Equitable and Affordable Smart Housing: AI–IoT Pathways to Urban Sustainability, Governance, and Justice

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Abstract This chapter examines how Artificial Intelligence (AI) and the Internet of Things (IoT) are transforming housing governance and the pursuit of equity in sustainable urban development. It conceptualizes smart, sustainable, and affordable housing as interdependent paradigms that, when integrated, form the foundation of equitable smart housing, an approach that aligns technological innovation with affordability, social justice, and environmental responsibility. Through a synthesis of recent literature, the chapter demonstrates how AI-driven predictive analytics enhance housing policy design, while IoT-enabled management systems improve energy efficiency, transparency, and resident well-being. However, it also highlights the ethical and institutional challenges associated with these technologies, including privacy risks, algorithmic bias, data inequality, and governance fragmentation. The analysis argues that technological progress alone cannot achieve housing justice; rather, inclusive governance, ethical design, and participatory oversight are essential to ensure accountability and fairness. Municipalities and policymakers must therefore embed transparency, digital literacy, and citizen participation into housing innovation frameworks. Ultimately, the chapter concludes that the integration of AI and IoT in housing is not merely a technical transformation but a moral and institutional one, representing an opportunity to reimagine housing as a domain where efficiency, affordability, sustainability, and justice converge to advance the human right to adequate shelter in the digital age.

Keywords Artificial intelligence (AI) · Internet of things (IoT) · Equitable and affordable smart housing · Sustainable housing · Housing justice · Data governance

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1 Introduction

The global housing crisis has emerged as one of the defining urban challenges of the twenty-first century. Across regions and income levels, the availability of affordable, adequate, and secure housing has failed to keep pace with the rapid growth of cities. Globally, the United Nations Human Settlements Programme estimates that between 1.6 billion and 3 billion people worldwide lack access to adequate housing, underscoring the scale of the global housing deficit (UN-Habitat, 2023). The result is a widening affordability gap that has produced new forms of socio-spatial inequality, including displacement, segregation, and precarious living conditions (Wetzstein, 2017). Across diverse urban contexts, housing markets have increasingly been transformed by financialization, turning them into arenas for speculative investment rather than instruments of social welfare (Fields & Uffer, 2014). Rising land costs, deregulated real-estate markets, and uneven patterns of urban development have undermined the social and environmental foundations of urban life (Arbaci et al., 2021; Lestegás et al., 2018).

Addressing this crisis is central to the global agenda for sustainable development. The United Nations' Sustainable Development Goal 11 (SDG 11) calls for making cities and human settlements inclusive, safe, resilient, and sustainable, with the provision of adequate and affordable housing as a core target (Goal 11.1). Achieving this goal requires rethinking how urban systems are planned, managed, and governed. The transition toward sustainable cities is therefore inseparable from the pursuit of equitable and affordable housing, a domain where social justice, spatial inclusion, and technological innovation must converge. Tetteh and Amponsah (2020) emphasize that the sustainable adoption of smart housing in the Global South, particularly in Sub-Saharan Africa, requires simultaneous progress in technological literacy, economic resilience, and institutional innovation. They argue that smart homes can advance the principles of SDG 11 by promoting inclusiveness, energy diversification, and environmental cleanliness, but caution that affordability and infrastructural deficits remain significant constraints. The promise of smart housing technology for sustainable development will remain unrealized unless it is integrated with socio-economic policies that address inequality and access gaps (Tetteh & Amponsah, 2020).

In this context, housing has become a critical arena for examining the interaction between digital transformation, governance, and social justice. The rise of digital urbanism has introduced new infrastructures of governance, sensors, data analytics, and intelligent systems that promise to optimize the management of urban space and resources (Alizadeh & Sharifi, 2023; Kitchin, 2013). Within this transformation, Artificial Intelligence (AI) and the Internet of Things (IoT) have emerged as core technologies within the broader vision of the "smart city." These systems facilitate real-time monitoring, predictive analytics, and automated decision-making, which can enhance efficiency and sustainability in housing systems. However, as Agarwal et al. (2025) note, the rapid expansion of smart city technologies also introduces trade-offs between technological innovation, sustainability, and equity. Persistent

governance and social-justice dilemmas accompany digital development and must be addressed through integrated and knowledge-based frameworks (Agarwal et al., 2025).

This tension between technological potential and socio-political constraints is particularly pronounced in the housing sector. Housing is not merely a commodity; it constitutes a fundamental human right and a cornerstone of social and environmental sustainability (Kimhur, 2022). It also shapes access to health, well-being, and environmental quality, influencing how individuals live and age within urban systems (Chrysikou et al., 2024). The integration of digital technologies into affordable housing governance introduces significant opportunities to enhance transparency, operational efficiency, and distributive equity (Zhao & Zou, 2024). Given the interconnected drivers of affordable housing deficits, a transition toward digitally enabled planning models incorporating AI, real-time analytics, and strategic communication is increasingly necessary. Such approaches not only improve the identification and spatial mapping of housing needs but also strengthen the policy narrative framing inclusive housing investment as a catalyst for equitable urban transformation (Dorgbefu, 2019). Predictive analytics can support evidence-based and equity-oriented policy design by optimizing resource allocation, while IoT-based systems contribute to energy efficiency and reduced operational costs in housing provision (Arabasy et al., 2024). However, the equity potential of these technologies is contingent upon robust ethical governance frameworks that institutionalize transparency, accountability, and participatory oversight (Alizadeh & Sharifi, 2023).

