Original Article

Artificial Intelligence in Sustainable Urban Housing and Infrastructure Planning: A Systematic Review of Emerging Approaches and Challenges

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Abstract

As urbanization accelerates, AI has emerged as a critical enabler of sustainable housing and infrastructure planning. This study presents a systematic review of peer-reviewed literature from 2000 to 2025, synthesizing advancements in AI applications across energy management, healthcare monitoring, environmental sensing, and user-centric design in smart urban systems. Drawing on 25 rigorously selected studies, the review identifies key AI techniques—including machine learning, neural networks, reinforcement learning, and AIoT frameworks—that facilitate adaptive, efficient, and inclusive urban environments. It also highlights geographic and methodological gaps in the literature, particularly the underrepresentation of the Global South and limited interdisciplinary integration. Challenges such as data privacy, algorithmic transparency, and lack of regulatory frameworks are critically examined. The findings emphasize the transformative potential of AI when aligned with sustainability goals, while calling for collaborative, ethically informed, and context-specific research and policy strategies.

Key words: AIoT, artificial intelligence, interdisciplinary governance, smart housing; energy efficiency, sustainable urban planning.

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Introduction

Artificial intelligence is revolutionizing the real estate industry, enhancing everything from property management efficiency to accelerating homebuyer searches. Technologies such as virtual staging have been shown to boost property inquiries by up to 200%, while predictive analytics are achieving market trend forecasting accuracy rates of around 90%. No longer a mere technological trend, AI has become a transformative force within the sector. As of 2024, the global AI in real estate market was valued at approximately USD 2.9 billion, with projections indicating a surge to USD 41.5 billion by 2033—reflecting a robust compound annual growth rate (CAGR) of 30.5% (Shalwa, 2024).

As cities grapple with accelerating urbanization, environmental degradation, and infrastructure inefficiencies, AI technologies have emerged as transformative tools capable of reshaping how urban systems are conceptualized, designed, and governed. Smart housing and intelligent infrastructure—hallmarks of the sustainable city paradigm—are increasingly relying on AI-driven solutions to enhance energy efficiency, environmental resilience, occupant well-being, and inclusive urban growth (Leal Filho et al., 2024; Satpathy et al., 2025). These developments are framed within the broader context of the United Nations' Sustainable Development Goal 11, which emphasizes the need for inclusive, safe, resilient, and sustainable cities.

Artificial intelligence is now central to a wide array of applications in urban housing, including energy management (Qela & Mouftah, 2012; Kastner et al., 2010), behavioral prediction (Reaz, 2013; Augusto & Nugent, 2006), assisted living and healthcare monitoring (Dermody & Fritz, 2018; Amiribesheli et al., 2015), and adaptive environmental control (Shi et al., 2021). These systems increasingly rely on machine learning, deep learning, reinforcement learning, and multi-agent models, which facilitate real-time data interpretation, automated decision-making, and personalized user experiences (de Silva et al., 2012; Arabasy et al., 2025). As these technologies become more integrated into daily life, scholars have stressed that widespread, ethically grounded AI literacy is vital to ensure that users can engage with these systems in informed, empowered, and context-sensitive ways (Khodabin et al., 2022).

Despite the growing proliferation of AI applications in smart housing, the field remains fragmented, with studies varying widely in scope, methodology, and domain focus. Moreover, the deployment of AI in urban planning is often constrained by persistent challenges, including limited interoperability, privacy concerns, algorithmic opacity, and lack of integration with participatory governance frameworks (Elkhalik, 2023; Sanchez et al., 2022). This parallels findings that insufficient education about emerging technologies can lead to life-threatening misapplications, as users unaware of system limitations may place dangerous trust in automated outputs (Soroori Sarabi et al., 2020). These issues are compounded by geographic and socioeconomic disparities in technological adoption, which risk exacerbating existing urban inequalities if left unaddressed (Koumetio Tekouabou et al., 2023). Professionals in other sectors have similarly emphasized that the transformative impact of AI depends not only on its technical capabilities but also on ethical design, user education, and institutional preparedness (Tomraee et al., 2022).

The current academic discourse reflects a dual imperative: to harness the potential of AI for sustainability while critically interrogating its limitations and socio-technical implications. However, a comprehensive and structured synthesis of this growing body of research is lacking. To address this gap, the present study undertakes a systematic review of peer-reviewed literature published between 2000 and 2025, examining how AI is being integrated into sustainable urban housing and infrastructure planning. The review explores key AI methodologies, application domains, and emerging challenges, thereby providing a consolidated knowledge base and identifying pathways for future interdisciplinary research and policy formulation.

Methodology

This study employed a systematic review methodology to explore the emerging applications, methodologies, and challenges associated with AI in sustainable urban housing and infrastructure planning. Systematic reviews offer a rigorous, transparent, and replicable framework for synthesizing existing literature and identifying knowledge gaps (Moher et al., 2009; Petticrew & Roberts, 2006; Snyder, 2019; Shahghasemi et al., 2011; Tranfield et al., 2003), particularly within complex interdisciplinary fields such as urban informatics, environmental planning, and AI integration.

The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological rigor and transparency. This included defining the research scope, identifying data sources, establishing inclusion and exclusion criteria, and conducting qualitative synthesis of the selected literature.

Relevant academic literature was sourced from high-impact scientific databases including Scopus, Web of Science, IEEE Xplore, SpringerLink, and ScienceDirect. The search strategy employed Boolean operators and combinations of key terms such as "artificial intelligence", "machine learning", "sustainable urban planning", "smart housing", "AIoT", "green cities", "energy efficiency", and "infrastructure". The search was restricted to peer-reviewed articles published between 2000 and 2025 to capture both foundational and contemporary contributions.

Studies were included if they:

- Focused on the application of AI in the context of urban housing or infrastructure.
- Emphasized sustainability dimensions, including energy efficiency, environmental monitoring, or social inclusivity.
- Employed or discussed recognized AI methodologies (e.g., neural networks, fuzzy logic, reinforcement learning, decision trees).
- Were published in English and in peer-reviewed venues.

