Analysis of the challenges of developing affordable housing using construction technologies: the case study in 22 district of Tehran

Ali Hosseini[1], Mahdi Piran Virsagh[2], Amirreza Aboohamzeh[3], Razieh Shahnazari[4]

[1]Associate Professor, Department of Human Geography and Planning, Faculty of Geography, University of Tehran, Tehran, Iran (Corresponding author: a.hosseini@ut.ac.ir)
[2]Master of Science, Department of Human Geography and Planning, Faculty of Geography, University of Tehran, Tehran, Iran
[3]Master of Science, Department of Human Geography and Planning, Faculty of Geography, University of Tehran, Tehran, Iran
[4]Master of Science, Department of Human Geography and Planning, Faculty of Geography, University of Tehran, Tehran, Iran

Original article
Received: 2025-12-17
Revised: 2026-02-03
Accepted: 2026-02-14

Abstract

Affordable housing, as a fundamental pillar of social justice and sustainable urban development, has become one of the most critical challenges facing metropolitan areas in recent years. Despite the growing body of research on affordable housing, the operational role of modern construction technologies within specific institutional and spatial contexts, particularly in project-oriented urban areas such as District 22 of Tehran, has received limited in-depth empirical investigation. In this regard, the application of modern construction technologies can play a significant role in reducing construction costs, enhancing productivity, and improving residents' quality of life, provided that these technologies are aligned with local institutional, social, and spatial conditions. The aim of this study is to examine the challenges and potential solutions for the development of affordable housing through the application of modern construction technologies in District 22 of Tehran. This applied research adopts a qualitative approach, in which data were collected through semi-structured interviews with 13 experts in the fields of housing, urban planning, and construction technologies, and analyzed using thematic analysis. The findings indicate that achieving affordable housing is not solely dependent on the adoption of modern technologies, but rather requires institutional coordination, supportive policies, and legal and financial frameworks tailored to local conditions. Five main categories were identified: institutional and social interaction, modern technologies and materials, structural challenges, characteristics of District 22 of Tehran, and policy recommendations. The results suggest that the use of technologies such as prefabricated systems, 3D printing, and lightweight and recycled materials, when appropriately

localized and standardized, can significantly reduce construction costs and time. Ultimately, the realization of affordable housing necessitates a systemic and coordinated approach involving policymakers, the private sector, and the advancement of modern construction technologies.

Keywords: Affordable housing, District 22 of Tehran, Emerging construction technologies, Sustainable urban development

1.Introduction and Problem Statement

Human activity on Earth is intrinsically linked to the concept of "home"; consequently, housing can no longer be regarded merely as a physical shelter, but rather as a foundational pillar of human development and societal progress (Dania et al., 2021). As human endeavors expand to meet the escalating demands of a growing global population, both natural and built environments are subjected to intensifying pressures. The construction sector alone accounts for approximately 36% of global energy consumption and nearly 40% of carbon emissions, underscoring its central role within the global economy and its substantial environmental footprint (Li et al., 2024). Within this context, effective urban planning emerges as a critical mechanism for ensuring equitable access to affordable housing (Matini & Soleimani, 2022).

Affordable housing has therefore become a central theme in international policy discourse, particularly across developing nations (Atta et al., 2021). Emerging technologies present a transformative opportunity to enhance living standards in developing regions (Ahmadi, 2024; Wynn, Hosseini, & Parpanchi, 2023), as access to adequate and cost-efficient housing is indispensable for poverty reduction, public health improvement, and broader social welfare advancement (Adetutu et al., 2024). Conventionally, housing is defined as "affordable" when household expenditure does not exceed 30% of gross income (Daud & Nor, 2018). Yet empirical studies indicate that households frequently allocate more than one-third of their income to housing-related costs, disproportionately burdening low-income populations (Sabah & Parvizi, 2023). This financial strain is directly associated with reduced quality of life and diminished well-being (Oskoui Aras et al., 2024). Beyond fulfilling basic shelter needs, housing must generate multidimensional value, encompassing locational advantages (proximity to employment, services, and education), environmental quality (safety, aesthetics, and neighborhood conditions), and investment capacity (asset accumulation and economic security). Rapid urbanization, evolving consumption patterns, and the increasing commodification of housing have intensified scrutiny of housing quality, particularly within megacities (Hosseini & Joulie-St-Vincent, 2023). As urban populations continue to grow, demand persistently outstrips supply, resulting in a structural global deficit of affordable housing units (Firoozi, 2024). Recent analyses confirm that the global affordability crisis is deepening rather than subsiding across both developing and advanced urban contexts (Birch & Wachter, 2025).

This crisis is further exacerbated by escalating construction costs, prolonged project delivery timelines, and the environmental consequences of conventional building practices (Firoozi, 2024). With the global population projected to reach 9.4 billion by 2050, the strain on housing provision(particularly in rapidly urbanizing developing countries)is approaching critical levels. Currently, more than 70% of residents in these regions inhabit informal or substandard settlements,

underscoring the severity of the challenge for vulnerable socio-economic groups (Purnomo & Harmiyati, 2023).

In response to these pressures, the integration of innovative and sustainable construction technologies has emerged as a strategic imperative. Such technologies aim to deliver low-cost, rapid-assembly, durable, and environmentally responsible housing solutions (Jain, 2020). As a key economic sector, the construction industry requires process optimization, productivity enhancement, and technological modernization. The adoption of advanced materials, automation systems, and digital platforms can substantially reduce execution delays and capital inefficiencies (Zolfagharifar & Roustaei, 2022). However, the implementation of modular, prefabricated, and digital construction technologies, despite their cost-reduction and quality-enhancement potential remain constrained by multiple structural barriers. These include high initial investment requirements, insufficient industrial infrastructure, regulatory fragmentation, limited specialized expertise, institutional inertia, and restricted public acceptance (Adeyemi et al., 2024; Bakhaty et al., 2024; Pannu & Hooda, 2025).

Furthermore, in emerging domains such as 3D construction printing (3DCP), the absence of coherent regulatory frameworks and the misalignment between technological capability and governance mechanisms constitute significant urban-scale bottlenecks (Banihashemi et al., 2025; Bayat et al., 2025). In project-oriented urban systems, these constraints become even more pronounced when housing development is dominated by high-density, large-scale schemes, patterns that directly influence environmental comfort, service accessibility, and overall urban quality of life (Omidi Hosseinabad & Ahmadi, 2020; Oskoui Aras et al., 2024). District 22 of Tehran exemplifies this development trajectory. Characterized by a project-centric planning model and extensive structural footprints, the district has experienced rapid vertical expansion. While technological innovation may increase housing supply, it simultaneously raises critical questions concerning spatial equity, environmental sustainability, and residents' lived experiences. Accordingly, this study aims to examine the challenges of affordable housing development through the lens of construction technologies and to assess their implications for residents' quality of life in District 22, Tehran.

2.Theoretical Framework

In recent decades, scholarly discourse on housing has evolved from a narrow understanding of shelter provision toward a multidimensional conceptualization that encompasses economic, social, cultural, psychological, and environmental dimensions. Housing is no longer interpreted merely as a physical enclosure; rather, it is conceptualized as a complex socio-spatial system embedded within broader urban and societal structures (Henilane, 2016). This expanded perspective situates housing at the intersection of fundamental human needs(security, rest, privacy, and daily functional routines)and structural determinants such as tenure systems, construction quality, and social integration. From a human geography standpoint, housing is therefore assessed not only in terms of physical attributes but also through indicators including residential stability, inhabitant satisfaction, tenure security, and neighborhood cohesion (Czischke, 2018). Beyond its material form, housing operates as a mediating platform between economic infrastructure and social systems. As an environmental unit, it significantly shapes public health outcomes, labor productivity, social behavior, and collective well-being, while simultaneously reflecting a

society's cultural values and economic priorities (Hosseini et al., 2024). Within this framework, housing becomes an integral component of the human life course, dynamically intertwined with changes in family composition, employment trajectories, and lifestyle transformations (Clapham et al., 2018).

From an economic perspective, land and housing possess a dual character: they function concurrently as consumption goods and capital assets. This dual nature positions housing as a pivotal element within market structures, investment strategies, and wealth distribution systems, thereby reinforcing its direct linkage to socio-economic status (Mirkatouli, Samadi, & Hosseini, 2018). In this sense, housing simultaneously fulfills immediate residential needs and serves as a mechanism for long-term wealth accumulation and intergenerational capital transfer. Simultaneously, housing is widely recognized as a primary social determinant of health. The physical and environmental conditions of dwellings(including thermal comfort, ventilation quality, absence of dampness and mold, structural safety, and tenure security)exert direct and indirect effects on both physical and mental health outcomes. Empirical evidence demonstrates strong correlations between substandard housing and elevated risks of respiratory illness, cardiovascular disease, mental health disorders, and communicable disease transmission. Conversely, safe and adequate housing enhances psychological stability, social security, and overall well-being (Bentley et al., 2025). Within contemporary sustainability discourse, housing is further conceptualized as a linchpin of sustainable urban development. The integration of sustainable and cost-efficient materials, thermal performance optimization, renewable energy adoption, and bioclimatic design principles has emerged as central to improving urban quality of life while simultaneously reducing environmental footprints. These dimensions increasingly form the backbone of policy frameworks seeking to reconcile environmental sustainability with affordable housing provision (Silva et al., 2024).

However, while project-oriented development and high-density construction are frequently deployed to expand housing supply, the absence of coherent policymaking and insufficient attention to environmental and social quality often generate unintended consequences, including spatial inequality and infrastructure overload (Arbab & Shabani, 2023). Consequently, the deployment of modern construction technologies (MCTs) within affordable housing initiatives cannot be understood solely as a technical intervention; rather, it requires institutional alignment with land-use regulations, governance systems, and urban planning objectives. MCTs increasingly represent a conceptual bridge between environmental sustainability and economic affordability. Industrialized and modular systems, sustainable materials, passive design strategies, and smart technologies have the potential to reduce construction costs, minimize energy consumption, and lower life cycle expenditures without compromising spatial quality or environmental performance. In this theoretical framing, technology is not merely an operational instrument but a structural variable that mediates the relationship between affordability, sustainability, and residential satisfaction (Mathu et al., 2026).

