imagery in Zen. *Modern Applied Science*, *12*(9), 200. https://doi.org/10.5539/MAS.V12N9P200
33. Pazouki, S., Behdad, M. (, Jamshidi,), Jalali, M., & Tafreshi, A. (2025). Transformative Impact of AI and Digital Technologies on the FinTech Industry: A Comprehensive Review. *International Journal of Advanced Research in Humanities and Law*, *2*(2), 1–27. https://doi.org/10.63053/IJREL.37
34. Pazouki, S., Jamshidi, M. (Behdad), Jalali, M., & Tafreshi, A. (2025). Artificial Intelligence and Digital Technologies in Finance: A Comprehensive Review. *Journal of Economics, Finance and Accounting Studies* , *7*(2), 54–69. https://doi.org/10.32996/JEFAS.2025.7.2.5
35. Pazouki, S., Metamax, M. B. J., Jalali, S. M., Tafreshi, A., Bank, M., & York, N. (2025). The Integration of Big Data in finTech: Review of Enhancing Financial Services Through Advanced Technologies. *World Journal of Advanced Research and Reviews*, *25*(1), 546–556. https://doi.org/10.30574/wjarr.2025.25.1.0060
36. Rieder, E., Schmuck, M., & Tugui, A. (2022). A Scientific Perspective on Using Artificial Intelligence in Sustainable Urban Development. *Big Data and Cognitive Computing 2023, Vol. 7, Page 3*, *7*(1), 3. https://doi.org/10.3390/BDCC7010003
37. Roya Nazari Najafabadi, Sana Avar, Mohammad Karimi, Mahsa Anbari, & Sajjad Naseri. (2024). Ecological restoration of historical monuments (With a Focus on the Restoration of Chogha Zanbil). *World Journal of Advanced Research and Reviews*, *23*(2), 240–250. https://doi.org/10.30574/WJARR.2024.23.2.2303
38. Sajjadi Mohammadabadi, S. M., Entezami, M., Karimi Moghaddam, A., Orangian, M., & Nejadshamsi, S. (2024). Generative artificial intelligence for distributed learning to enhance smart grid communication. *International Journal of Intelligent Networks*, *5*, 267–274. https://doi.org/10.1016/J.IJIN.2024.05.007
39. Sajjadi Mohammadabadi, S. M., Yang, L., Yan, F., & Zhang, J. (2024). Communication-Efficient Training Workload Balancing for Decentralized Multi-Agent Learning. *Proceedings - International Conference on Distributed Computing Systems*, 680–691. https://doi.org/10.1109/ICDCS60910.2024.00069
40. Saremi, Y., Aghaei, M., Esfid, M. R., Hasangholipour, T., & Ansari, M. (2024). Providing Digital Marketing Model with Customer Participation Approach with intervening role of knowledge management. *International Journal of Knowledge Processing Studies*, *4*(2), 148–167. https://doi.org/10.22034/KPS.2023.410230.1154
41. Saremi, Y., Yalda, S., 1+, S., & Taghizadeh, M. (2013). RFID Adoption by Supply Chain Organizations in Malaysia. *International Proceedings of Economics Development & Research*, 59. https://doi.org/10.7763/IPEDR
42. Splechtna, R., Behravan, M., Jelovic, M., Gracanin, D., Hauser, H., & Matkovic, K. (2024). Interactive Design-of-Experiments: Optimizing a Cooling System. *IEEE Transactions on Visualization and Computer Graphics*. https://doi.org/10.1109/TVCG.2024.3456356

43. Talebian, S., Golkarieh, A., Eshraghi, S., Naseri, M., Naseri, S., & Naseri, S. (2025). Artificial Intelligence Impacts on Architecture and Smart Built Environments: A Comprehensive Review. *Aceesjr.Com, 2024*(1), 45–56. https://doi.org/10.22034/ acees.2025.488106.1013
44. Wang, W., Li, L., Shi, V., & Espahbod, S. (2024). Carbon Emission Accounting and Reduction for Buildings Based on a Life Cycle Assessment: A Case Study in China's Hot-Summer and Warm-Winter Region. *Sustainability 2024, Vol. 16, Page 5842*, *16*(14), 5842. https://doi.org/10.3390/SU16145842
45. Xu, H., Omitaomu, F., Sabri, S., Zlatanova, S., Li, X., & Song, Y. (2024). Leveraging generative AI for urban digital twins: a scoping review on the autonomous generation of urban data, scenarios, designs, and 3D city models for smart city advancement. *Urban Informatics 2024 3:1*, *3*(1), 1–44. https://doi.org/10.1007/S44212-024-00060-W
46. Yigitcanlar, T., & Cugurullo, F. (2020). The Sustainability of Artificial Intelligence: An Urbanistic Viewpoint from the Lens of Smart and Sustainable Cities. *Sustainability 2020, Vol. 12, Page 8548*, *12*(20), 8548. https://doi.org/10.3390/SU12208548
47. Zafar, S. (2024). Smart Cities: The Role of AI in Urban Planning and Sustainable Development. *Artificial Intelligence Multidisciplinary Journal of Systems and Applications*, *1*(1), 27–39. https://www.researchcorridor.org/index.php/aimjsa/article/view/266