Exclusion criteria comprised:

- Editorials, white papers, or non-peer-reviewed sources.
- Studies focusing exclusively on commercial smart home products without broader urban planning implications.
- Articles lacking a substantial focus on AI or sustainability.

A total of 246 documents were initially identified, from which 25 studies were deemed eligible after full-text review and relevance screening. Each study was examined for the type of AI techniques used, application domain (e.g., energy, healthcare, mobility), research design, and relevance to sustainable urban development goals. Thematic analysis was conducted to categorize findings into key domains: energy and resource management, environmental monitoring, user-centered design, urban growth modeling, and ethical governance.

To assess the methodological quality of included studies, a modified version of the Critical Appraisal Skills Programme (CASP) checklist was applied. Studies were evaluated based on clarity of objectives, methodological transparency, validity of findings, and contribution to the field. Discrepancies in quality assessment were resolved through discussion among the review team to ensure consistency and minimize bias.

Findings

Augusto and Nugent (2006) examined the conceptual evolution of smart homes, arguing that while significant progress has been made in embedding technological devices into residential environments, there remains a disparity between hardware advancements and the development of intelligent processing capabilities. The authors defined smart homes as technologically enriched living environments designed to enhance inhabitants' quality of life through habitual support. They contended that the mere presence of devices is insufficient without meaningful, context-aware interpretation of the data these devices generate. To address this gap, the article advocated for deeper integration of traditional AI domains—such as knowledge representation, reasoning, learning, and decision-making—into smart home systems. These AI methodologies can facilitate proactive support, user behavior prediction, and adaptive automation, thereby improving the responsiveness and personalization of home environments. The discussion emphasized that AI has the potential to significantly advance user-centric outcomes by enabling smart homes to move beyond reactive control toward intelligent anticipation of user needs. In the context of sustainable urban housing, this perspective highlights the importance of algorithmic intelligence in maximizing the functional and societal value of smart home infrastructures. By aligning AI research with real-world residential applications, the study laid foundational insights for the development of more responsive, adaptive, and efficient living environments.

Kastner, Kofler, and Reinisch (2010) explored the application of artificial intelligence in optimizing both energy efficiency and user comfort within residential smart homes, presenting the ThinkHome project as a conceptual and practical framework. The authors highlighted the diverse motivations for deploying automation technologies in homes, including energy savings—especially in heating and air-conditioning systems—as well as enhanced comfort, ambient assisted living, and user convenience. Acknowledging the challenge of balancing these objectives holistically rather than in isolation, the ThinkHome architecture was designed to integrate AI-based learning mechanisms and context-aware systems capable of autonomously adapting to resident behaviors and preferences. One key feature detailed in the study is an AI-driven control strategy for optimizing the start and stop cycles of heating systems. This involves dynamically adjusting temperature setback schedules on a room-by-room basis through simulation-based evaluations, thereby aligning thermal comfort with energy conservation. The study demonstrated that by employing AI for such adaptive control, smart homes can reduce energy consumption without compromising inhabitant comfort. Although the work centers on residential energy management, its implications extend to sustainable urban housing infrastructure, showcasing how AI-enabled control strategies can contribute to smarter energy systems and user-centered design in future urban developments.

Qela and Mouftah (2012) proposed the Observe, Learn, and Adapt (OLA) algorithm as an AI-driven energy management solution for smart homes, aiming to enhance the functionality of programmable communicating thermostats (PCTs) through intelligent adaptation to occupant behavior. Drawing on principles of adaptable learning systems, the algorithm integrates wireless sensors and artificial intelligence to enable real-time observation of household patterns, continuous learning, and adaptive control of heating and cooling systems. A house simulator was developed to act as an expert system shell for implementing and validating the OLA algorithm. Through simulation experiments, the study demonstrated that homes equipped with zone control, a knowledge base, and the OLA algorithm significantly outperformed traditional homes in terms of energy efficiency and occupant comfort. The AI-enhanced PCTs adjusted dynamically to changes in residents' schedules and preferences, facilitating personalized energy-saving strategies without compromising daily convenience. This research contributes to sustainable urban housing by illustrating how sensor-integrated, adaptive AI systems can optimize energy usage and support smart grid initiatives. It underscores the potential of learning-based energy automation to deliver scalable, intelligent infrastructure in smart buildings and urban environments, aligning with broader goals of energy conservation and user-centered design in future residential planning.

de Silva, Morikawa, and Petra (2012) presented a comprehensive review of the state of the art in smart home technologies, categorizing existing research by technical approaches and application domains. The study first examined smart home systems through the lens of modality-specific technologies, including computer vision, audio analysis, and multimodal sensor fusion, each enabling different dimensions of environmental awareness and user interaction. These technologies were assessed for their roles in enhancing automation, safety, and personalization within domestic settings. The authors then explored application-oriented research, with particular emphasis on eldercare, childcare, energy efficiency, and multimedia retrieval in ubiquitous computing environments. The survey revealed that while certain applications—such as video-based security systems—have matured, others, including energy management and video summarization, are rapidly evolving and represent significant research frontiers. The paper highlighted the growing trend toward integrating AI to manage contextual information, user behavior, and environmental parameters to support intelligent decision-making. In the context of sustainable urban housing and infrastructure, this review underscores the need for scalable and adaptive smart home solutions that align with demographic shifts and energy conservation imperatives. The authors called for further research in multimodal integration and intelligent system adaptability, pointing to AI's critical role in driving the next generation of smart residential environments.

Reaz (2013) provided a comprehensive review of AI techniques used in the implementation of advanced smart home systems, emphasizing the transition from appliance-based automation to intelligent, self-adaptive environments. The article examined various AI paradigms, including multi-agent systems, action prediction, neural networks, fuzzy logic, and reinforcement learning, each contributing to the development of context-aware, energy-efficient, and user-centered residential technologies. Multi-agent systems were discussed for their ability to coordinate distributed devices and resources within the home, while action prediction techniques using Markov models and data mining enabled homes to anticipate user behavior and automate responses accordingly. Neural networks supported real-time learning and adaptation to inhabitant preferences, particularly in activity recognition and personalized environmental control. Fuzzy logic was highlighted for its robustness in managing heterogeneous devices with vague or imprecise input, offering intuitive control mechanisms adaptable to user behavior. Reinforcement learning further enhanced automation by enabling systems to learn optimal control policies through feedback from environmental interactions. Collectively, these approaches were shown to significantly enhance the intelligence, adaptability, and sustainability of smart homes. The article concluded by advocating for future research in hardware prototyping, especially using FPGA technology, to increase processing speed and energy efficiency in AI-driven home systems. This review is directly relevant to sustainable urban housing, illustrating how diverse AI techniques can converge to create flexible, scalable, and responsive residential infrastructures.