Building on these concerns, critical scholarship on data-driven urbanism highlights the structural risks embedded in algorithmic governance. Kitchin (2013) provides one of the earliest and most influential critiques of data-driven urbanism, conceptualizing the "real-time city" as both a technological opportunity and a governance dilemma. He argues that the integration of big data and algorithmic systems into urban management transforms cities into complex socio-technical environments governed by data logics rather than democratic processes. This technocratic shift can produce opaque decision-making, reinforce corporate dominance, and normalize surveillance through what Kitchin terms "the panoptic city." These insights are critical for understanding how AI–IoT systems in housing governance may reproduce inequality, bias, and exclusion if not designed with ethical safeguards.

The digital transformation of housing governance therefore raises a fundamental normative question: can smart technologies make cities not only more efficient, but also more just? While AI and IoT provide the capacity to measure, predict, and manage complex urban systems, their value ultimately depends on how they are embedded within broader social and institutional structures. Without inclusive governance mechanisms and equitable access to data, technological innovation risks reinforcing existing inequalities rather than resolving them. Consequently, the challenge is not merely technological adoption but the ethical and political alignment of these tools with the principles of justice, inclusion, and sustainability.

This chapter therefore argues that AI–IoT technologies offer both diagnostic and transformative tools for addressing housing inequities within sustainable cities. Diagnostically, they enable a deeper understanding of housing markets, environmental

performance, and social vulnerabilities through real-time, data-driven insights. Transformatively, they create opportunities for participatory and transparent governance that can redistribute resources, reduce ecological footprints, and empower marginalized communities. By combining technological innovation with ethical and sustainability-oriented governance, cities can move toward housing models that are not only efficient and connected but also equitable, affordable, and resilient.

Ultimately, housing sits at the intersection of technological innovation, social equity, and sustainable urbanism. The future of smart cities will not be measured solely by how interconnected or data-rich they become but by how these innovations advance the human right to shelter while contributing to inclusive, resilient, and sustainable urban futures. The integration of AI–IoT into housing systems thus represents more than a technical evolution; it is an opportunity to reimagine urban development as a project of justice and sustainability.

2 Background and Conceptual Evolution of Housing Policy

The evolution of housing policy and thought reflects broader transformations in urban governance, economic systems, and technological paradigms. Historically, housing was embedded within post-war welfare states as a public good fundamental to social stability and urban equity. In the mid-twentieth century, welfare-oriented housing regimes emphasized universal access and state-led provision as central pillars of social justice (Kimhur, 2022). These institutional models, however, began to erode under the influence of neoliberal reforms in the 1980s and 1990s, when market mechanisms and privatization displaced public-sector intervention as dominant policy tools (Arbaci et al., 2021; Fields & Uffer, 2014). As neoliberal reforms deepened, housing progressively shifted from a social right to a financial asset, embedding urban space within transnational flows of capital. This transformation redefined the relationship between citizens, the state, and the built environment, positioning housing at the intersection of market speculation, rent extraction, and urban inequality (Arbaci et al., 2021; Lestegás et al., 2018).

The financialization of housing marked a critical turning point in global urbanism. Fields and Uffer (2014) demonstrate how cities such as New York and Berlin became laboratories for the conversion of rental housing into speculative financial assets, fundamentally reshaping affordability and access. This process, initially concentrated in advanced economies, has increasingly extended to cities of the Global South, where rapid urbanization intersects with weak regulatory frameworks and volatile property markets, amplifying vulnerability and exclusion (Tetteh & Amponsah, 2020). Consequently, the pursuit of affordable housing has become inseparable from the challenge of governance: how states, institutions, and emerging digital technologies can mediate the competing demands of growth, equity, and sustainability. This governance transition is also reflected in recent housing transformations in Saudi Arabia, where the state has repositioned itself from a direct provider to an enabling regulator within housing markets (Alhajri, 2024).

Within this context, the early 2000s witnessed the emergence of the "smart city" paradigm, which sought to integrate information and communication technologies into urban management. The concept of "Smart Housing" developed as a subtheme within this broader movement, emphasizing automation, energy efficiency, and data-driven optimization of urban systems (Maalsen, 2018). These initiatives reflected the growing influence of technocratic governance, where urban problems were increasingly framed as issues of data management rather than political or social choice (Kitchin, 2013). However, the techno-centric orientation of early smart housing policies often marginalized questions of affordability, participation, and justice. By prioritizing efficiency and control, smart housing initially risked reproducing the same inequalities it claimed to solve.

A critical reorientation emerged as scholars began to question the limits of technology-centric urbanism. Alizadeh and Sharifi (2023) introduced the notion of the societal smart city, an alternative paradigm that situates technological innovation within frameworks of democratic governance and distributive justice. They argue that technology should serve as a facilitator of inclusion and transparency rather than as a tool of surveillance or market expansion. Their analysis identifies four dimensions of justice-oriented urban development, citizen-centered governance, inclusive access to services, resilient infrastructure, and information literacy, that together define the normative foundation of sustainable smart cities (Alizadeh & Sharifi, 2023). This shift from technocracy to social responsiveness marks a conceptual evolution toward "equitable smart housing," where digital innovation aligns with human-centered urbanism.