Accordingly, this study conceptualizes housing as a multidimensional system in which construction technologies operate as an intervening mechanism linking economic constraints, environmental performance, and social well-being. By situating MCTs within this integrated

framework, the research moves beyond purely technical evaluations and instead examines their systemic implications for quality of life and sustainable urban development.

Broadly, housing characteristics encompass floor area, internal configuration, kitchen functionality, living space dimensions, and overall construction quality (Walisinghe & Wickramaarachchi, 2021). Neighborhood characteristics (comprising both the physical and social attributes of the residential environment) also exert a significant influence on residential satisfaction (Bangkim et al., 2020; Mridha & Moore, 2011; Türkoglu et al., 2019). Empirical studies conducted in China, Malaysia, and Australia consistently identify dwelling size and physical features as primary determinants of residential satisfaction (Huang & Du, 2015; Chen et al., 2013; Buys & Miller, 2012). Affordable housing remains a foundational pillar of social justice. Affordability emerges from a complex interaction among housing costs, household income, and essential non-housing expenditures. It represents a state of financial equilibrium in which housing expenses do not compromise a household's capacity to secure other basic needs (Stone, 2006). Conventionally, housing is defined as affordable when total housing expenditure does not exceed 30% of gross household income (Stacy et al., 2025).

In evaluating government interventions, the state is recognized as a pivotal actor operating through fiscal and institutional mechanisms. Policy instruments such as subsidized credit schemes, reduced interest rates, and targeted investment incentives may enhance accessibility (Çelik, 2024). However, such measures can also produce unintended consequences, including price inflation and market distortions, thereby generating new affordability pressures. Residential satisfaction research identifies five core dimensions: physical housing attributes, neighborhood resilience, social environment, access to public amenities, and management service quality (Huang & Du, 2015; Mohit et al., 2010).

Within this framework, economic stability and affordability remain decisive factors in sustaining long-term housing satisfaction and broader urban sustainability. Efficient economic governance models contribute not only to financial viability but also to environmental performance and sustainable urban development outcomes (Saleem & Alchalabi, 2025). The issue of affordability often stems not from a physical shortage of housing, but rather from the inability of households to meet housing costs (Duca et al., 2011; Gatt, 2023). Within this framework, monetary and fiscal policies—such as interest rates, mortgage subsidies, and Loan-to-Value (LTV) limits—play a pivotal role in shaping the affordable housing market. An increase in the flow of mortgage credit can drive prices upward without inducing a corresponding change in the real supply of housing.

Building upon this perspective, it can be argued that the root cause of the affordability crisis lies not merely in a physical supply shortage, but in a structural mismatch between fiscal policies, housing production frameworks, and the degree to which cost-reducing construction and operational technologies are implemented. This lack of coordination ensures that increases in financial credit, without a corresponding improvement in construction productivity, result primarily in price inflation (Deshmukh et al., 2025). Research by Stacy indicates that stringent rent control policies have led to a 52% increase in the supply of affordable units for extremely low-income households, while the supply of units suitable for higher-income brackets decreased by 46%. These findings underscore the dual effect of rent control: while it benefits low-income

segments, it exerts a negative impact on new construction activities (Diamond et al., 2019; Rajasekaran et al., 2019).

Smart technologies and innovative design solutions have increasingly become influential components of residential satisfaction. Smart systems for energy management, ventilation, and safety not only reduce recurring household expenses but also enhance the residents' sense of control, comfort, and psychological security. In affordable housing projects where smart technologies and energy-efficient designs have been implemented, levels of residential satisfaction and social sustainability have been significantly higher—provided that these technologies are aligned with household economic capacity and supported by enabling policies (Mathu et al., 2026; Deshmukh et al., 2025).

The conceptual framework of this research elucidates the link between modern construction technologies, the multidimensional aspects of housing, and the realization of high-quality affordable housing. This model demonstrates that construction technologies act as a linking variable, influencing residential satisfaction through their simultaneous impact on economic, socio-cultural, environmental, and health dimensions. Furthermore, the role of land policies, financial instruments, and the urban planning system is highlighted as the institutional context that determines the efficiency of these technologies. Overall, the conceptual model suggests that achieving affordable housing is only feasible through the alignment of technology, policymaking, and the physical-social characteristics of housing (Figure 1).

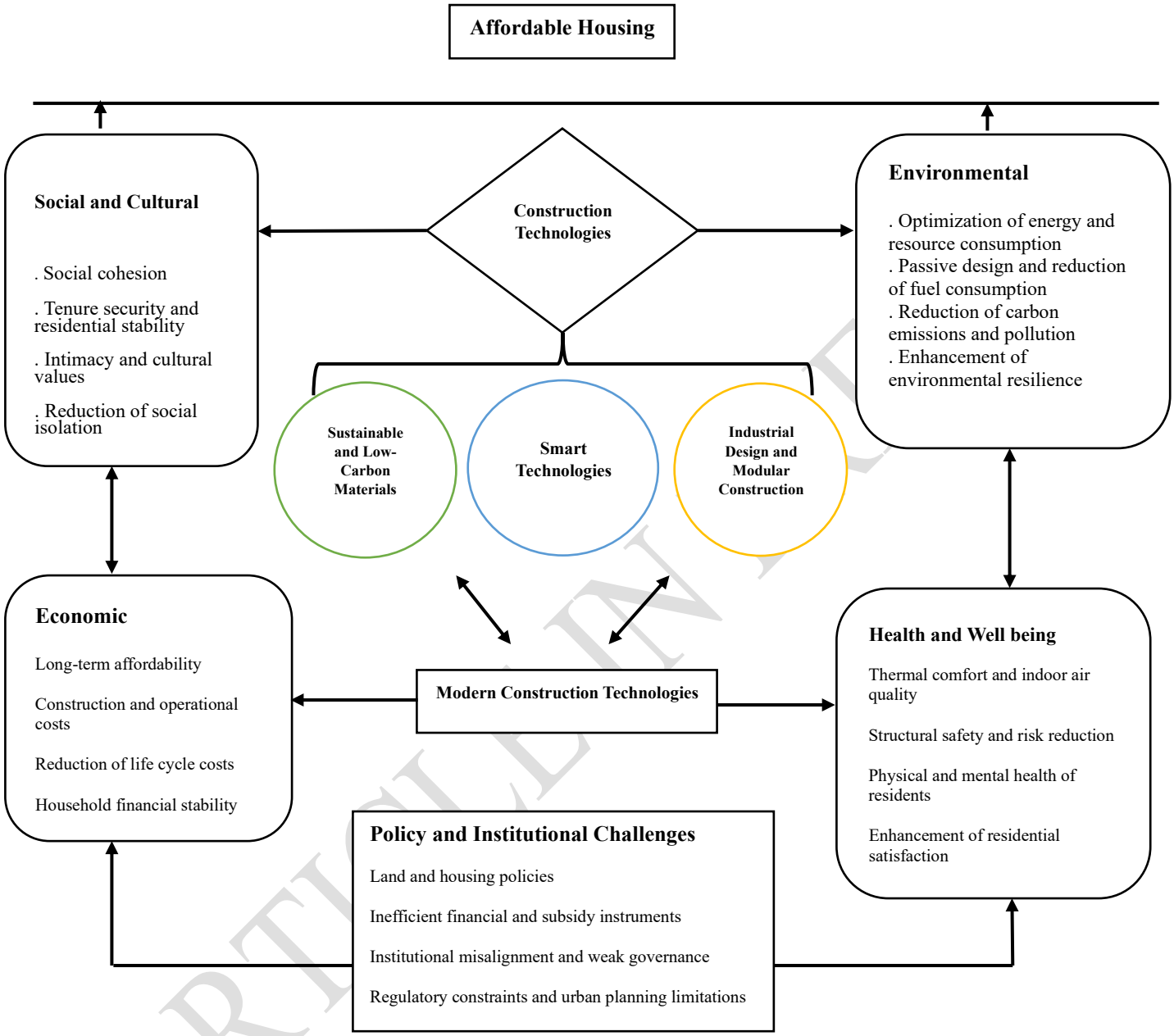

Fig. 1 Conceptual Framework of the Study

2.1.Development of Construction Technologies

Macro-level challenges in the construction sector, particularly in affordable housing provision, are increasingly shaped by technological transformation. A central objective in this domain is the integration of solutions capable of reducing construction costs, enhancing spatial performance, and accelerating project delivery. Historically, low-cost housing has depended on conventional

materials and methods, including fired clay bricks, cement-based components, and corrugated metal sheets. However, recent developments reflect a strategic shift toward innovative technologies that prioritize thermal efficiency and environmental sustainability (Moghayedi et al., 2023). Notable advancements include filtered rainwater harvesting systems capable of providing potable water with minimal operational expenditure (Muazu et al., 2023), as well as the replacement of conventional plastics with biodegradable alternatives (Moghayedi et al., 2021; Windapo et al., 2021). For such innovations to be viable in affordable housing contexts, they must combine ease of installation, cost-effectiveness, rapid implementation, and environmental durability (Moghayedi et al., 2022). Life cycle assessments indicate that the construction industry consumes approximately 60% of global raw materials, while the production of steel and cement contributes substantially to worldwide CO_2 emissions. Consequently, carbon-intensive material consumption patterns remain a primary driver of emissions in the building sector, reinforcing the urgency of transitioning toward sustainable construction methodologies (Wang et al., 2024).

Empirical evidence supports the productivity gains associated with modern construction technologies. Findings from the Sidi Abdallah project in Algeria demonstrate significant improvements in housing delivery efficiency (Makhloufi, 2025).

Similarly, comparative research in Indian housing projects (Tam, 2011) highlights the performance advantages of low-cost innovative systems over conventional techniques. Whereas traditional construction relies on standard foundations, solid brick masonry, reinforced concrete slabs, and extensive plastering, alternative methods,such as arch foundations, Rat Trap Bond masonry, and filler slab systems,substantially reduce material use while improving thermal performance and minimizing maintenance demands. Cost analyses reveal potential savings of 26.11% in wall construction and 22.68% in roofing systems.