Amiribesheli, Benmansour, and Bouchachia (2015) examined the landscape of smart home technologies in healthcare, emphasizing their potential to support independent living and improve quality of life for residents, particularly the elderly and chronically ill. Their review employed a layered architectural framework—comprising sensing, communication, data processing, and interface layers—to systematically assess the technological components and methodologies underlying ambient assisted living systems. Central to this framework is the role of AI, which enables the recognition of human activities, prediction of behaviors, anomaly detection, and system adaptability through models such as decision trees, neural networks, fuzzy logic systems, support vector machines, and hidden Markov models. The review also detailed the infrastructural backbone of smart homes, including sensor networks (e.g., PIR, RFID, pressure and multimedia sensors) and communication protocols like ZigBee, Wi-Fi, and power-line communication. Although the study focused on healthcare applications, its findings have broader implications for sustainable urban housing and infrastructure planning. Specifically, it highlighted how AI-integrated smart environments can reduce formal healthcare demands, promote aging in place, and enhance energy and resource efficiency—key goals in sustainable urban development. The authors also addressed significant challenges such as system interoperability, privacy concerns, and the need for intuitive human-computer interfaces, underscoring areas that must be addressed to advance the deployment of intelligent, sustainable residential environments.

Zimmermann, Ableitner, and Strobbe (2017) investigated user needs and preferences in smart home environments, with particular attention to older adults and individuals with severe physical disabilities. Rooted in a user-centred design paradigm, the study synthesized findings from previous research and the authors' own work in Germany to identify functional and emotional expectations users have regarding smart home technologies. The paper underscored the centrality of explicit and implicit user interaction in shaping effective and acceptable smart home systems, proposing that future solutions must adapt dynamically to users' evolving requirements. Key areas of interest included autonomy support, safety, comfort, and unobtrusiveness. The authors articulated how artificial intelligence could be instrumental in addressing these needs, through adaptive learning, context-aware personalization, and anticipatory system responses that reduce the cognitive and physical demands on users. While the study was primarily focused on healthcare and assisted living, its implications for sustainable urban housing are notable—especially in designing inclusive, AI-enhanced infrastructure that supports aging in place and long-term habitability. By emphasizing AI's role in tailoring home environments to vulnerable populations, the research contributes to the broader discourse on socially sustainable and intelligent urban residential planning.

Dermody and Fritz (2018) presented a conceptual framework to guide nurse researchers working with AI and health-assistive Smart Homes, aiming to support aging-in-place among older adults. Recognizing the growing aging population and associated healthcare burdens, the authors advocated for Smart Homes as a sustainable alternative to institutional care. These homes incorporate sensors and AI agents to monitor residents' daily activities and detect clinically relevant anomalies. Central to their framework is the "Clinician-in-the-Loop AI" (CIL-AI) model, underpinned by critical realism, pragmatism, and post-phenomenology. This philosophical foundation emphasizes the integration of quantitative sensor data with qualitative contextual information provided by nurse-clinicians. The framework introduces the Fritz Method, a mixed-methods participatory approach that empowers nurse researchers to generate, analyze, and contextualize sensor data in collaboration with engineers and computer scientists. By labeling sensor data with ground truth informed by clinical expertise, the method enhances the training of AI agents. The study underscores the necessity of nurse involvement in AI development to ensure that Smart Home technologies align with the needs, values, and experiences of older adults. Moreover, it emphasizes participatory design, advocating for direct engagement with older adults and other stakeholders to co-develop user-centric solutions. This interdisciplinary model fosters the construction of clinically meaningful AI systems that respect autonomy and promote independence, providing a blueprint for advancing nursing science and health technology innovation. These findings align with broader evidence that ethical implementation of advanced technologies requires intentional education, as even highly trained professionals often lack awareness of core ethical principles in practice (Sabbar et al., 2019).

Fritz and Dermody (2019) presented a nurse-driven methodological framework for the development of artificial intelligence in health-assistive smart homes aimed at supporting aging-in-place. The study involved the deployment of ten smart homes for chronically ill older adults between 2015 and 2018, integrating five types of sensors (infrared motion, contact, light, temperature, and humidity) to collect continuous in-home activity data. Nurse investigators played a central role by using telehealth and home visitation to gather contextual health data and provide clinically grounded annotations, thereby supplying the "ground truth" necessary for training machine learning algorithms. The authors emphasized the importance of practical, consistent data collection protocols and advocated for the development of nurse-defined metrics for analytics, which ensure that AI systems are aligned with clinical realities and patient needs. Furthermore, they recommended that multidisciplinary teams adopt engineering-preferred platforms to facilitate effective communication and collaboration. This research is particularly relevant to sustainable urban housing and infrastructure planning, as it underscores how integrating nursing expertise into AI development can yield personalized, non-intrusive, and adaptive smart home environments that enhance the autonomy and well-being of older adults. By offering a replicable approach to embedding healthcare considerations into intelligent housing design, the study advances the discourse on user-centered, AI-enabled sustainable residential systems.