Governance remains the structural backbone of this transformation. Almulhim and Yigitcanlar (2025) conceptualize smart governance as an institutional framework that integrates AI- and IoT-based technologies into decision-making while promoting transparency, accountability, and civic participation. Through their global review, they identify inclusivity, responsiveness, and accountability as the three pillars of sustainable governance that enable cities to align digital innovation with social and environmental objectives (Almulhim & Yigitcanlar, 2025). Although their work focuses on urban governance broadly, the same mechanisms are critical for equitable housing systems, where policy design, data management, and citizen participation must operate in concert to ensure fairness.

Tetteh and Amponsah (2020) extend this discussion to the Global South, emphasizing that technological transitions in housing must be grounded in contextual realities of affordability, infrastructure, and digital literacy. They argue that smart housing in Sub-Saharan Africa can contribute to SDG 11 by diversifying energy sources and enhancing environmental cleanliness, but caution that structural inequalities may prevent equitable implementation. Their findings underscore that technology alone cannot resolve deep-rooted disparities without institutional reform and inclusive policy frameworks.

The conceptual evolution of smart housing has also been shaped by critical debates surrounding data justice and the ethics of algorithmic governance. Kitchin (2013) identifies the emergence of "the real-time city," where data infrastructures mediate

urban experience and governance. While real-time analytics enable predictive maintenance and resource optimization, they also risk producing opaque decision systems governed by algorithmic biases. These concerns have been extended into housing, where AI-based models for credit scoring, rent pricing, and eligibility assessment can unintentionally reinforce discrimination and exclusion. Thus, the evolution of digital housing governance must engage with questions of transparency, fairness, and accountability as central elements of social sustainability (Kitchin, 2013).

Parallel to these governance debates, empirical studies have expanded the understanding of how AI and IoT can reshape housing systems. Zhao and Zou (2024) highlight the importance of coherent smart governance frameworks that integrate institutional innovation with ethical safeguards to achieve public value, arguing that the success of AI–IoT integration depends not merely on technological sophistication but on the coordination of policy, regulation, and stakeholder participation. Arabasy et al. (2024) further demonstrate that machine learning can optimize energy use, waste management, and safety in smart housing, reducing energy consumption by 20% and enhancing renewable utilization by 15%. These applications illustrate how AI-driven approaches contribute not only to efficiency but also to environmental sustainability, an essential dimension of housing equity.

Empirical studies further reveal that spatial analytics and data-driven modeling can illuminate the geographic determinants of housing affordability and inform targeted interventions. Zhao et al. (2024) demonstrated that AI-enabled spatial analysis using Geographically Weighted Regression can identify spatial variations in rental housing prices, offering a data-informed pathway toward equitable housing governance. Complementary findings by Bagheri and Shaykh-Baygloo (2021) indicate that smart-growth principles, such as human scale, mixed land use, environmental health, balanced service distribution, and compact urban development, enhance housing values while simultaneously producing spatial disparities that necessitate equitable policy responses. This observation aligns with Maalsen (2018), who conceptualizes smart housing as a socio-technical formation in which data infrastructures, governance mechanisms, and market dynamics co-produce new forms of inequality and opportunity. Collectively, these insights underscore that achieving equitable smart housing requires integrating spatial intelligence with sustainability-oriented and justice-based urban planning frameworks.

Building on this foundation, Gbran and Alzamil (2025) introduce a model-based engineering framework that integrates AI, IoT systems, and renewable-energy technologies into holistic urban planning. Their framework enables real-time monitoring, predictive analysis, and adaptive design for sustainable housing systems. Crucially, Gbran and Alzamil (2025) emphasize that technological sophistication alone is insufficient; effective governance, policy coordination, and public participation are essential. By aligning smart housing innovation with SDG 11, they demonstrate how intelligent systems can promote environmental responsibility, social inclusion, and long-term urban resilience. Dorgbefu's (2019) study further complements this perspective by presenting a multidisciplinary strategy that combines behavioral segmentation, targeted communication, and AI-powered real estate analytics. It illustrates how communication strategies can condense this information into investor-relevant

formats, including narrative dashboards, equity-centric reports, and scenario-based visualizations, while machine learning algorithms estimate housing demand, price sensitivity, and risk exposure.

The geographic dimension of this integration is further elaborated by Jung (2025), who compares South Korea's centralized, technology-driven housing policies with the United Kingdom's decentralized, community-based model. Jung (2025) argues that while centralized models allow rapid deployment of AI-enabled housing systems, decentralized governance ensures inclusivity and accountability. The comparison highlights that institutional design, rather than technological capacity alone, determines the social outcomes of smart housing initiatives.

Recent scholarship also recognizes the human-centered and experiential dimensions of smart housing as essential components of sustainability. Agee et al. (2020) propose a human-centered design framework that embeds ethical and behavioral considerations into AI- and IoT-enabled housing systems, ensuring that technology serves user well-being. Similarly, Kim et al. (2020) demonstrate that smart housing technologies must adapt to users' daily routines, emotions, and social interactions to enhance livability and autonomy. These humanistic approaches extend the notion of sustainability beyond environmental metrics, encompassing psychological comfort, accessibility, and inclusivity.