Addressing housing shortages among low-income populations further requires leveraging local materials and simplified construction skills to enhance economic feasibility. The use of indigenous materials reduces transportation costs, stimulates local economic activity, and simplifies construction processes without compromising structural integrity (Daud & Nor, 2018). Interlocking Blocks and Compressed Earth Blocks (CEBs), for instance, rely on locally available soil and require minimal mechanization, thereby reducing logistical complexity and capital expenditure (Sengupta, 2008; Herskedal et al., 2012). Energy-efficiency strategies also play a crucial role. External thermal insulation systems can reduce annual energy consumption by 13–16%, significantly lowering operational costs while improving indoor thermal comfort and reducing greenhouse gas emissions (Paraschiv et al., 2021). Structurally, Lightweight Steel Frame (LSF) systems offer an efficient and resilient alternative due to their low weight, rapid assembly capacity, and compatibility with diverse finishing materials (Mahdavinejad et al., 2011).

Despite these advantages, technological progress alone cannot resolve affordability challenges. In the absence of alignment with housing policies and urban planning frameworks, the scalability of innovative construction systems remains constrained. The disconnect between the technical capacity of modular construction and institutional or regulatory requirements constitutes a persistent barrier (Moussavi et al., 2025). Empirical research indicates that the effectiveness of modern technologies is strongly conditioned by land-use policies; zoning reform and density

optimization in high-demand areas are essential to unlocking their full potential (Büchler & Lutz, 2024).

In District 22 of Tehran, inefficiencies in affordable housing provision stem less from technological limitations and more from systemic weaknesses in land governance, fragmented decision-making processes, and institutional misalignment. Density regulations, permit fee structures, and insufficient oversight have significantly undermined policy outcomes in this area (Goudarzi et al., 2022).

2.2.The Nexus Between Affordability and Construction Technologies

Contemporary scholarship increasingly identifies modular construction as one of the most efficient pathways toward industrialized housing production. Off-site fabrication within controlled factory environments reduces human error, standardizes quality, minimizes material waste, and enhances on-site safety. Systematic reviews demonstrate that countries adopting modular systems have significantly reduced project timelines while increasing the large-scale production capacity of affordable housing units (Ahmad Khan et al., 2024). Complementary digital management systems, such as Building Information Modeling (BIM), further optimize design coordination, reduce material waste, and enhance labor productivity (Azhar, 2011).

Beyond industrialization, low-carbon structural systems such as Cross-Laminated Timber (CLT/X-Lam) contribute to long-term operational savings by eliminating thermal bridges and improving airtightness (Nocera et al., 2018). Ultra-low-energy housing projects in the United Kingdom, for example, report up to a 60% reduction in heating expenditures alongside measurable improvements in resident satisfaction (Pomponi & Moncaster, 2017).

Nevertheless, the scalability of such technologies in dense urban contexts is frequently constrained by zoning restrictions, administrative fragmentation, and governance inefficiencies (Gan et al., 2018; Choi et al., 2019). Thus, the operational viability of modern construction systems is inseparable from policy reform within urban planning frameworks (Steinhardt et al., 2020). Technological innovation, therefore, must be embedded within coherent regulatory ecosystems to effectively contribute to affordability objectives.

3.Case Study

District 22 of the Tehran Municipality is situated at the westernmost edge of the city, adjacent to the southern foothills of the Alborz Mountains and Chitgar Lake (Martyrs of the Persian Gulf Lake). It has been regarded as one of the principal zones of Tehran's physical expansion in recent decades. The availability of extensive land reserves, relatively low population density compared to central districts, and a substantial share of residential and mixed-use land uses have positioned this district as a potential setting for planned housing interventions. In practice, however, the development pattern of District 22 has been largely characterized by high-rise construction and large-scale residential projects. Although this model relies physically on relatively modern

construction techniques and the use of industrial materials, its emphasis on investment-oriented and luxury housing units—along with rising land prices and speculative activities—has constrained low-income groups' access to housing and posed challenges to the realization of spatial justice. From this perspective, the issue of affordable housing in District 22 is not merely a physical or morphological matter, but rather the outcome of interactions among economic, institutional, and spatial factors.

Nevertheless, characteristics such as large parcel sizes, adequate access to transportation infrastructure, and the feasibility of industrialized construction provide the capacity—if guided by appropriate urban policies—to reduce construction costs and enhance the efficiency of residential projects. Within this framework, the adoption of emerging construction technologies, including prefabricated systems, three-dimensional (3D) printing, and energy-efficient technologies, is technically and economically justifiable given the scale of development and the climatic conditions of the area. Such technologies have the potential to shorten construction time and reduce energy consumption; however, their effectiveness remains contingent upon their alignment with building regulations and the supportive policies of urban management.

These attributes, together with relatively adequate infrastructure provision, create a valuable opportunity for the application of innovative construction technologies and the implementation of pilot affordable housing projects at the urban scale. From this perspective, the examination of District 22 is significant, as it may serve as a model for other districts of Tehran and major cities across the country in leveraging new construction technologies to reduce costs and improve access to adequate housing for diverse social groups.

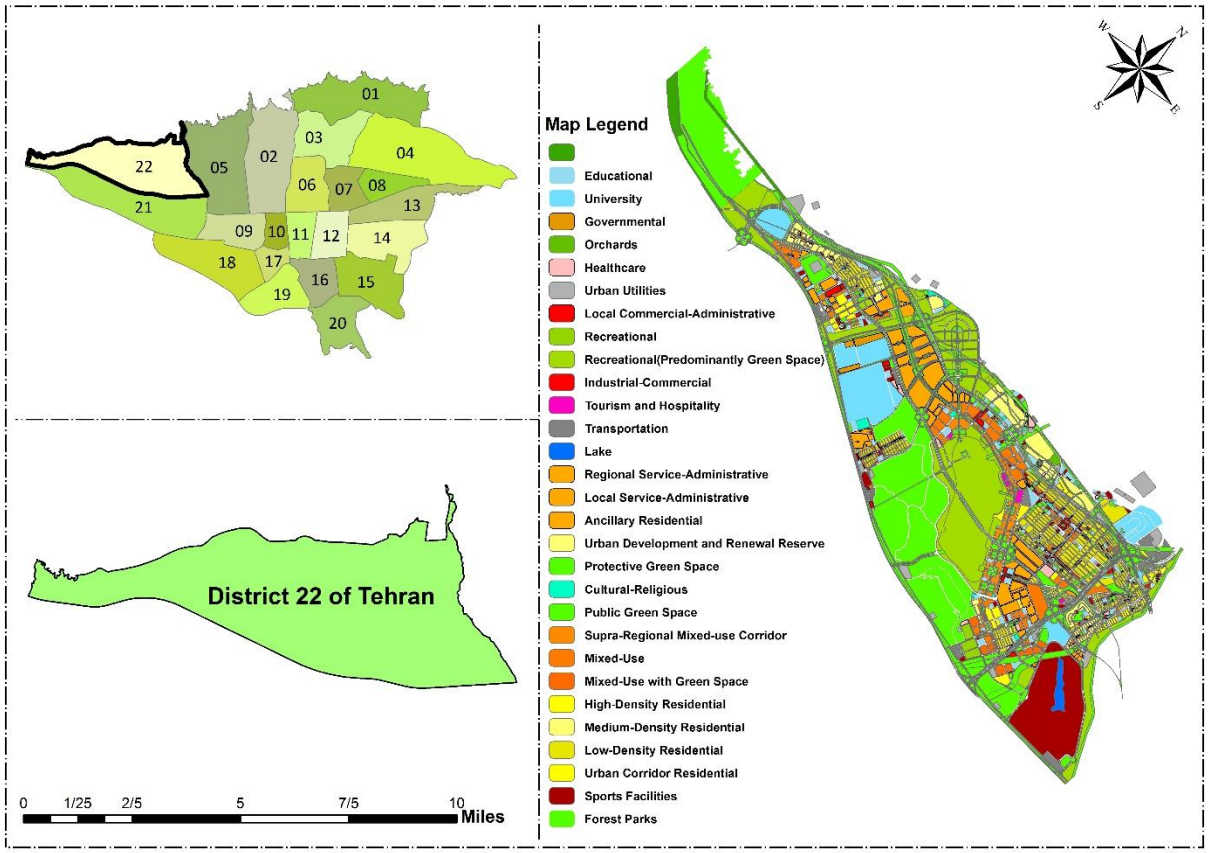

Fig. 2 Map of the case study area

4.Research method

The present study is applied in terms of its objective and qualitative in nature, adopting an exploratory approach to examine the challenges and strategies associated with the development of affordable housing through the use of emerging construction technologies in District 22 of Tehran. The study population comprised housing and urban planning experts, urban managers, private-sector developers, and academic researchers. Using purposive sampling, 13 experts with specialized knowledge and professional experience in construction technologies and housing policy were selected for in-depth interviews. Data were collected through semi-structured interviews. The interview protocol was designed around key themes, including the role of innovative construction technologies in reducing building costs, institutional and technical barriers, the development capacities of District 22, and the supportive policies of urban management.

Table 1. Semi-structured interview themes and questions

No.	Interview Theme	Interview Question
1	Experience with Emerging Technologies	What has been your experience in implementing affordable housing projects using emerging construction technologies, and what lessons can be drawn from the successes or failures of these projects?
2	Structural Challenges	From your perspective, what structural challenges (legal, technical, and financial) have constrained the development of affordable housing using emerging technologies in Tehran?
3	Innovative Building Materials	What types of innovative building materials could reduce housing construction costs in Tehran?
4	Institutional Interaction and Stakeholders	How would you describe the interaction among stakeholders (municipality, developers, and residents) in technology-based projects in District 22, and what forms of conflict or collaboration have been observed?
5	Role of Urban Policies	What is the role of urban management policies in supporting or constraining the development of affordable housing in Tehran?
6	Characteristics of District 22	How do the unique characteristics of District 22 (e.g., infrastructure provision, demographic structure, and access to resources) create opportunities for piloting and implementing innovative housing technologies?
7	Cost Reduction and Sustainability	How can housing costs be reduced while maintaining construction quality in a way that also contributes to the sustainability of District 22?
8	Developmental Recommendations	What recommendations do you propose to improve the development of affordable housing in District 22 of Tehran?