Sepasgozar et al. (2020) conducted a systematic content review to evaluate the current landscape of AI and Internet of Things (IoT) applications in smart homes, with a particular focus on sustainability and intelligent infrastructure. Analyzing 65 peer-reviewed articles, the study identified prevailing research trends, key technologies, and application domains central to AIoT-enabled smart living environments. The authors categorized the literature across six thematic areas: energy management, security and surveillance, health monitoring, entertainment, home automation, and user behavior modeling. Their analysis revealed that energy efficiency and home automation remain the most actively explored domains, often employing AI techniques such as fuzzy logic, neural networks, and reinforcement learning. Additionally, the study emphasized the critical role of IoT infrastructure—including sensors, actuators, and network protocols—in facilitating real-time monitoring, adaptive control, and data-driven decision-making. Despite technological advances, the authors noted persistent challenges, including limited interoperability, insufficient standardization, data privacy concerns, and underdeveloped user-centric design frameworks. They advocated for deeper interdisciplinary collaboration to align technical development with social and environmental sustainability goals. For sustainable urban housing, this review provides a robust knowledge base highlighting how AIoT integration can transform residential systems into adaptive, energy-conscious, and user-responsive environments, reinforcing the importance of intelligent technologies in shaping future urban infrastructures. These findings gain further validation from comparative studies of graded decision systems, where continuous evaluation frameworks have proven essential for maintaining equity and addressing systemic implementation gaps across domains (Siahpour et al., 2024).

Bicakci and Gunes (2020) developed a hybrid simulation system to facilitate real-time testing of AI algorithms in smart home environments, addressing the limitations of both purely virtual simulations and real-world testing. Their approach involved integrating a cloud-based smart home system installed in a physical room with a virtual simulation environment capable of modeling various household configurations and user behaviors. The hybrid simulation (HS) allowed the testing of AI algorithms under controlled yet realistic conditions by simulating complex life scenarios with both real and virtual inhabitants. The system architecture comprised temperature, lighting, and power control devices managed via a centralized web interface and MQTT protocol, while all sensor data and user interactions were recorded in a MySQL database. Researchers could access these data logs to develop and test predictive algorithms. Two AI algorithms were implemented to validate the HS: one for predicting room occupancy using an ant colony optimization approach and another for estimating user preferences for temperature and lighting. Over a two-month test period, the system demonstrated stability and the ability to emulate real-life routines with minimal deviations, while enabling meaningful performance evaluations of the AI algorithms. This novel hybrid setup provided a flexible, low-risk, and cost-effective platform for iterative algorithm development, with broader implications for enhancing user comfort, energy efficiency, and adaptive control in smart home applications.

Pala and Özkan (2020) proposed an AI-driven home lighting automation system designed to enhance smart home security by simulating occupancy and deterring theft, particularly during nighttime absences. Using an Arduino-based hardware platform integrated with software tools written in C# and Python, the authors created a synthetic dataset modeled on real-life lighting patterns in a residential setting. The dataset, comprising 5,500 samples with nine input features and one output class, reflected realistic home lighting behavior between 19:00 and 23:59, allowing the system to imitate the presence of occupants when the home is vacant. Multiple machine learning classification algorithms—including Multi-layer Perceptron (MLP), Linear Support Vector Machine (L-SVM), Gaussian Naive Bayes (NB), Linear Discriminant Analysis (LDA), Decision Trees (DT), and k-Nearest Neighbors (k-NN)—were employed to control the automated lighting system based on learned patterns. Among these, MLP achieved the highest classification accuracy (96.69%), followed by L-SVM (94.98%) and NB (91.23%). This study contributes to the broader field of AI-enabled smart home systems by demonstrating a cost-effective and practical solution for integrating AI into residential infrastructure for enhanced safety. From the perspective of sustainable urban housing, this approach offers a privacy-conscious and energy-efficient strategy to reduce crime risk and increase occupants' peace of mind, further supporting the development of intelligent, adaptive urban living environments.

Shi et al. (2021) introduced an Artificial Intelligence of Things (AIoT)-enabled floor monitoring system tailored for smart home applications, addressing critical limitations of triboelectric sensors—namely, humidity sensitivity and long-term instability. The proposed system synergistically integrates triboelectric coding mats with deep-learning-based data analytics to create a robust, scalable, and privacy-preserving platform for human activity sensing. The mats employ quaternary coding electrodes, normalized through a reference electrode, to ensure reliable and stable signal detection irrespective of environmental fluctuations or user behavior. A significant innovation lies in the universal electrode design, allowing all mats to be mass-produced with a single screen-printing mask, while individualized functionality is achieved through external wiring configurations. This approach enables a parallel-array setup that minimizes wiring complexity and output terminals, supporting large-area deployment. When combined with deep learning algorithms, the system can perform precise trajectory tracking, identity recognition, and automatic control actions, thereby enhancing user interaction and adaptive automation in residential environments. By circumventing the use of invasive surveillance systems like cameras, the platform preserves privacy while still achieving high-resolution behavioral monitoring. The study demonstrates the potential of AIoT-integrated sensor infrastructures in enabling intelligent, efficient, and user-friendly smart home systems, making it particularly relevant to sustainable urban housing by providing cost-effective and scalable monitoring solutions.

Jha et al. (2021) conducted a review focused on the application of AI and the Internet of Things (IoT) in urban planning to support the development of smart and sustainable cities. The study contextualized urban planning as a multidisciplinary effort to address the challenges posed by rapid urbanization, including infrastructure management, public health, sanitation, and resource optimization. Highlighting AI and IoT as transformative technologies of the fourth industrial revolution, the authors discussed how real-time data collected from connected devices can be leveraged to develop intelligent urban systems. Their review covered a range of use cases, such as traffic management, environmental monitoring, public safety, energy-efficient infrastructure, and smart healthcare, illustrating how AI-powered analytics and IoT-enabled sensing can enhance decision-making and system responsiveness. The paper also emphasized the potential of these technologies to reduce human intervention in routine urban functions while enhancing quality of life and sustainability. By synthesizing existing literature, the authors provided a foundation for integrating intelligent systems into urban planning frameworks. Their work reinforces the relevance of AI and IoT in shaping responsive, data-driven, and citizen-centric urban environments, which is critical for future urban housing and infrastructure planning aligned with sustainability goals.