Building on this perspective, Pirinen et al. (2025) examine how smart home technologies shape daily life and community relations in Finnish cohousing. They find that digital tools such as smart locks and booking systems enhance efficiency yet may constrain autonomy and reinforce subtle hierarchies. Pirinen et al. (2025) conclude that aligning smart housing with community values of inclusivity, transparency, and shared governance is vital for fostering equity and trust.

A growing body of research also reframes housing justice as a multidimensional construct. Goodall et al. (2025) argue that injustices in shared housing arise not only from material deficiencies but also from structural and relational dynamics embedded within policy frameworks. Kimhur (2022) advances this argument through the capability approach, contending that housing justice should prioritize expanding individuals' real freedoms and opportunities rather than merely redistributing resources. This perspective bridges normative ideals with actionable policy practices, aligning with the ethical imperatives of AI–IoT housing governance.

Finally, the literature on inclusive design and aging further situates smart housing within the broader agenda of social sustainability. Chrysikou et al. (2024) link smart home technologies to SDG targets 7.3 (energy efficiency) and 10.2 (social inclusion), demonstrating that automation and telemedical systems can extend independent living and enhance quality of life for vulnerable groups. Their work reinforces that the social mission of smart housing extends beyond efficiency; it encompasses dignity, care, and long-term well-being. As a result, the evolution of housing thought reveals a clear trajectory, from state-led welfare housing to marketized urbanism, and from techno-centric smart housing to justice-oriented, human-centered digital governance. The convergence of AI, IoT, and ethical design represents the most recent phase in this trajectory, where data analytics and social justice intersect to define the future of equitable housing in sustainable cities.

3 Conceptualizing Smart, Sustainable, and Equitable Housing

The emergence of smart technologies in urban governance has redefined how cities conceptualize housing as both a social good and a digital system. Yet, as the discourse on smart urbanism evolves, it becomes increasingly clear that technology alone cannot resolve deep-rooted inequities in access, affordability, and inclusion. The notion of equitable smart housing thus seeks to move beyond purely technocratic interpretations of "smartness" to emphasize housing as a multidimensional construct, technological, social, economic, and ethical. Establishing a conceptual foundation is essential because contemporary urban policy often conflates efficiency-driven smart housing with socially inclusive housing reform. This section, therefore, conceptualizes the relationships between *smart, sustainable*, *and affordable housing*, illustrating how their integration forms the basis of equitable smart housing, a framework that aligns digital innovation with spatial justice and economic accessibility.

Building upon this foundation, the first dimension of smart housing illustrates how digital transformation has reshaped the relationship between technology, governance, and the home. *Smart housing* represents the application of digital technologies, particularly AI, the IoT, and automation, to residential environments. It encompasses systems designed to enhance operational efficiency, safety, and user comfort through data-driven monitoring and control. Early conceptualizations of smart housing primarily emphasized automation, connectivity, and energy management, positioning technology as a tool to enhance household convenience and environmental performance. However, the Architecture, Engineering, and Construction industry has yet to widely adopt human-centered design methods, often prioritizing cost-driven, technology-centered approaches that overlook human needs and broader questions of accessibility and social well-being (Agee et al., 2020). Recent research reframes smart housing as a socio-technical domain embedded in wider urban governance processes. Kim et al. (2020) emphasize that the success of smart housing depends on its responsiveness to residents' lived experiences and social interactions rather than on technical sophistication alone. Similarly, Kitchin (2013) conceptualizes the broader shift toward data-driven urbanism, illustrating how algorithmic systems and real-time analytics reconfigure power relations and governance mechanisms in cities. Building on these perspectives, Maalsen (2018) interprets smart housing as both a technological and political construct, where data infrastructures and algorithmic decision-making shape inclusion, exclusion, and spatial inequality. Therefore, defining smart housing today requires recognizing its dual nature: it is simultaneously a technological innovation aimed at improving efficiency and a governance mechanism embedded within institutional and social frameworks that determine who benefits from technological transformation.

Following the technological dimension of smart housing, sustainability introduces an ecological and long-term perspective on housing. While smart housing emphasizes digital efficiency, *sustainable housing* centers on resource conservation, resilience, and ecological responsibility. Rooted in the principles of the Brundtland Report

and the United Nations' Sustainable Development Goals, particularly SDG 11 and SDG 7, sustainable housing extends beyond technical efficiency to address the interdependence between environmental and social systems. According to Chrysikou et al. (2024), sustainable housing must integrate environmental performance with human well-being, particularly for vulnerable populations. This perspective aligns with Arabasy et al. (2024), who demonstrate that integrating AI, IoT, and renewable energy systems can enhance energy optimization and waste reduction, contributing to broader sustainability objectives. Yet, as Tetteh and Amponsah (2020) caution, technological sustainability cannot be isolated from socio-economic context; without affordability and institutional support, smart and energy-efficient housing innovations risk reinforcing spatial inequality. Hence, sustainable housing entails more than low-carbon construction or smart energy systems; it requires governance models that connect ecological performance with accessibility, justice, and long-term urban resilience.