The professional profiles and areas of expertise of the interviewed experts are presented in Table 2.

Table 2. Profile of Interviewed Experts

No.	Field of Expertise	Professional Role / Affiliation
1	Urban Planning	Urban Planning Specialist
2	Urban Planning	Urban Planning Expert
3	Civil Engineering	District Developer
4	Civil Engineering	Local Developer
5	Civil Engineering	Civil Engineer
6	Civil Engineering	Construction Specialist
7	Architecture	Construction Specialist
8	Urban Management	Urban Management Expert
9	Housing and Real Estate	Karino Real Estate Agency Representative
10	Housing and Real Estate	Chitgar Real Estate Agency Representative
11	Housing and Real Estate	Kouhak Real Estate Agency Representative

12	Housing Policy	Urban Planning Expert
13	Academia	University Professor

Each interview lasted on average between 45 and 60 minutes. After complete transcription, the data were analyzed using thematic analysis. The analysis proceeded through three stages: open coding, axial coding, and selective coding, resulting in the identification of 221 open codes and the extraction of five main categories: institutional and social interaction, innovative technologies and building materials, structural challenges, characteristics of District 22, and policies and recommendations. To ensure the accuracy and validity of the data, member checking was conducted with participants, and cross-validation of the analyses was performed by collaborating researchers. All interviews were conducted with informed consent and in accordance with ethical research considerations. The outcomes of the coding and categorization process, including open and axial codes, are presented in Table 4.

5.Findings

5.1.Institutional and Social Interaction

The analysis of the "Institutional and Social Interaction" category revealed that the development of affordable housing in District 22 of Tehran is not solely achieved through technical and economic policies. Rather, it heavily depends on a network of institutional relationships, social trust, and collaboration among organizations and stakeholders. Participation among governmental agencies, the municipality, the private sector, and the local community in the planning and implementation of housing projects was identified as a fundamental condition for achieving housing justice and urban sustainability. At the same time, weak institutional coordination, fragmented decision-making, and administrative bureaucracy were identified as significant barriers to the adoption of innovative construction technologies. For instance, one urban planning expert stated: "The permitting and institutional coordination system is not aligned with new technologies at all, and the processes have become extremely lengthy." Examples of the statements and narratives extracted in relation to this category are presented in Table 3.

Table 3. Sample Statements Extracted from Interviews

Axial Code	Open Code	Relevant Interview Statement	Interviewee
Institutional and Social	Incompatibility of technology with residents' financial capacity	Residents do not have the financial capacity to adopt new technologies, and there is no effective loan mechanism.	Expert
	Inter-agency collaboration	Without institutional interaction, even the best technologies are practically ineffective.	Urban Planning Specialist
	Administrative corruption	The municipality does not cooperate at all and there is even a lack of transparency in land allocation.	Karino Real Estate Agency Representative

The participants' responses indicated that the absence of a transparent and coordinated mechanism for inter-agency interaction has caused many projects to experience delays, increased costs, and public distrust. As one local developer in District 22 noted: "Municipal bureaucracy prolongs the process and multiplies costs." In particular, non-transparent allocation of land and financial resources has weakened the motivation of investors and private-sector developers, widening the gap between stated objectives and actual outcomes. A real estate consultant from Karino also emphasized: "The municipality does not cooperate at all and there is even a lack of transparency in land allocation."

From a social perspective, the gap between residents' financial capacity and the costs of new construction technologies represents a significant challenge. One participant stated: "Residents do not have the financial capacity to adopt new technologies, and there is no effective loan mechanism." Although innovative construction technologies have the potential to reduce energy consumption, enhance building durability, and improve quality of life, high upfront costs and the lack of supportive policies have made these technologies largely inaccessible to low-income households. Consequently, the mismatch between technology and household financial capacity not only impedes the provision of affordable housing but also increases feelings of relative deprivation in the community. The theoretical framework of this study defines housing not merely as physical shelter but as a social institution with a central role in quality of life and urban sustainability. Therefore, when institutional structures lack cohesion and transparency, the social foundation for active participation and a sense of belonging among citizens is also weakened.

Data analysis revealed that the development of "institutional trust" and "inter-organizational interaction" can play a facilitating role in the diffusion of innovative construction technologies. When agencies operate collaboratively and in a coordinated manner, decision-making regarding construction technologies, land allocation, and credit policies proceeds more efficiently and transparently. As one expert stated: "Without institutional interaction, even the best technologies are practically ineffective."Such synergy bridges the gap between technological objectives and social justice, ultimately enhancing the quality of life for residents in newly developed areas. In other words, the development of affordable housing without institutional cohesion is akin to constructing a building on an unstable foundation: even the most advanced technologies lose their effectiveness in the absence of social and institutional interaction. Overall, the analysis demonstrates that institutional and social interaction constitutes the cornerstone of urban sustainability and justice. Establishing transparent decision-making mechanisms, enhancing public awareness and training regarding innovative technologies, and strengthening inter-agency communication networks can elevate this interaction to a level where construction technologies function not merely as technical tools but as social instruments of development. Under such conditions, affordable housing transcends a purely economic policy and becomes a mechanism for citizen empowerment and the realization of sustainable livability.

Table 4. Open and Axial Coding of Categories

No.	Open Code	Frequency	Percentage	Axial Code
1	Incompatibility of technology with residents' financial capacity	10	4.5%	Institutional and Social Interaction
2	Inter-agency collaboration	12	5.4%	Institutional and Social Interaction
3	Administrative corruption	5	2.3%	Institutional and Social Interaction
4	Use of lightweight and local building materials	20	9%	Innovative Technologies and Materials
5	Low safety of new materials	4	1.8%	Innovative Technologies and Materials
6	Application of technology in construction and materials	24	10.9%	Innovative Technologies and Materials
7	Recycling technology for construction waste	6	2.7%	Innovative Technologies and Materials
8	Lengthy permit approval processes	4	1.8%	Structural Challenges (Legal, Financial, Technical)
9	Lack of training and technical infrastructure	8	3.6%	Structural Challenges (Legal, Financial, Technical)
10	Reduced motivation of developers	7	3.2%	Structural Challenges (Legal, Financial, Technical)
11	Financial incapacity of households	6	2.7%	Structural Challenges (Legal, Financial, Technical)
12	Standards of innovative materials	9	4.1%	Structural Challenges (Legal, Financial, Technical)
13	Opportunity for pilot project implementation	5	2.3%	Characteristics of District 22, Tehran
14	Natural characteristics of the district	5	2.3%	Characteristics of District 22, Tehran
15	Adequate transportation infrastructure	19	8.6%	Characteristics of District 22, Tehran
16	Promotion of public-private partnerships (PPP)	9	4.1%	Characteristics of District 22, Tehran
17	Training human resources for new construction technologies	14	6.3%	Policies and Recommendations
18	Localized regulation of construction technologies	15	6.8%	Policies and Recommendations

19	Allocation of government land for housing projects	9	4.1%	Policies and Recommendations
20	Supportive urban management policies	30	13.6%	Policies and Recommendations
Total		221	100%	

5.2.Modern Technology and Materials

An analysis of the data regarding "Modern Technology and Materials" reveals that the integration of innovative technologies into the construction process—particularly within affordable housing projects—is recognized as one of the most promising solutions for reducing costs, accelerating execution timelines, and enhancing quality of life. Throughout the interviews, participants repeatedly emphasized that technology, if appropriately selected and localized, can play a pivotal role in achieving residential equity and urban sustainability. As one construction expert noted: "Technology without an integrated educational system and a localized supply chain is merely modern in appearance; in practice, it lacks the necessary efficiency." A selection of propositions and narratives extracted in relation to this category is presented in Table 5.

Table 5. Sample Statements Extracted from Interviews

Axial Code	Open Code	Related Narrative/Quote	Interviewee
Modern Technology and Materials	Use of lightweight and indigenous materials	"Lightweight and recycled materials reduce construction costs, but we lack the necessary production infrastructure."	Construction Expert
	Safety weaknesses of new materials	"Some new materials do not perform well against fire, and as a result, the public does not trust them."	Local Developer
	Application of technology in materials and construction	"Prefabrication reduced execution time by 30%, but it requires meticulous planning and standardization."	Regional Developer
	Construction waste recycling technology	"If construction waste recycling becomes industrialized, costs will decrease; however, the infrastructure is currently missing."	Civil Engineer

Despite these advantages, challenges related to initial costs, access to advanced equipment, a lack of technical expertise, and structural resistance to change were identified as major barriers to the effective implementation of these technologies in Iran, particularly in District 22 of Tehran. As one regional developer stated: "Modern technology entails high initial costs, and an untrained technical workforce increases the risks of execution." Within the qualitative data, there was a strong emphasis on the necessity of replacing traditional materials with innovative and lightweight alternatives. Many interviewees believed that utilizing lightweight, recycled, and eco-friendly

indigenous materials would not only lead to a reduction in construction and energy costs but also enhance the durability and efficiency of buildings. A construction specialist noted: "Lightweight and recycled materials simultaneously lower construction costs and improve environmental sustainability."

Nonetheless, field experiences indicate that a lack of industrial infrastructure for the mass production of these materials, coupled with a deficiency in harmonized national standards, has hindered their widespread adoption. As one expert noted: "There are no specific executive standards for innovative materials such as lightweight panels and lightweight concrete." Furthermore, some developers pointed out that modern materials have occasionally compromised building safety due to inadequate supervision or non-standard imports, thereby negatively impacting public trust in new technologies. One developer stated: "Some of the new materials do not perform well against fire or moisture, and consequently, the public lacks confidence in them."