Sanchez et al. (2022) examined the evolving role of AI in urban planning, tracing its slow integration relative to other technological advancements despite increased data availability and computational capacity. Historically, urban planning has selectively adopted analytical tools such as Geographic Information Systems (GIS), Decision Support Systems (DSS), and Expert Systems (ES), with GIS achieving the most widespread acceptance. The authors highlighted how AI, though transformative in sectors like retail and logistics, has yet to realize its full potential in planning practice. Drawing on a recent literature review and a national survey of urban planners, the study found that while academic interest in AI applications for planning is growing, the profession remains cautious and divided. Planners recognize the potential benefits of AI in managing large-scale data, enhancing procedural justice, and addressing persistent urban issues like inequality and housing. However, concerns about accessibility, ethical implications, and professional relevance continue to hinder widespread adoption. The survey revealed parallels to earlier skepticism surrounding computers in planning, which ultimately gave way to their ubiquity. The authors argue that now is an opportune moment for planners to engage with AI tools—not only to improve planning outcomes but also to advance inclusivity and accountability in decision-making processes. This research underscores the importance of bridging the gap between academic innovation and practical implementation, suggesting that AI's role in future sustainable urban housing and infrastructure planning will depend on proactive engagement by planners and institutions alike.

Elkhalik (2023) conducted a comprehensive survey of AI-driven smart homes, focusing on the technological, practical, and societal dimensions of this evolving domain. The study synthesized recent literature to evaluate how artificial intelligence is shaping smart home environments, identifying current applications, underlying technologies, and emerging challenges. The review began with an overview of foundational AI methods—including machine learning, natural language processing, and data analytics—and their role in enabling smart home functionalities such as automation, personalization, energy management, and security. It further outlined critical infrastructure requirements necessary for effective AI integration, such as sensor networks, data processing frameworks, and communication protocols. Key application areas discussed included environmental control, surveillance, health monitoring, and user behavior modeling. Elkhalik also highlighted significant barriers to widespread adoption, including concerns over privacy and data sharing, system latency, interoperability issues, and the need for user-centric design. These open issues present both obstacles and opportunities for future innovation in sustainable urban housing, where AI-driven smart homes may contribute to resource-efficient living and enhanced resident well-being. The paper concluded by proposing future research directions aimed at strengthening security measures, improving adaptive learning capabilities, and fostering ethical and inclusive AI systems. This work provides a valuable perspective on how intelligent technologies can be effectively integrated into housing systems to promote sustainable and adaptive urban living environments.

Koumetio Tekouabou, Diop, Azmi, and Chenal (2023) conducted a systematic survey of AI-based methods used in smart and sustainable urban planning, aiming to provide a structured assessment of the rapidly expanding body of research in this field. Analyzing 172 studies published in 2020 alone—up from only eight prior to 2010—the authors examined how machine learning and deep learning techniques are applied to various urban planning challenges. The review identified the five most commonly addressed issues as land use/cover classification, urban growth modeling, building analysis, mobility optimization, and environmental monitoring. While simple and ensemble machine learning models were frequently used in applications involving sensor-derived data, deep learning methods were more prevalent in areas involving satellite imagery, particularly for analyzing land use, building structures, and climate-related variables. The study also highlighted a geographic disparity in the focus of existing research, with China and the United States dominating the literature, and Africa receiving minimal attention despite pressing urbanization challenges. High levels of international collaboration were observed, particularly among researchers affiliated with institutions in China, the U.S., and the U.K. The authors emphasized the need for future research to address data accessibility, geographic inclusivity, and methodological consistency while promoting interdisciplinary approaches. This review is especially relevant for sustainable housing and infrastructure planning, offering a valuable synthesis of AI-driven tools that can guide more equitable, efficient, and environmentally responsive urban development strategies.

Rieder, Schmuck, and Tugui (2023) provided a scientific examination of the application of AI in sustainable urban development, focusing on how AI technologies can enhance urban infrastructure and environmental planning. The article outlined the central challenges posed by rapid urbanization—such as increased resource demand, ecological degradation, and inefficiencies in urban systems—and argued for AI as a key enabler of intelligent, data-driven responses. The authors presented a conceptual framework that links AI capabilities (e.g., machine learning, neural networks, and optimization algorithms) with specific urban planning domains, including energy efficiency, mobility, waste management, and building operations. They discussed real-world implementations and theoretical potentials of AI to optimize transportation networks, predict infrastructure stress, and support dynamic energy distribution systems in line with sustainability goals. Emphasis was also placed on integrating AI with urban digital twins and simulation tools to test planning scenarios and forecast environmental impacts. Despite its transformative potential, the article acknowledged several critical concerns, including algorithmic bias, transparency, and the need for regulatory oversight. The authors advocated for interdisciplinary collaboration and ethical governance to ensure that AI is employed in a manner that supports inclusive and sustainable urban growth. The paper contributes significantly to the discourse on AI's role in the sustainable design and management of smart urban systems.

Shafik (2024) provided a comprehensive examination of how AI can be integrated into the development of smart cities to promote urban sustainability. The chapter outlined key components of smart city infrastructure, including sustainable development, enhanced public services, and responsive governance, all underpinned by advanced AI technologies. It addressed foundational AI concepts and their applicability to real-time urban challenges, such as surveillance, environmental monitoring, and predictive threat mitigation—including issues like deforestation and environmental degradation. The discussion extended to AI's role in improving data governance and policy implementation, fostering transparent systems where citizens are empowered to engage with and hold institutions accountable. Through case studies and theoretical analysis, the author emphasized AI's potential to facilitate inclusive economic growth, optimize resource allocation, and streamline municipal functions in ways that enhance the resilience and adaptability of urban ecosystems. Importantly, the study highlighted how citizen engagement in AI-enabled systems can increase public trust and institutional accountability, crucial for long-term sustainability. This chapter contributes significantly to the discourse on AI in urban planning, offering a strategic vision for integrating intelligent technologies into infrastructure and policy frameworks that prioritize environmental stewardship, social equity, and technological innovation. This aligns with longstanding insights from legal scholarship, which emphasize that compliance and long-term effectiveness are most likely when laws and systems are anchored in clear, principled frameworks that foster public legitimacy and trust (Aghigh et al., 2022).