Beyond technology and ecology, the social and economic dimension of housing, namely its affordability, remains the most pressing and persistent concern. *Affordability* remains one of the most complex and persistent challenges in housing systems, situated at the intersection of economics, policy, and social justice. Affordable housing extends beyond household purchasing power to include institutional, spatial, and environmental conditions that shape access, stability, and quality of life. Chan and Adabre (2019) argue that bridging the gap between affordability and sustainability requires six critical success criteria: household satisfaction, stakeholder collaboration, cost efficiency, timeliness, location accessibility, and quality performance. These dimensions transform affordability into a multidimensional framework that integrates social, economic, and environmental goals. From an urban planning perspective, Mohamad et al. (2020) demonstrate that integrating eco-friendly and smart technologies within affordable housing enhances community well-being and sustainability. Similarly, Aurand (2010) shows that compact design, mixed land use, and diverse housing types serve as effective tools for improving affordability and spatial equity. However, Fields and Uffer (2014) and Arbaci et al. (2021) reveal that financialization and speculative investment have intensified exclusion, proving that markets alone cannot deliver equitable housing outcomes. Zhao and Zou (2024) propose smart governance as a pathway to fairness and transparency by embedding digital tools within participatory and accountable institutions in affordable housing systems. Collectively, these insights redefine affordable housing as a cornerstone of sustainable and inclusive urban development.

The intersection of these dimensions, technological, ecological, and social, culminates in the emerging concept of *equitable smart housing*. Equitable smart housing represents the convergence of technological innovation, environmental sustainability, and social justice. It envisions housing systems that use digital technologies to advance inclusion, transparency, and accountability rather than merely optimize efficiency. Alizadeh and Sharifi (2023) link this concept to data justice and human-centered urbanism, emphasizing that AI and IoT applications must serve as instruments for equitable participation and distributive fairness. Zhao and Zou (2024) further conceptualize this integration through their model of smart governance,

which combines digital infrastructure, institutional coordination, and ethical safeguards to allocate resources fairly and enhance policy responsiveness. Gbran and Alzamil (2025) illustrate this principle within SDG 11, showing that smart technologies, when supported by governance integration and public participation, can operationalize sustainability in practical housing systems. Yang and Yi (2026) provide empirical validation by applying explainable AI to analyze affordable housing provision in Seoul. Their findings reveal that land price, accessibility, and development potential are decisive spatial determinants of equity. Collectively, these studies affirm that equitable smart housing depends less on technological advancement than on the ethical, institutional, and participatory structures that guide its implementation toward inclusive and sustainable urban futures.

When analyzed together, these conceptual strands point toward an integrated model of housing that balances innovation, justice, and sustainability. When viewed comparatively, the distinctions among smart, sustainable, and affordable housing lie primarily in their technological, environmental, and economic orientations, yet their ultimate objectives converge. Smart housing focuses on efficiency and innovation, sustainable housing emphasizes ecological responsibility, and affordable housing ensures social inclusion and accessibility. Equitable smart housing synthesizes these dimensions into an integrated framework where technological intelligence advances environmental goals and affordability reinforces social equity (see Fig. 1). This synthesis reflects a paradigm shift in which urban development is assessed not merely by growth or efficiency but by fairness, inclusiveness, and sustainability. Almulhim and Yigitcanlar (2025) emphasize that integrating technology with governance is essential for realizing SDG 11's vision of inclusive, safe, resilient, and sustainable cities. Similarly, Alizadeh and Sharifi (2023) argue that justice-oriented digital governance ensures that technological innovation supports collective well-being rather than exacerbating inequality. Equitable smart housing therefore represents both a conceptual framework and a practical pathway through which cities can deploy digital innovation to achieve not only smartness but also justice and sustainability.

4 AI and IoT in Smart Housing Governance

The integration of AI and the IoT within housing systems represents the most dynamic and transformative frontier of smart urbanism. Building upon the conceptual foundations outlined in the previous section, this part examines how these technologies are being applied across the housing lifecycle to enhance policy design, operational management, and systemic coordination. AI-driven predictive analytics enable governments and planners to anticipate housing demand, optimize resource allocation, and identify social vulnerabilities, while IoT infrastructures facilitate real-time monitoring of energy, safety, and maintenance performance. Together, these technologies form the backbone of intelligent housing ecosystems that promise efficiency, sustainability, and inclusivity.