The thematic analysis indicates that innovative technologies can lead to cost reductions and quality improvements only if they are aligned with the institutional framework and the economic needs of society. Otherwise, technology becomes a merely "decorative" element—modern in appearance but economically inefficient in practice. Many participants believed that the government and urban management must facilitate the adoption of new technologies through financial support, human resource training, and the promotion of a technical culture of innovation. As one urban planning specialist stated: "Without supportive policies, even the best technologies will not enter the housing production cycle." This perspective aligns with the study's theoretical framework, which identifies technology as a pillar of sustainable development and a key driver in enhancing the quality of life.

On the other hand, the application of prefabricated construction technologies, Lightweight Steel Framing (LSF), 3D printing, and Building Information Modeling (BIM) can make housing projects economically more accessible by reducing material waste, accelerating execution speed, and lowering labor costs. Throughout the interviews, several participants referred to successful experiences using industrial formwork and prefabricated systems, which resulted in a noticeable reduction in construction time and enhanced execution quality. As one construction specialist stated: "In our prefabricated projects, we experienced a 30% reduction in construction time." These findings indicate that if modern technologies are accompanied by meticulous planning, specialized training, and targeted investment, they can significantly bridge the gap between cost and quality, making housing truly affordable.

5.3.Structural Challenges (Legal, Financial, and Technical)

An analysis of the data regarding "Structural Challenges (Legal, Financial, and Technical)" reveals that one of the most fundamental obstacles to the development of affordable housing is the existence of inefficient structures at various levels of decision-making, execution, and oversight. Interviewees believed that complex administrative procedures and the protracted nature of the permitting process have led to increased costs and diminished motivation among private sector actors. As one developer in District 22 stated: "Currently, obtaining a construction permit takes between a year and a year and a half, which discourages investment in construction." This issue is

more pronounced in District 22 of Tehran than in other areas, given the urgent need to accelerate residential projects in this region.

Policy inefficiencies and a lack of coordination among relevant institutions result in even innovative technologies—which possess the potential to reduce costs and time—facing practical, legal, and operational barriers. As one urban planning expert noted: "Construction regulations are largely drafted based on traditional methods and are incompatible with modern technologies." From an economic perspective, many participants highlighted the scarcity of financial resources, the absence of effective banking facilities, and the inability of low-income households to cover initial costs. A real estate consultant in the Kuhak neighborhood stated: "If the funding were available, there would be no issue; however, there are no genuine facilities for affordable construction." Existing financial policies, rather than supporting small-scale developers and vulnerable households, are often skewed toward large-scale, capital-intensive projects. This situation has marginalized the primary objective of affordable housing—providing shelter for low-income groups. A selection of propositions and narratives extracted in relation to this category is presented in Table 6.

Table 6. Sample Statements Extracted from Interviews

Axial Code	Open Code	Related Narrative/Quote	Interviewee
Structural Challenges (Legal, Financial, Technical)	Protracted licensing and permitting processes	"Obtaining a construction permit takes from one year to one and a half years."	District Developer
	Lack of technical training and infrastructure	"The workforce is not prepared or trained for modern technologies."	Construction Specialist
	Reduced developer motivation	"Informal payments and behind-the-scenes processes have caused developers to distance themselves from low-cost projects."	Local Developer
	Financial inability of households	"For the public, the initial cost of new technology is prohibitively high."	Urban Planning Expert
	Lack of standards for modern materials	"We lack specific executive guidelines for innovative materials, such as lightweight panels."	Urban Planning Expert

Moreover, rising construction material prices, the lack of effective market controls, and economic fluctuations have rendered the construction environment unstable for investment in low-cost projects. From a technical perspective, the data indicates that deficiencies in human resource training, a lack of technical expertise regarding modern technologies, and the absence of unified standards for materials and construction methods constitute significant barriers to the qualitative development of housing projects. As one construction specialist stated: "Until the workforce is adequately trained, the implementation of innovative technologies will remain high-risk and time-consuming." Many developers pointed out that in the absence of clear technical guidelines and

educational support, adopting new technologies is perceived as not only difficult but inherently risky.

In fact, the technological gap between global innovations in the construction industry and the existing domestic technical level has created a barrier to achieving sustainability and affordability goals. As one construction specialist added: "In developed countries, the workforce only handles specific weights and tasks are technology-driven, but in Iran, we are still heavily dependent on manual labor." From a social and institutional perspective, these structural problems are linked in a chain reaction. Inefficient regulations and heavy bureaucracy slow down the financial flow of projects, and these delays, in turn, increase overhead costs. In such an environment, non-transparent decision-making is exacerbated. One participant noted: "In some departments, decisions are not transparent, which leads to extra costs and delays." This lack of transparency also deters private sector developers from engaging in low-income projects and diminishes trust in supportive policies. As one developer pointed out: "Informal payments and behind-the-scenes processes have caused developers to distance themselves from low-cost projects." Conversely, instances where institutional coordination and economic stability were present demonstrate that even under financial constraints, affordable projects can be successfully implemented.

5.4.Characteristics of District 22 of Tehran

An analysis of the data regarding the category "Characteristics of District 22 of Tehran" indicates that this region, as one of the new urban development zones, possesses unique capacities for implementing affordable housing models based on innovative technologies. Interviewees repeatedly emphasized that District 22—with its relatively vacant land, favorable access to transportation networks, and specific natural and climatic features—serves as an ideal platform for pilot and innovative housing projects. As one real estate consultant active in the area stated: "District 22 is truly unique in terms of available land and its position for implementing new projects." While the district has witnessed extensive physical transformation and rapid high-rise growth in recent years, it still faces social and infrastructural challenges that must be addressed in future planning.

In the data analysis, the "opportunity for pilot projects" emerged as a significant sub-code. Many participants identified District 22 as an ideal location for testing innovative construction technologies due to its relatively modern fabric and its young, educated population. As one urban planning specialist noted: "This district is the best platform for piloting new construction technologies." This characteristic could lead to the creation of successful affordable housing models that possess generalizability to other urban areas. At the same time, past experiences indicate that a lack of coordinated planning and an integrated development strategy has resulted in a misalignment between infrastructure, population density, and the quality of urban services. One participant remarked: "Construction has outpaced urban services, and this imbalance has affected the quality of life." This imbalance directly impacts residents' quality of life and, in some cases, has led to social dissatisfaction and a decline in the sense of urban belonging. A selection of propositions and narratives related to this category is presented in Table 7. The interview findings suggest that the availability of relatively vacant land, suitable transportation infrastructure, and opportunities for technological pilot projects—if guided by targeted urban policies—could

improve housing accessibility for low-income groups, young households, and renters, thereby preventing development from focusing solely on luxury units. Within this framework, District 22 has the potential to become a platform for achieving spatial justice and a more balanced distribution of residential opportunities by linking technological development with supportive urban management policies. However, according to codes related to household financial inability and diminished developer motivation, a lack of equity-oriented policies could result in technological development merely reproducing unequal residential patterns and the social exclusion of low-income groups from this urban zone. Therefore, aligning the locational capacities of District 22 with the study's coding results is a fundamental prerequisite for the success of the affordable housing model.

Table 7. Sample Statements Extracted from Interviews

Axial Code	Open Code	Related Narrative/Quote	Interviewee
Characteristics of District 22	Opportunity for pilot projects	"District 22 is the ideal platform for piloting innovative construction technologies."	Urban Planning Expert
	Natural characteristics of the district	"The presence of the lake and extensive green spaces has distinguished this district."	Chitgar Real Estate Agent
	Favorable transportation infrastructure	"Transportation accessibility is one of the most significant advantages here."	Construction Specialist

The natural characteristics of the district, including the presence of Chitgar Lake and the surrounding open and green spaces, were highlighted in the discussions as prominent advantages. These areas serve not only ecological and environmental roles but can also be integrated into the design of sustainable and human-centric housing models. As a consultant from Karino Real Estate noted: "The presence of the lake and green spaces has distinguished this district from an environmental perspective." Many interviewees believed that combining modern technologies with the district's natural and environmental capacities could foster a "Green Housing Development" model—an approach that is both economically affordable and capable of enhancing residents' quality of life through improved livability and environmental quality.

However, some participants warned that neglecting environmental capacities and allowing unregulated construction sprawl could transform these advantages into threats, diminishing the district's environmental quality in the long run. As one regional developer stated: "If construction is not controlled, these very advantages will turn into environmental problems." Furthermore, the district's extensive access to highways, metro lines, and service areas was highlighted in the data as a major strength. These transportation infrastructures facilitate a reduction in both time and financial costs for residents and, from the perspective of spatial equity, contribute to a more balanced distribution of urban services. As one urban expert noted: "The transportation accessibility of District 22 is one of its most significant advantages for housing development."

Nevertheless, challenges such as the shortage of educational centers and social services in certain areas, along with a heavy automobile dependency, constitute existing limitations to the full

utilization of these capacities. As one participant stated: "The service infrastructure for some blocks is still incomplete, and people are forced to use cars for most of their daily needs." The findings indicate that while District 22 of Tehran can be recognized as a practical model for achieving affordable housing within a contemporary urban context, leveraging these capacities necessitates intersectoral planning and institutional coordination.

5.5.Recommendations and Policies

The data analysis regarding the category "Recommendations and Policies" indicates that to achieve affordable housing development through construction technologies, technical innovation alone is insufficient; rather, it requires coherent policymaking, financial support, and institutional coordination. Interviewees extensively emphasized the necessity of the government and urban management's role in steering the housing market, reforming regulations, and creating incentives for developers and investors. As one urban expert stated: "Technology without institutional and policy support remains merely at a symbolic level and fails to enter mass production." Many participants believed that without a policy backbone and macro-level planning, innovative technologies—no matter how effective—will remain limited in scope and cannot be integrated into the mainstream of housing production.

In the data, supportive urban management policies were identified as one of the most critical facilitators for the development of construction technologies. These policies include providing low-interest bank facilities, allocating government-owned land, reducing permitting fees for technological projects, and encouraging Public-Private Partnerships (PPP). Many respondents believed that such policies could reduce the final cost of housing production and increase private sector participation in affordable projects. As one developer stated: "If construction fees for new technologies are reduced, developers will have a greater incentive to enter this field." In contrast, the absence of transparent and stable policies increases investment risks and deters developers from engaging in low-income housing projects. A selection of propositions and narratives extracted in relation to this category is presented in Table 8.