Leal Filho et al. (2024) examined the potential of AI to support the implementation of the United Nations Sustainable Development Goal 11 (SDG 11), which emphasizes the creation of inclusive, safe, resilient, and sustainable cities and communities. Through an expert-driven literature review and illustrative case studies, the study identified key domains where AI can significantly enhance urban sustainability, including energy optimization, waste management, traffic regulation, and environmental monitoring. The authors emphasized AI's role in addressing complex socio-economic and environmental challenges by enabling data-driven urban planning, predictive analytics, and real-time decision-making support. Despite these benefits, the study also highlighted critical challenges such as ethical governance, inclusivity, and data privacy, asserting that AI deployment must be carefully managed to avoid exacerbating inequalities or infringing on civil liberties. To fully leverage AI's capabilities, the authors advocated for interdisciplinary collaboration between urban planners, policymakers, and AI experts to ensure that implementations align with local contexts and sustainability goals. This research contributes significantly to the discourse on AI in sustainable urban planning by bridging the gap between technological innovation and global development objectives, reinforcing the importance of AI as a transformative enabler for achieving SDG 11 within smart and sustainable city frameworks.

The study by Anwar and Sakti (2024) investigated the integration of AI and environmental science for advancing sustainable urban planning through the use of Geographic Information Systems (GIS). Recognizing the challenges posed by rapid urbanization, the authors aimed to assess how AI-enhanced GIS tools could improve urban development strategies and sustainability assessments. Employing a mixed-methods approach, the research combined quantitative spatial data analysis using GIS and AI algorithms with qualitative stakeholder insights from urban planners and environmental experts. Spatial datasets included land use patterns, demographic distributions, environmental quality indices, and real-time sensor data, all subjected to preprocessing for integration and normalization. The study applied spatial analysis techniques such as overlay and buffer analysis to evaluate environmental impacts, while machine learning models—specifically decision trees and neural networks—were utilized to predict urban growth patterns. Additionally, simulation through Cellular Automata modeled the spatial dynamics of urban expansion under various scenarios. Findings indicated that AI significantly improved the accuracy and usability of GIS analyses, enabling better-informed planning decisions by forecasting land use transformations and their associated environmental impacts. Key insights included the identification of high-risk zones for ecological disturbance and the necessity for targeted environmental management in specific urban regions. The study concluded that integrating AI with environmental science not only enhances planning efficiency and predictive capacity but also strengthens resilience and sustainability in urban systems, offering a model framework for future research and policy implementation in smart city development.

Al-Raeei (2024) explored the transformative potential of AI in promoting sustainable urbanization, offering a comprehensive review of AI-driven solutions that support sustainable development goals. The article detailed how AI technologies—including data analytics, machine learning, and predictive modeling—are being deployed across urban planning, infrastructure management, and disaster response systems to enhance decision-making, optimize resource use, and improve urban living conditions. The paper emphasized the capability of AI to drive efficiency and resilience in urban environments by facilitating real-time data processing and system automation. However, the review also acknowledged persistent challenges associated with AI adoption, notably concerns surrounding data privacy, algorithmic bias, and ethical governance. These limitations highlight the need for continued interdisciplinary research and proactive policymaking to ensure equitable and responsible implementation. The author called for closer collaboration among urban planners, policymakers, and technology developers to fully leverage AI for sustainable city development. By addressing current limitations and fostering inclusive governance frameworks, AI can become a central enabler in building resilient, efficient, and environmentally sustainable urban systems. This work contributes valuable insights into the strategic integration of AI into urban planning processes and reinforces its role in shaping the smart cities of the future. Studies further demonstrate that effective governance must include mandatory digital literacy programs, as AI systems consistently fail when users cannot critically evaluate automated decisions—a requirement equally vital for urban planning as for disaster response (Hosseini et al., 2021).

Adediran et al. (2025) conducted a bibliometric analysis to assess the academic landscape of AI adoption in the housing sector, examining 246 indexed publications from Scopus and Web of Science databases spanning the years 2000 to 2024. The study revealed a significant surge in research output, with publications rising from just one in 2000 to 68 by 2024, reflecting a growing scholarly interest in the intersection of AI and housing. The majority of the documents were peer-reviewed journal articles (172 out of 246), underscoring the academic rigor in this domain. The analysis identified key contributors, with researchers such as Ahmad, Chatterjee, Cho, Lee, Mehmood, Shaheen, Yang, and Zhao each authoring three papers. Institutions with high publication outputs were notably supported by the U.S.-based National Science Foundation, which emerged as the leading funding source with support for eight studies. Co-authorship and keyword co-occurrence network analyses revealed four dominant research clusters: technical tools and AI methodologies, theoretical and conceptual developments, practical applications in housing markets, and the socioeconomic and financial implications of AI integration. The study concluded that future research will likely center on deploying advanced machine learning and neural network models to enhance predictive accuracy for housing market behaviors, pricing, and transaction trends across global contexts. These insights are especially relevant for researchers and policymakers seeking to harness AI for more efficient, data-driven housing systems within the broader framework of sustainable urban development.

Arabasy, Hussein, Abu Osba, and Al Dweik (2025) investigated the application of machine learning (ML) in smart housing as a means to advance sustainable urban planning, interior design, and development. The study addressed major urban challenges such as population growth, traffic congestion, and inefficient energy use by evaluating ML's role in optimizing resource management, environmental performance, and public safety. Using a comprehensive dataset, the researchers applied ML algorithms to assess energy consumption, waste management, and emergency response efficiency. The results demonstrated a 20% reduction in total energy use, a 15% increase in renewable energy adoption, and a 25% improvement in waste management processes. Additionally, public safety response times were reduced by 30%. ML models achieved an average accuracy of 92% in predicting power consumption, traffic flow, and air quality, which contributed to a 10% reduction in carbon emissions. The findings underscored ML's capacity to provide accurate, data-driven forecasts that support real-time urban management and strategic planning. Importantly, the study highlighted ML's potential not only in system-level infrastructure optimization but also in enhancing livability through intelligent interior design and adaptive spatial planning. This work reinforces the pivotal role of ML in addressing pressing urban issues and supports its integration into future-focused sustainable housing initiatives.