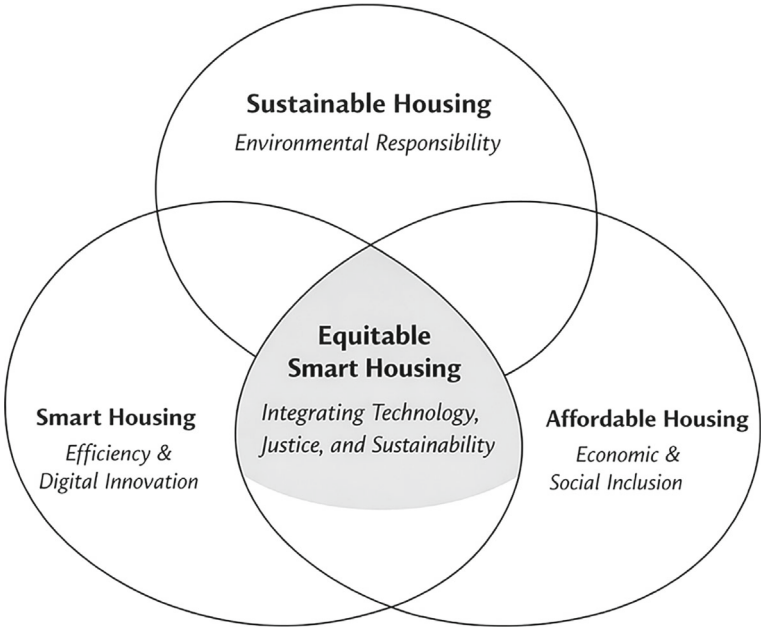

Fig. 1 Conceptual framework illustrating the intersection of smart, sustainable, and affordable housing dimensions forming the basis of equitable smart housing

4.1 AI-Driven Predictive Analytics for Housing Governance

AI is increasingly recognized as a critical instrument for improving housing governance through predictive analytics, data integration, and evidence-based decision-making. Machine learning models can process complex socio-economic, spatial, and demographic data to forecast housing demand, predict rental price fluctuations, and segment markets with far greater precision than conventional statistical tools. Yang and Yi (2026) demonstrate how explainable-AI models can analyze the spatial determinants of affordable-housing provision in Seoul, identifying key variables such as land price, accessibility, and development potential that shape spatial equity outcomes. Similarly, Arabasy et al. (2024) show that integrating AI-driven analytics into housing management improves resource efficiency and supports sustainability objectives through data-informed planning.

Beyond market forecasting, predictive algorithms are increasingly applied to social-housing allocation and vulnerability assessment. Yet, as Kitchin (2013) cautions, algorithmic decision-making can reproduce existing biases when training data reflect structural inequities, underscoring the need for ethical oversight and accountability mechanisms. Consequently, the value of predictive analytics lies not only in its technical accuracy but in how it is embedded within participatory and transparent governance systems. When responsibly implemented, AI can serve as

both a diagnostic and normative instrument, revealing hidden patterns of exclusion while informing fairer, data-driven housing policies that align with the goals of social justice and sustainable urban development. By linking predictive accuracy with social accountability, AI-driven analytics can become not only tools for technical forecasting but also instruments of housing justice, supporting affordability assessments, fair subsidy targeting, and inclusive policy design.

4.2 IoT-Enabled Management of Smart and Sustainable Housing

The IoT has transformed housing management by enabling real-time monitoring, spatial intelligence, and data-driven energy optimization. Through interconnected sensors and digital platforms, IoT technologies regulate heating, lighting, and ventilation efficiently, reducing operational costs and environmental impact. Agarwal et al. (2025) argue that IoT-enabled urban systems exemplify the logic of smart governance, where adaptive control mechanisms link technological efficiency with sustainability and inclusiveness. Arabasy et al. (2024) demonstrate that IoT-based monitoring systems can reduce energy consumption by up to twenty percent and increase renewable energy use by fifteen percent, underscoring the role of data-driven management in sustainable housing. Chrysikou et al. (2024) expand this view by connecting IoT-enabled housing to social sustainability goals, showing that smart home technologies enhance autonomy and well-being for vulnerable groups, positioning IoT as a driver of dignity, accessibility, and inclusion.

Li et al. (2020) developed a blockchain- and IoT-based smart product-service system for prefabricated housing, revealing how integrated cyber-physical platforms enhance sustainability by synchronizing production, logistics, and on-site assembly. Their model demonstrates how digital ecosystems reduce material waste, improve transparency, and strengthen housing resilience. Spatial analytics further support housing equity. Bagheri and Shaykh-Baygloo (2021) show that modeling smart growth indicators helps identify spatial disparities and guide equitable housing strategies, aligning with Mohamad et al. (2020), who found that IoT and eco-technologies improve well-being in affordable housing. Yet, as Kitchin (2013) and Alizadeh and Sharifi (2023) caution, increasing digitalization requires governance that ensures privacy, accountability, and participatory oversight. IoT-based housing management thus represents a socio-technical transformation that redefines how cities govern energy, care, and equity at the household scale. Ultimately, IoT-based housing management achieves its true value when it enhances not only operational efficiency but also social equity, ensuring that energy savings, digital connectivity, and smart services are accessible and affordable for all residents, particularly marginalized households. Integrating AI and IoT within ethical and participatory governance frameworks thus transforms smart housing from a purely technical system into a

vehicle for affordability, inclusion, and urban justice, advancing the broader mission of equitable and sustainable smart cities.

4.3 Integrating AI and IoT for Equitable and Inclusive Housing Governance

The integration of AI and the IoT has enabled real-time digital ecosystems that connect tenants, utilities, and urban planners within adaptive housing networks. Zhao and Zou (2024) describe how these systems use spatial data and smart governance frameworks to coordinate housing management across institutional and community levels. Gbran and Alzamil (2025) demonstrate that integrating AI and IoT platforms into sustainable housing policy facilitates collaboration between residents, service providers, and government entities. These systems allow continuous monitoring of housing performance, resource distribution, and maintenance needs, creating feedback loops that align user experience with policy goals. Li et al. (2020) show how blockchain and IoT integration can enhance traceability and trust in prefabricated housing by ensuring transparent data flows across construction, logistics, and occupancy stages. Almulhim and Yigitcanlar (2025) highlight that AI and IoT convergence under smart governance strengthens accountability and inclusivity by connecting data systems to participatory policy processes. However, technological integration alone cannot ensure equity. Kitchin (2013) warns that algorithmic systems may reproduce institutional bias without democratic oversight, while Alizadeh and Sharifi (2023) emphasize that digital innovation achieves value only through ethical and participatory governance. Equitable smart housing therefore depends on transparency, inclusion, and governance frameworks that align technology with social justice and sustainability.