Table 8. Sample Statements Extracted from Interviews

Axial Code	Open Code	Related Narrative/Quote	Interviewee
Recommendations and Policies	Encouraging Public-Private Partnerships (PPP)	"If the municipality provides land and part of the infrastructure while the private sector handles construction, projects will be completed faster and at a lower cost."	Construction Specialist
	Workforce training for emerging technologies	"Until the workforce is adequately trained, the implementation of innovative technologies remains high-risk."	Kuhak Real Estate Agent
	Localized legislation for	"Current regulations are not suitable for new technologies and must be revised."	Chitgar Real Estate Agent

	construction technologies		
	Allocation of government land to residential projects	"The municipality should allocate public land to technological housing projects."	Civil Engineer
	Supportive urban management policies	"Without municipal support and financial incentives, technology remains merely symbolic."	Urban Planning Expert

Alongside economic policies, human resource training was identified as a core pillar of sustainable development. The data indicates that the scarcity of specialized skills in the field of modern construction technologies constitutes a serious barrier to the correct and safe implementation of these innovations. As one construction specialist stated: "Without a trained workforce, implementing new technologies with appropriate quality is impossible." Consequently, recommendations were made to establish technical training centers for construction, conduct specialized workshops for engineers and laborers, and foster university-industry collaboration. Beyond enhancing the quality of execution, such educational initiatives can facilitate the social acceptance of emerging technologies and mitigate resistance to change.

Furthermore, several participants emphasized the necessity of localized legislation for emerging technologies. They argued that current regulations are often incompatible with modern innovations, and the absence of clear legal frameworks has rendered the permitting and project evaluation processes slow and complex. As one expert stated: "New technologies require specific regulations and clear guidelines; otherwise, they get bogged down in administrative bureaucracy." From their perspective, revising construction regulations and national standards—particularly regarding innovative materials and methods—could mitigate operational risks and facilitate the expansion of sustainable technologies within the housing market. Additionally, public participation and citizen awareness regarding the role of technology in cost reduction and quality of life enhancement were highlighted as the social dimension of policymaking. Without social understanding and cooperation, even the most robust government policies will have limited effectiveness. One interviewee noted: "If the public is unaware of the benefits of technology, they will not embrace it, leading to project failure." In this context, media outlets and local institutions can play a pivotal role in promoting a culture of technological construction and strengthening public trust.

Figure 3 illustrates the interconnected structure between the primary research categories and demonstrates how institutional factors, technology, structural problems, regional characteristics, and policymaking influence one another within a meaningful network. This diagram effectively represents the multidimensional nature of the affordable housing issue and underscores the necessity of a systems-oriented approach in its analysis.

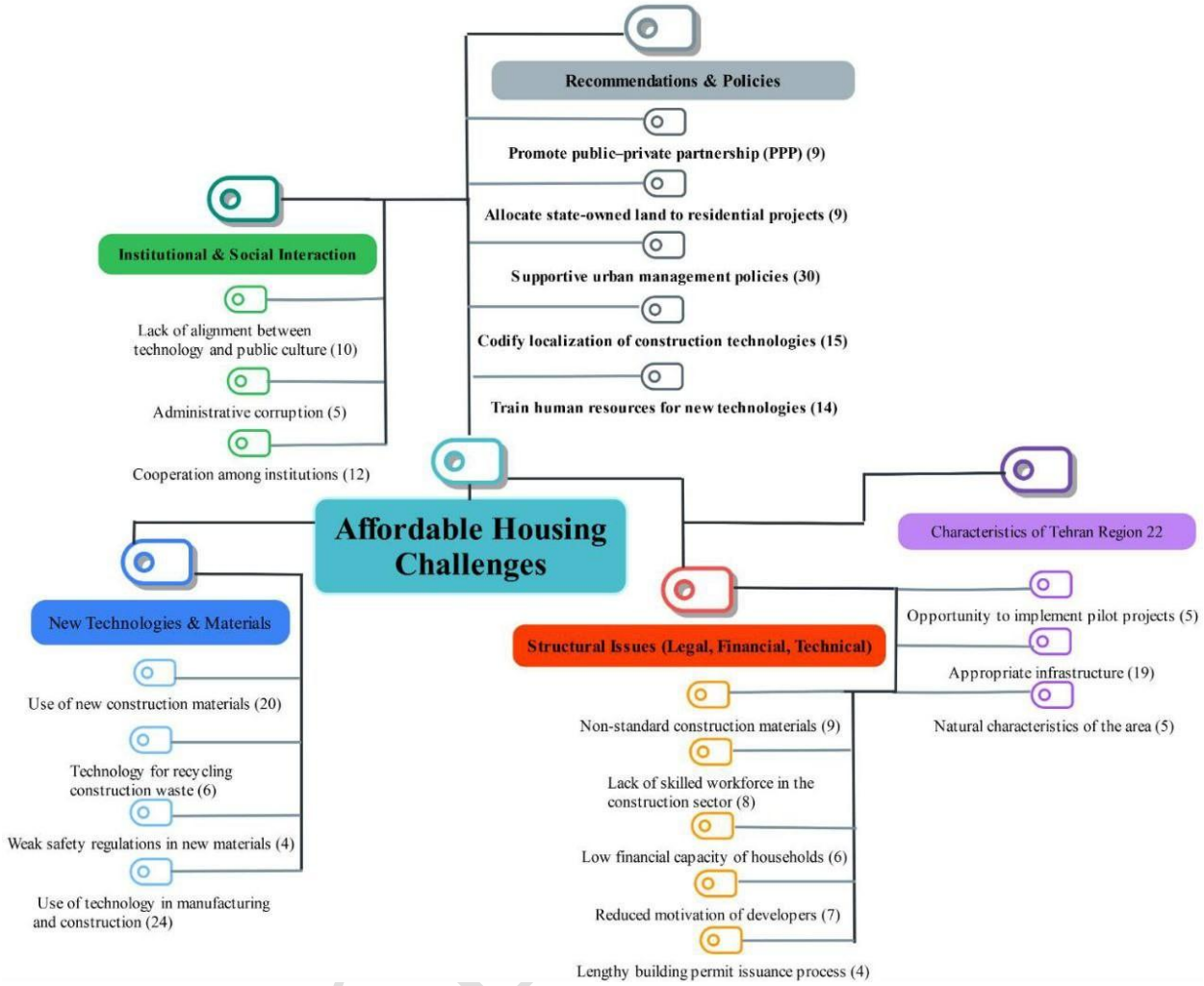

Fig. 3 Relational map of categories and extracted codes

The results illustrated in Figure 4 indicate that supportive urban management policies (14%) play the most significant role in affordable housing development. Following this, the application of technology in materials and construction (11%) and the use of lightweight and localized materials (9%) have the greatest impact on cost reduction and quality enhancement. Additionally, suitable transportation infrastructure (9%), localized legislation for construction technologies (7%), and human resource training for emerging technologies (6%) are identified as crucial reinforcing factors. In contrast, factors such as administrative corruption (2%), protracted permitting processes (2%), and safety weaknesses in new materials (2%) constitute the primary barriers to the implementation of modern technologies. Overall, success in affordable housing development necessitates supportive policymaking, institutional coordination, and the localization of construction technologies. The frequency distribution of each component and a comparison of their respective roles in the affordable housing development process are depicted in Figure 4.

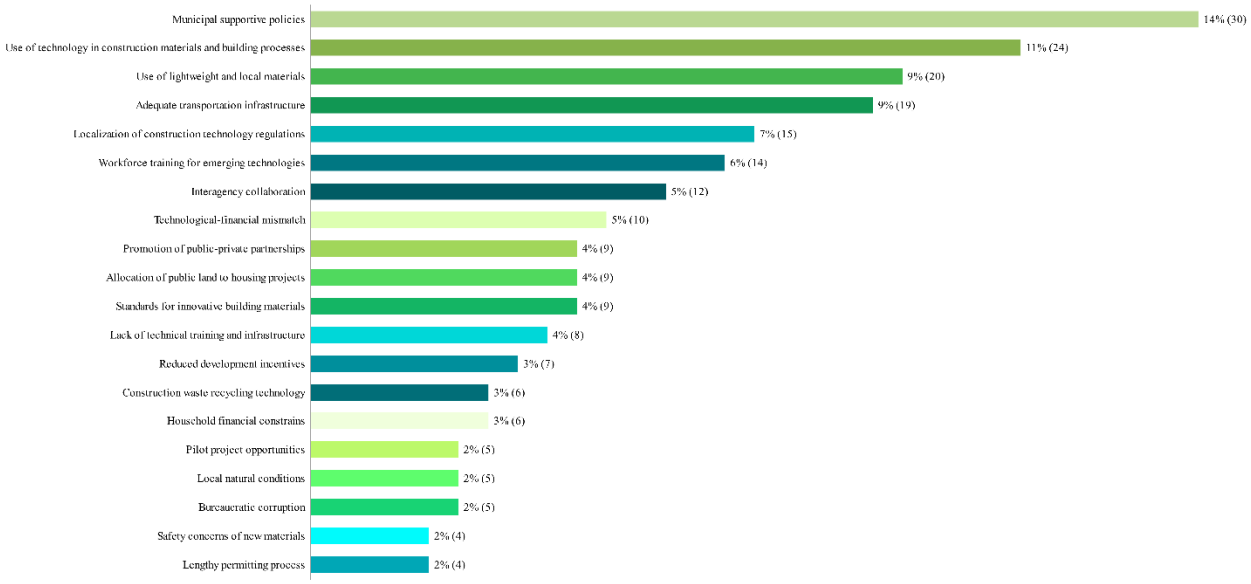

Fig. 4 Relative frequency analysis of sub-categories

6.Conclusion

The results of this research indicate that the development of affordable housing in District 22 of Tehran depends more on the quality of policymaking and the institutional structures governing the housing production process than on purely technical and technological capacities. The frequency analysis of the codes and the study's final results demonstrate that "Supportive Urban Management Policies"—with the highest share (14%)—play a more dominant role than other factors in achieving affordable housing. This factor operates in direct interaction with construction technologies and the district's spatial characteristics. In the next tier, the application of technology in materials and the construction process (11%) and the use of lightweight and localized materials (9%) were identified as the most significant technical factors for cost reduction and quality enhancement. However, the findings suggest that the effectiveness of these technologies will remain limited and unsustainable without institutional support, human resource training, and standardization. Consequently, technology functions not as an independent driver, but as a tool contingent upon policymaking and institutional coordination.