Satpathy, Nayak, and Jain (2025) examined the role of Green Artificial Intelligence (Green AI) in advancing sustainable and smart urban living, emphasizing its transformative capacity in urban planning and management. The chapter outlined how AI technologies contribute to environmental sustainability, energy efficiency, and public safety through intelligent automation systems. Specific applications included AI-driven energy management, intelligent transportation systems, infrastructure assessment for durability, and predictive policing for urban security. Drawing on case studies from Amsterdam, Singapore, New York, and London, the authors illustrated the practical outcomes of AI integration—such as reductions in energy consumption and emissions, improved traffic flow, and heightened situational awareness through real-time sensor analysis. These cities demonstrated measurable improvements in operational efficiency and urban resilience, reinforcing the strategic role of AI in enhancing infrastructure performance and environmental monitoring. The authors emphasized that AI's ability to interpret and act on sensor data enables proactive responses to infrastructure stress, congestion, and safety threats. The study highlighted AI's value not only as a technological tool but as a foundational element of green urban planning that aligns ecological goals with digital innovation. This work contributes meaningful insights into how AI can drive systemic change in urban environments, offering a roadmap for integrating sustainable, intelligent solutions into housing and infrastructure planning.

Conclusion

AI has emerged as a transformative force in the planning and development of sustainable urban housing and infrastructure. This systematic review reveals that AI technologies—ranging from machine learning and neural networks to multi-agent systems and AIoT integrations—are already playing critical roles in energy management, behavioral prediction, healthcare support, and adaptive environmental control. These applications not only contribute to operational efficiency and user comfort but also align with broader environmental and social sustainability goals.

However, the deployment of AI in sustainable urban contexts remains marked by fragmentation, both in terms of methodological approaches and geographic representation. While developed regions such as North America, Europe, and parts of Asia have demonstrated significant progress, underrepresented regions—particularly in the Global South—remain insufficiently integrated into the academic and technological discourse. Moreover, challenges such as data privacy, ethical governance, lack of interoperability, and the need for user-centric design continue to impede the full realization of AI's potential in this domain.

The findings underscore a pressing need for interdisciplinary collaboration among urban planners, data scientists, engineers, healthcare professionals, and policymakers. Future research should prioritize the development of standardized frameworks for AI integration, explore participatory and inclusive design strategies, and address regulatory concerns to ensure equitable and ethical deployment. As cities evolve in response to environmental pressures and demographic shifts, AI holds the promise to facilitate not only more efficient infrastructure but also more adaptive, inclusive, and resilient urban living environments.

Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Conflicts of interests

The author declares that there is no conflict of interests.

Data availability

The dataset generated and analyzed during the current study is available from the author on reasonable request.

Reference

Adediran, A.O.; Ajibade, S.S.M.; Jasser, M.B.; Bashir, F.M.; Dodo, Y.A. & Mohd Yassin, Y.N.H. (2025). "Artificial intelligence adoption in housing: A bibliometric analysis". *21st IEEE International Colloquium on Signal Processing & Its Applications (CSPA).* 343-348. https://doi.org/10.1109/CSPA64953.2025.10933225.

Aghigh, S.R.; Salehi, K. & Barkhordari, A. (2022). "Ignoring the legal requirements of criminal law in the field of crimes against security". *Public Law Knowledge Quarterly.* 11(38): 104-140. https://doi.org/10.22034/qjplk.2022.1490.1393.

Al-Raeei, M. (2024). "The smart future for sustainable development: Artificial intelligence solutions for sustainable urbanization". *Sustainable Development.* 33(1): 508-517. https://doi.org/10.1002/sd.3131.

Amiribesheli, M.; Benmansour, A. & Bouchachia, A. (2015). "A review of smart homes in healthcare". *Journal of Ambient Intelligence and Humanized Computing.* 6: 495-517. https://doi.org/10.1007/s12652-015-0270-2.

Anwar, M.R. & Sakti, L.D. (2024). "Integrating artificial intelligence and environmental science for sustainable urban planning". *IAIC Transactions on Sustainable Digital Innovation (ITSDI).* 5(2): 179-191. https://aptikom-journal.id/itsdi/article/view/666.

Arabasy, M.; Hussein, M.F.; Abu Osba, R. & Al Dweik, S. (2025). "Smart housing: integrating machine learning in sustainable urban planning, interior design, and development". *Asian Journal of Civil Engineering*. 26: 59-71. https://doi.org/10.1007/s42107-024-01144-3.

Augusto, J.C. & Nugent, C.D. (2006). "Smart homes can be smarter". In J. C. Augusto & C. D. Nugent (Eds.). *Designing Smart Homes.* 4008: 1-15. Springer, Berlin, Heidelberg. https://doi.org/10.1007/11788485_1.

Bicakci, S. & Gunes, H. (2020). "Hybrid simulation system for testing artificial intelligence algorithms used in smart homes". *Simulation Modelling Practice and Theory.* 102: 101993. https://doi.org/10.1016/j.simpat.2019.101993.

de Silva, L.C.; Morikawa, C. & Petra, I.M. (2012). "State of the art of smart homes". *Engineering Applications of Artificial Intelligence.* 25(7):

1313-1321. https://doi.org/10.1016/j.engappai.2012.05.002.

Dermody, G. & Fritz, R. (2018). “A conceptual framework for clinicians working with artificial intelligence and health-assistive Smart Homes”. *Nursing Inquiry.* 26(1): e12267. https://doi.org/10.1111/nin.12267.

Elkhalik, W.A. (2023). “AI-driven smart homes: Challenges and opportunities”. *Journal of Intelligent Systems & Internet of Things.* 8(2): 54. https://doi.org/10.54216/JISIoT.080205.

Fritz, R.L. & Dermody, G. (2019). “A nurse-driven method for developing artificial intelligence in ‘smart’ homes for aging-in-place”. *Nursing Outlook.* 67(2): 140-153. https://doi.org/10.1016/j.outlook.2018.11.004.

Hosseini, S.H.; Khodabin, M.; Soroori Sarabi, A. & Sharifi Poor Bgheshmi, M.S. (2021). “Artificial intelligence and disaster risk management: A need for continuous education”. *Socio-Spatial Studies.* 5(1): 13-29. https://doi.org/10.22034/soc.2021.219422.

Jha, A.K.; Ghimire, A.; Thapa, S.; Jha, A.M. & Raj, R. (2021). “A review of AI for urban planning: Towards building sustainable smart cities”. *6th International Conference on Inventive Computation Technologies (ICICT)*. 937-944. https://doi.org/10.1109/ICICT50816.2021.9358548.