5 Challenges and Policy Implications for Equitable Smart Housing

The integration of AI and the IoT into housing governance presents transformative opportunities for efficiency, sustainability, and inclusion. Yet, it also introduces profound ethical, social, and institutional challenges. As cities increasingly rely on data-driven systems to allocate resources, monitor housing performance, and shape urban policy, questions surrounding privacy, equity, and accountability become central to the future of housing justice. This section outlines the major challenges and examines the policy and governance implications necessary to ensure that AI–IoT technologies advance equitable and sustainable housing outcomes rather than to reproduce existing urban inequalities.

A primary challenge concerns privacy and data ownership in IoT-equipped homes. Smart housing systems depend on continuous data collection, from sensors tracking energy and occupancy to devices monitoring health and security. While these technologies offer convenience and efficiency, they also create risks of surveillance and misuse. Data generated within private living spaces often flow to corporate platforms, raising issues of ownership, consent, and control. Without robust data governance, tenants may lose autonomy over how personal information is used. Chrysikou et al. (2024) highlight that although IoT systems can enhance autonomy for vulnerable groups, they may also expose residents to intrusive monitoring if not safeguarded by clear privacy frameworks.

Algorithmic bias presents another critical concern. Predictive AI systems used for mortgage scoring, rent assessment, or social-housing allocation can replicate existing inequalities when trained on biased historical data. Kitchin (2013) warns that algorithmic systems often lack transparency, making discrimination difficult to detect or correct. Biased models can overestimate rents or exclude marginalized populations, reinforcing socio-spatial inequities. Addressing this challenge requires the integration of explainable AI and algorithmic fairness frameworks to ensure that automated decision-making supports, rather than undermines, housing equity. The digital divide further limits equitable participation in smart housing ecosystems. Low-income and marginalized communities frequently lack digital infrastructure, broadband access, and technical literacy, restricting their ability to benefit from AI–IoT systems. Alizadeh and Sharifi (2023) emphasize that technological innovation without accessibility widens socio-spatial disparities, turning digital progress into a new form of exclusion.

Beyond these systemic risks, technical and institutional barriers also impede adoption. Duvier et al. (2018) and Agarwal et al. (2025) identify weak data quality, limited interoperability, resistance to change, and a lack of digital skills as persistent obstacles in housing governance. Zhao and Zou (2024) reveal that top-down digital platforms can increase efficiency while simultaneously expanding surveillance and limiting citizen participation, especially among low-income and elderly residents. Tetteh and Amponsah (2020) add that in the Global South, infrastructural gaps, affordability constraints, and limited digital capacity continue to hinder smart housing implementation. Ultimately, achieving equitable smart housing requires an ethical-by-design approach that embeds fairness, inclusivity, and accountability across the technological lifecycle. As Arabasy et al. (2024) argue, technological sustainability is inseparable from social responsibility. Ethical-by-design housing systems must therefore balance innovation with citizen protection, ensuring that digital transformation strengthens rather than threatens equity and justice.

The integration of AI and IoT into housing systems presents not only technological opportunities but also critical governance responsibilities. As housing systems become increasingly data-driven, municipalities assume a central role as institutional intermediaries between technology providers, developers, and citizens, ensuring that digital transformation aligns with the public interest through clear standards for transparency, privacy, and inclusivity. In this context, governance extends beyond regulatory oversight to encompass participatory coordination, ethical standard-setting,

and the management of digital infrastructures. Recent research highlights that the integration of IoT and blockchain can function as a governance layer that enhances transparency, accountability, and participatory decision-making in urban systems (Almulhim, 2025). Such a governance-oriented technological architecture reinforces the need for multi-actor collaboration, clearly defined institutional roles, and adaptive policy frameworks within smart housing ecosystems. Similarly, Alzamil (2024) demonstrates that sustainable housing activation depends on aligning legislative reform, financing instruments, subsidy mechanisms, and management structures within a coherent governance framework. Equitable AI–IoT-enabled housing ultimately depends on integrated policy design that aligns technological innovation with coherent institutional and regulatory frameworks.

Translating this integrated policy vision into practice requires robust and transparent data governance frameworks. Duvier et al. (2018) emphasize the importance of multi-level governance forums that include municipal authorities, service providers, and community representatives to guarantee accountability and inclusiveness in digital housing systems. Such co-governance arrangements enhance data quality, interoperability, and ethical sharing practices, ensuring that AI–IoT technologies operate as instruments of equitable governance rather than tools of exclusion.