From a spatial perspective, District 22 of Tehran possesses significant potential for realizing affordable housing models due to its favorable transportation infrastructure and the feasibility of implementing pilot projects. However, in the absence of an equity-oriented orientation, this potential could lead to the reproduction of unequal housing patterns and a disproportionate focus on investment-driven units. Accordingly, the research findings emphasize that success in developing affordable housing necessitates a systems-oriented approach, wherein supportive policies, construction technologies, and spatial capacities are simultaneously and harmoniously aligned to serve the intended target housing groups.

Despite possessing suitable development land, favorable transportation infrastructure, and the capacity for technological pilot projects, District 22 can only transform into a successful model for affordable housing if targeted urban policies, financial support, and institutional coordination are

established. Overall, the research results indicate that the development of affordable housing requires an integrated and systems-oriented approach—one in which technology, policymaking, financial resources, and the institutional framework operate in synergy to enhance the quality of life and increase accessibility to adequate housing for diverse social strata.

Based on the research findings, the following recommendations are proposed:

General Recommendations:

 Institutional Reform: Reforming institutional mechanisms and accelerating the permitting process specifically for affordable housing projects.

 Economic Incentive Packages: Designing targeted financial support packages for construction projects based on sustainable technologies.

 Capacity Building: Developing human resource training programs specialized in modern construction technology sectors.

 Regulatory Revision: Updating and revising national construction regulations and standards to ensure compatibility with innovative technologies.

Specific Recommendations for District 22, Tehran:

 Institutional Coordination Taskforce: Establishing a "District 22 Affordable Housing Coordination Taskforce," led by the regional municipality, to streamline inter-agency cooperation.

 Public Land Allocation: Allocating government-owned land and vacant urban brownfields within District 22 to pilot affordable housing projects.

 Pilot Technological Projects: Implementing experimental projects utilizing prefabricated technologies and lightweight materials in the developing zones of District 22.

 Targeted Social Incentives: Directing the district’s incentive policies toward low-income target groups and young households to ensure social equity.

Author Contributions

The authors contributed equally to this research.

Acknowledgments

The authors would like to express their sincere gratitude to everyone who assisted and supported them throughout this research project. ChatGPT (version 5.3) was applied for organizing and editing the translation.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

References

Adetooto, J., Windapo, A., & Pomponi, F. (2024). The use of alternative building technologies as a sustainable affordable housing solution: Perspectives from South Africa. *Journal of Engineering, Design and Technology, 22*(5), 1447–1463. https://doi.org/10.1108/JEDT-05-2022-0257

Adeyemi, A. B., Akinlabi, E. T., Mashinini, P. M., & Tsolekile, L. (2024). Integrating modular and prefabricated construction techniques in affordable housing: Architectural design considerations and benefits. *Sustainability, 16*(17), 7773. https://doi.org/10.3390/su16177773

Ahmadi, F. (2024). Residential satisfaction with affordable housing in northern Iran. *Open House International, 49*(1), 144–162. https://doi.org/10.1108/OHI-09-2022-0226

Arbab, P., & Shabani, Z. (2023). Consequences of Project-Based Development on the Quality of Urban Life (Case Study: Tehran). *Urban Economics and Planning*, 4(2), 176–191. https://doi.org/10.22034/uep.2023.397976.1382

Atta, N., Dalla Valle, A., Campioli, A., Chiaroni, D., & Talamo, C. (2021). Construction technologies for sustainable affordable housing within fragile contexts: Proposal of a decision support tool. *Sustainability, 13*(11), 5928. https://doi.org/10.3390/su13115928

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241–252. https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

Bakhaty, Y., Udeaja, C., & Levatti, H. U. (2024). A framework to adopt modern methods of construction in social housing projects. *Sustainability, 16*(18), 7973. https://doi.org/10.3390/su16187973

Bangkim, M. V., Bardhan, R., & Kubota, T. (2020). Factors affecting residential satisfaction in slum rehabilitation housing in Mumbai, India. *Sustainability, 12*(6), 2344. https://doi.org/10.3390/su12062344

Banihashemi, S., Moussavi, S. H., & Ghaedi, K. (2025). 3D printing in construction: Sustainable technology for building industry. *Journal of Building Engineering, 81*, 104762. https://doi.org/10.1016/j.jobe.2025.104762

Basim, M., Moheamen, A., & Others. (2020). Affordable housing and cost-reduction factors for affordable housing. *Muthanna Journal of Engineering and Technology, 8*(1), 32–41.

Bayat, M., Gohari, S. H., & Jalaei, F. (2025). On the effects of additive manufacturing on affordable housing development. *Automation in Construction, 144*, 105815. https://doi.org/10.1016/j.autcon.2025.105815

Bentley, R., Mason, K., Jacobs, D., Blakely, T., Howden-Chapman, P., Li, A., Adamkiewicz, G., & Reeves, A. (2025). Housing as a social determinant of health: A contemporary framework. *The Lancet Public Health, 10*, e855–e864. https://doi.org/10.1016/S2468-2667(25)00142-2

Birch, E. L., & Wachter, S. M. (Eds.). (2025). *Expert Voices 2025: Access to sustainable and affordable housing*. Penn Institute for Urban Research. https://penniur.upenn.edu/publications/expert-voices-2025-access-to-sustainable-and-affordable-housing Penn IUR

Büchler, S., & Lutz, E. (2024). Making housing affordable? The local effects of relaxing land-use regulation. *Journal of Urban Economics*, 103689. https://doi.org/10.1016/j.jue.2024.103689

Buys, L., & Miller, E. (2012). Residential satisfaction in inner urban higher-density Brisbane, Australia: Role of dwelling design, neighbourhood and neighbours. *Journal of Environmental Planning and Management, 55*(3), 319–338. https://doi.org/10.1080/09640568.2011.597592

Çelik, Ö. (2024). Cracking the housing crisis: Financialization, the state, struggles, and rights. *Housing Studies, 39*(6), 1385–1394. https://doi.org/10.1080/02673037.2024.2333569

Chen, L., Zhang, W., Yang, Y., & Yu, J. (2013). Disparities in residential environment and satisfaction among urban residents in Dalian, China. *Habitat International, 40*, 100–108. https://doi.org/10.1016/j.habitatint.2013.03.002

Choi, J. O., Chen, X., & Kim, T. W. (2019). Opportunities and challenges of modular methods in dense urban environments. *International Journal of Construction Management, 19*(2), 93–105. https://doi.org/10.1080/15623599.2017.1382093

Clapham, D., Foye, C., & Christian, J. (2018). The concept of subjective well-being in housing research. *Housing, Theory and Society, 35*(3), 261–280. https://doi.org/10.1080/14036096.2017.1348391

Czischke, D., & van Bortel, G. (2018). An exploration of concepts and policies on affordable housing in England, Italy, Poland and the Netherlands. *Journal of Housing and the Built Environment, 38*, 283–303. https://doi.org/10.1007/s10901-018-9598-1

Dania, S. F., Lim, N. H. A. S., & Mazlan, A. N. (2021). Sustainable affordable housing strategies for solving low-income earners housing challenges in Nigeria. *Studies of Applied Economics, 39*(4). https://doi.org/10.25115/eea.v39i4.4571

Daud, N. M., & Nor, N. M. (2018). Challenges and technologies for affordable housing system. *International Journal of Academic Research in Business and Social Sciences, 8*(6), 1121–1126. https://doi.org/10.6007/IJARBSS/v8-i6/4306

Deshmukh, M., Shanthi Priya, R., & Senthil, R. (2025). Influence of technological and socioeconomic factors on affordable and sustainable housing development. *Urban Sciences, 9*(12), 547. https://doi.org/10.25034/ijcua.2025.v9n1-14

Diamond, R., McQuade, T., & Qian, F. (2019). The effects of rent control expansion on tenants, landlords, and inequality. *American Economic Review, 109*(9), 3365–3394. https://doi.org/10.1257/aer.20181289

Duca, J. V., Muellbauer, J., & Murphy, A. (2011). House Prices and Credit Constraints: Making Sense of the U.S. Experience. The Economic Journal, 121(552), 533–551. DOI: https://doi.org/10.1111/j.1468-0297.2011.02424.x

Firoozi, A. A., & Firoozi, A. A. (2024). 3D printing in civil engineering: Pioneering affordable housing solutions. *Journal of Civil Engineering and Urbanism, 14*(2), 63–75. https://doi.org/10.54203/JCEU.2024.5

Gan, X., Chang, R., Wen, T., & Zuo, J. (2018). Barriers to the transition towards off-site construction in China. *Journal of Cleaner Production, 197*, 8–18. https://doi.org/10.1016/j.jclepro.2018.06.184

Gatt, W. (2025). Housing boom-bust cycles and asymmetric macroprudential policy. *Journal of Money, Credit and Banking, 57*(2–3), 615–643. https://doi.org/10.1111/jmcb.13097

Goudarzi, A., Haghzad, A., Ramezanipour, M., & Bozorgmehr, K. (2022). Analyzing the Factors Affecting the Failure of Land and Housing Policies in District 22 of Tehran. *Environmental Management (Amayesh-e Mohit)*, 15(85), 59–80. https://journals.iau.ir/issue_1136887_1137824_.html

Henilane, I. (2016). Housing concept and analysis of housing classification. *Baltic Journal of Real Estate Economics and Construction Management, 4*(1), 168–179. https://doi.org/10.1515/bjreecm-2016-0013

Herskedal, N. A., Laursen, P. T., Jansen, D. C., & Qu, B. (2015). *Out-of-plane structural response of interlocking compressed earth block walls*. Materials and Structures/Materiaux et Constructions, 48(1-2), 321–336. https://doi.org/10.1617/s11527-013-0186-2

Hosseini, A., & Julie-Saint-Vincent, N. (2023). Assessing Residents' Satisfaction with Housing Quality in Urban Neighborhoods with a Spatial Justice Approach (Case Study: Neighborhoods of District 2, Tehran). *Journal of Urban Environmental Planning and Development*, 3(10), 69–86. https://doi.org/10.30495/juepd.2023.1982743.1167

Hosseini, A., Pourahmad, A., & Ahadi, Z. (2024). Analysis of the Effects of Spatial Factors and Housing Value on the Quality of Life in Densely Populated Urban Areas (Case Study: District 10, Tehran). *Journal of Geographical Survey of Space*, 14(4), 95–116. https://doi.org/10.30488/gps.2024.365825.3590

Huang, Z., & Du, X. (2015). Assessment and determinants of residential satisfaction with public housing in Hangzhou, China. *Habitat International, 47*, 218–230. https://doi.org/10.1016/j.habitatint.2015.01.025

Ibem, E., & Aduwo, E. (2015). A framework for understanding sustainable housing for policy development and practical actions. *Architects Colloquium*, Abuja, Nigeria.