Kastner, W.; Kofler, M.J. & Reinisch, C. (2010). “Using AI to realize energy efficient yet comfortable smart homes”. *2010 IEEE International Workshop on Factory Communication Systems Proceedings.* 169-172. https://doi.org/10.1109/WFCS.2010.5548612.

Khodabin, M.; Sharifi Poor Bgheshmi, M.S.; Piriyaei, F. & Zibaei, F. (2022). “Mapping the landscape of AI literacy: An integrative review”. *Socio-Spatial Studies.* 6(1). https://doi.org/10.22034/soc.2022.223715.

Koumetio Tekouabou, S.C.; Diop, E.B.; Azmi, R. & Chenal, J. (2023). “Artificial intelligence based methods for smart and sustainable urban planning: A systematic survey”. *Archives of Computational Methods in Engineering.* 30: 1421-1438. https://doi.org/10.1007/s11831-022-09844-2.

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.

Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G. & The PRISMA Group. (2009). “Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement”. *PLoS Medicine.* 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097.

Pala, Z. & Özkan, O. (2020). "Artificial intelligence helps protect smart homes against thieves". *Dicle University Journal of Engineering*. 11(3): 945-952. https://doi.org/10.24012/dumf.700311.

Petticrew, M. & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Blackwell Publishing. https://psycnet.apa.org/doi/10.1002/9780470754887.

Qela, B. & Mouftah, H.T. (2012). "Observe, Learn, and Adapt (OLA)—An algorithm for energy management in smart homes using wireless sensors and artificial intelligence". *IEEE Transactions on Smart Grid.* 3(4): 2262-2272. https://doi.org/10.1109/TSG.2012.2209130.

Reaz, M.B.I. (2013). "Artificial intelligence techniques for advanced smart home implementation". *ACTA Technica Corviniensis–Bulletin of Engineering.* 6(2): 51-57. http://acta.fih.upt.ro/pdf/archive/ACTA-2013-2-07.pdf.

Rieder, E.; Schmuck, M. & Tugui, A. (2023). "A scientific perspective on using artificial intelligence in sustainable urban development". *Big Data and Cognitive Computing*. 7(1): 3. https://doi.org/10.3390/bdcc7010003.

Sabbar, S.; Masoomifar, A. & Mohammadi, S. (2019). "Where we don't know how to be ethical; A research on understanding plagiarism". *Journal of Iranian Cultural Research.* 12(3): 1-27. https://doi.org/10.22035/jicr.2019.2243.2747.

Sanchez, T.W.; Shumway, H.; Gordner, T. & Lim, T. (2022). "The prospects of artificial intelligence in urban planning". *International Journal of Urban Sciences.* 27(2): 179-194. https://doi.org/10.1080/12265934.2022.2102538.

Satpathy, I.; Nayak, A. & Jain, V. (2025). "The green city: Sustainable and smart urban living through artificial intelligence". In L. Alla, B. Alj, & B. Bentalha (Eds.). *Utilizing Technology to Manage Territories* (pp. 273–304). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-6854-1.ch009.

Sepasgozar, S.; Karimi, R.; Farahzadi, L.; Moezzi, F.; Shirowzhan, S.; Ebrahimzadeh, S.M.; Hui, F. & Aye, L. (2020). "A systematic content review of artificial intelligence and the Internet of Things applications in smart home". *Applied Sciences.* 10(9): 3074. https://doi.org/10.3390/app10093074.

Shafik, W. (2024). "Incorporating artificial intelligence for urban and smart cities' sustainability". In B. Singh, C. Kaunert, K. Vig, & S. Dutta (Eds.). *Maintaining a Sustainable World in the Nexus of Environmental Science and AI* (pp. 23-58). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-6336-2.ch002.

Shahghasemi, E.; Heisey, D.R. & Mirani, G. (2011). "How do Iranians and

U.S. Citizens Perceive Each Other: A systematic Review". *Journal of Intercultural Communication.* 11(3): 1-13. https://doi.org/10.36923/jicc.v11i3.539.

Shalwa. (2024). *AI in real estate: Key statistics, market trends, and future growth*. Artsmart.ai. December 14. https://artsmart.ai/blog/ai-in-real-estate-statistics.

Shi, Q.; Zhang, Z.; Yang, Y.; Shan, X.; Salam, B. & Lee, C. (2021). "Artificial Intelligence of Things (AIoT) enabled floor monitoring system for smart home applications". *ACS Nano.* 15(11): 18312-18326. https://doi.org/10.1021/acsnano.1c07579.

Siahpour, M.R.; Bahmmanpouri, A. & Salehi, K. (2024). "The effects, results and defects of the grading of punitive punishments". *The Quarterly Journal of Judicial Law Views.* 29(106): 21-44. https://doi.org/10.22034/jlvi.2024.2002469.1001.

Snyder, H. (2019). "Literature review as a research methodology: An overview and guidelines". *Journal of Business Research*. 104: 333-339. https://doi.org/10.1016/j.jbusres.2019.07.039.

Soroori Sarabi, A.; Arsalani, A. & Toosi, R. (2020). "Risk management at hazardous jobs: A new media literacy?". *Socio-Spatial Studies.* 4(1): 13-25. https://doi.org/10.22034/soc.2020.212126.

Tomraee, S.; Hosseini, S.H. & Toosi, R. (2022). "Doctors for AI? A systematic review". *Socio-Spatial Studies*. 6(1): 13-26. https://doi.org/10.22034/soc.2022.219431.

Tranfield, D.; Denyer, D. & Smart, P. (2003). "Towards a methodology for developing evidence-informed management knowledge by means of systematic review". *British Journal of Management*. 14(3): 207-222. https://doi.org/10.1111/1467-8551.00375.

Zimmermann, T.; Ableitner, A. & Strobbe, C. (2017). "User needs and wishes in smart homes: What can artificial intelligence contribute?". *14th International Symposium on Pervasive Systems, Algorithms and Networks (ISPAN) & 11th International Conference on Frontier of Computer Science and Technology & 3rd International Symposium of Creative Computing (ISCC)*. 449-453. https://doi.org/10.1109/ISPAN-FCST-ISCC.2017.66.