Zhao and Zou (2024) argue that equitable smart housing depends on institutional innovation and participatory oversight. They propose multi-level data governance systems that integrate public authorities, private developers, and community organizations through shared digital platforms to improve coordination and accountability. Transparent data management, allowing residents to understand and control how their data are used, is central to restoring public trust and preventing technocratic dominance. Co-governance models, where citizens contribute to policy design and feedback, bridge administrative efficiency with social equity and ensure that smart systems reflect lived realities.

Gbran and Alzamil (2025) similarly emphasize that public participation and governance integration are essential to achieving sustainability objectives in housing systems. Establishing multi-stakeholder councils or community data trusts can institutionalize participation and distribute decision-making power beyond centralized bureaucracies. Tetteh and Amponsah (2020) expand this perspective by highlighting that successful smart housing governance must integrate technological progress with socio-economic empowerment. They stress the need for policies promoting digital literacy, local innovation, and affordable access to smart housing features, ensuring inclusiveness across diverse income groups.

Finally, policy integration across urban, housing, and digital sectors is vital to avoid fragmented governance. AI–IoT adoption should align with broader strategies for urban resilience, environmental sustainability, and social inclusion. As Almulhim and Yigitcanlar (2025) note, the synergy between technology and governance determines whether smart urban systems advance sustainability or deepen inequality. Achieving housing justice in the digital era thus requires embedding fairness, transparency, and ethical design into every layer of policy and technological infrastructure, transforming innovation into a foundation for equitable and sustainable urban futures.

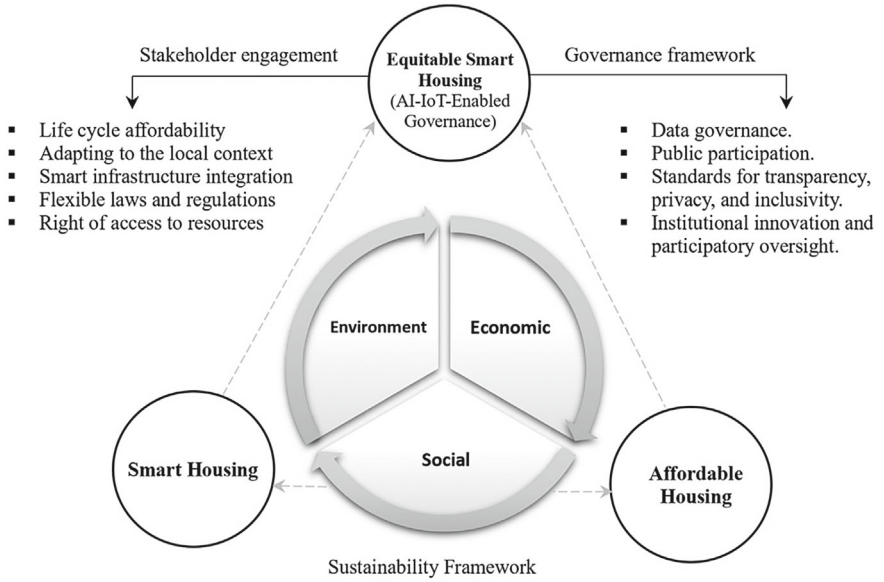

Fig. 2 Integrated AI–IoT-enabled governance framework for equitable smart housing

To synthesize these governance imperatives, Fig. 2 presents an integrated governance framework for Equitable Smart Housing, illustrating how AI–IoT-enabled governance aligns smart and affordable housing through sustainability principles, stakeholder engagement, and institutional accountability.

6 Conclusion

The integration of AI and the IoT within housing governance represents one of the most profound transformations in contemporary urban development. This chapter has argued that while these technologies hold immense potential to improve affordability, sustainability, and efficiency, their true value lies in their capacity to advance social justice and inclusion. AI and IoT are not merely instruments of optimization but tools for reshaping how cities conceptualize and deliver the right to housing in an era defined by digitalization and ecological urgency.

The analysis presented here traced the conceptual evolution of housing, from welfare-based provision to neoliberal marketization and finally to the digital governance era, revealing how technological innovation has reconfigured relationships among citizens, the state, and the built environment. Within this transformation, smart, sustainable, and affordable housing have emerged as distinct yet interconnected paradigms. Their convergence forms the foundation of equitable smart housing, a framework that integrates technological intelligence with environmental

sustainability and social inclusion. By combining efficiency with fairness, this model redefines smart urbanism as a moral and civic project rather than a purely technical one.

The theoretical and literature-based insights discussed throughout the chapter underscore that technology alone cannot guarantee justice. Without ethical design, transparent governance, and participatory oversight, AI–IoT systems risk reinforcing rather than reducing inequality. Ensuring algorithmic accountability, protecting data privacy, and fostering digital literacy are thus essential preconditions for fair and inclusive housing transformation. Municipalities, policymakers, and technologists share a collective responsibility to embed these safeguards within every stage of smart housing development.

Ultimately, the future of housing justice in the digital age depends on aligning technological innovation with human values. Smartness must not be measured by connectivity or automation alone but by the extent to which it enhances dignity, accessibility, and sustainability in everyday life. Equitable smart housing embodies this vision: a housing paradigm where data and design serve people, where governance is participatory, and where technological progress becomes a pathway toward inclusive, resilient, and sustainable urban futures. The challenge ahead is not technological capacity but moral commitment to ensuring that the digital transformation of housing advances humanity itself.

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