Jain, C. (2020). Innovative housing technologies for a better urban future. *International Journal of Creative Research Thoughts, 8*(12).

Khan, A. A., Amirkhani, M., & Martek, I. (2024). Overcoming deterrents to modular construction in affordable housing. *Sustainability, 16*(17), 7611. https://doi.org/10.3390/su16177611

Li, Z., He, X., Ding, Z., Hossain, M. M., Rifat, M. T. R., Sobuz, M. H. R., & Zhao, Y. (2024). Analysis of influencing factors for housing construction technology in China. *Humanities & Social Sciences Communications, 11*, 432. https://doi.org/10.1057/s41599-024-02937-2

Mahdavinejad, M., Hajian, M., & Doroodgar, A. (2011). Role of LSF technology in economic housing for urban sustainability. *Procedia Engineering, 21*, 114–121. https://doi.org/10.1016/j.proeng.2011.11.1980

Makhloufi, L. (Ed.). (2025). *Housing, heritage and urbanisation in the Middle East and North Africa*. Open Book Publishers. https://doi.org/10.11647/OBP.0460

Mathu, D. N., Wanjala, B. M., Owino, E. O., & Richu, S. W. (2026). Integrating innovative design strategies in advancing sustainable housing in Kenya. *Land Use Policy*, 107840. https://doi.org/10.1016/j.landusepol.2025.107840

Mirkatouli, J., Samadi, R., & Hosseini, A. (2018). Evaluating socio-economic variables on land and housing prices in Mashhad. *Sustainable Cities and Society, 41*, 695–705. https://doi.org/10.1016/j.scs.2018.06.022

Moghayedi, A., & Awuzie, B. (2023). Towards a net-zero carbon economy. *Sustainable Cities and Society, 99*, 104907. https://doi.org/10.1016/j.scs.2023.104907

Moghayedi, A., Awuzie, B., Omotayo, T., Le Jeune, K., & Massyn, M. (2022). Sustainability-oriented innovation adoption in affordable housing. *Sustainable Development, 30*(5), 1117–1134. https://doi.org/10.1002/sd.2306

Moghayedi, A., Awuzie, B., Omotayo, T., Le Jeune, K., Massyn, M., Ekpo, C. O., & Braune, M. (2021). Critical success factors for sustainable innovative housing. *Buildings, 11*(8), 317. https://doi.org/10.3390/buildings11080317

Mohit, M. A., Ibrahim, M., & Rashid, Y. R. (2010). Assessment of residential satisfaction in low-cost housing. *Habitat International, 34*(1), 18–27. https://doi.org/10.1016/j.habitatint.2009.04.002

Moussavi, P., Choi, J. O., & Park, J. (2025). Research trends in affordable modular housing. *Proceedings of the Modular and Offsite Construction Summit (MOC Summit 2025)*, Montreal, Canada. https://doi.org/10.29173/mocs316

Mridha, A. M. M. H., & Moore, G. T. (2011). Quality of life and residential satisfaction in Dhaka. In *Investigating Quality of Urban Life* (pp. 251–272). Springer. https://doi.org/10.1007/978-94-007-1742-8_11

Muazu, I., Bosa, N., & Phiri, C. (2023). Evaluating sustainable housing technologies in Africa. *Scientific African, 21*, e01819. https://doi.org/10.1016/j.sciaf.2023.e01819

Munaro, M. R., Tavares, S. F., & Bragança, L. (2020). Circular economy in the built environment. *Journal of Cleaner Production, 260*, 121134. https://doi.org/10.1016/j.jclepro.2020.121134

Nocera, F., Gagliano, A., & Detommaso, M. (2018). Energy performance of cross-laminated timber buildings. *Mathematical Modelling of Engineering Problems, 5*(3), 175–182. https://doi.org/10.18280/mmep.050307

Omidi, M., Hosseinabadi, H., & Ahmadi, Gh. (2020). Analysis of density patterns in vertical housing development. *Urban Economy and Planning Quarterly, 1*(2), 92–105. https://doi.org/10.22034/UE.2020.09.02.04

Oskoui Aras, A., Teimouri, I., Hosseini, A., Badamchizadeh, P., & Babaei Agdam, F. (2024). Explaining the Mediating Role of Influential Variables in Determining Housing Prices (Case Study: Tabriz Metropolis). *Urban Economics and Planning*, 5(3), 58-78. https://doi.org/10.22034/uep.2024.471664.1523

Pan, W., & Sidwell, R. (2011). Cost barriers to offsite construction in the UK. *Construction Management and Economics, 29*(11), 1081–1099. https://doi.org/10.1080/01446193.2011.637938

Pannu, S., & Hooda, J. (2025). Integration of BIM in modular construction. *International Journal of Research in Civil Engineering and Technology, 6*(1), 101–106. https://doi.org/10.22271/27078264.2025.v6.i1b.85

Paraschiv, S., Paraschiv, L. S., & Serban, A. (2021). Increasing the energy efficiency of a building by thermal insulation to reduce the thermal load of the micro-combined cooling, heating and power system. *Energy Reports, 7*, 286–298. DOI: https://doi.org/10.1016/j.egyr.2021.07.122

Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment. *Journal of Cleaner Production, 143*, 710–718. https://doi.org/10.1016/j.jclepro.2016.12.055

Purnomo, D., & Harmiyati. (2023). Affordable housing in developing countries. *Journal of Applied Engineering and Technological Science, 5*(1), 291–304. https://doi.org/10.37385/jaets.v5i1.3116

Rajasekaran, P., Reed, D., & Howard, G. (2019). Rent control policies and housing markets. *Housing Policy Debate, 29*(4), 635–653. https://doi.org/10.1080/02673037.2019.1600169

Roustaei, E., & Zolfagharifar, S. Y. (2022). Evaluation of Modern Building Technologies in Terms of Efficiency in Iran and Selection of the Best Method Based on Fuzzy Analytic Hierarchy Process (FAHP). *Jaddeh (Road)*, 30(113), 167-182. https://doi.org/10.22034/road.2022.325663.2025

Sabah, N., & Parvizi, R. (2023). Examining the role of economic-social factors in the formation of low-cost housing architecture in the post-Islamic Revolution era of Iran. *Architectural Technologies, 2*(3), 65–82. https://civilica.com/doc/1617783

Saleem, S., & Alchalabi, O. (2025). Factors impacting housing satisfaction. *International Journal of Sustainable Development and Planning, 20*(1), 119–131. https://doi.org/10.18280/ijsdp.200113

Sengupta, N. (2008). *Use of cost-effective construction technologies in India to mitigate climate change*. Current Science, 94(1), 38–43. Retrieved from https://www.osti.gov/etdeweb/biblio/21073906

Silva, L. P. P., Najjar, M. K., da Costa, B. B. F., Amario, M., Vasco, D. A., & Haddad, A. N. (2024). Sustainable affordable housing. *Sustainability, 16*(10), 4187. https://doi.org/10.3390/su16104187

Soleimani, K., & Matini, M. R. (2022). Reusing earthquake rubble in temporary housing. *Journal of Architectural Engineering, 28*(2), 04022015. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000542

Stacy, C., Hodge, T. R., Komarek, T. M., Davis, C., Stern, A., Noble, O., & Morales-Burnett, J. (2025). Rent control reforms and rental housing supply. *Journal of Housing Economics, 68*, 102063. https://doi.org/10.1016/j.jhe.2025.102063

Steinhardt, D. A., Manley, K., & Miller, W. F. (2020). Resilience and sustainability in industrialized construction. *Engineering, Construction and Architectural Management, 27*(3), 569–586. https://doi.org/10.1108/ECAM-08-2018-0349

Stone, M. E. (2006). What is housing affordability? *Housing Policy Debate, 17*(1), 151–184. https://doi.org/10.1080/10511482.2006.9521564

Stone, M. E., Burke, T., Ralston, L., & Hulse, K. (2015). A social construction of housing affordability. *Housing Studies, 30*(7), 1–22. https://doi.org/10.1080/02673037.2015.1013090

Tam, V. W. Y., Tam, C. M., Zeng, S. X., & Ng, C. Y. (2011). Adoption of prefabrication in construction. *Building and Environment, 42*(10), 3642–3654. https://doi.org/10.1016/j.buildenv.2006.10.003

Türkoğlu, H., Terzi, F., Salıhoğlu, T., Bölen, F., & Okumuş, G. (2019). Residential satisfaction in Istanbul. *International Journal of Architectural Research, 13*(1), 112–132. https://doi.org/10.1108/ARCH-12-2018-0030

Walisinghe, P. N. C., & Wickramaarachchi, N. C. (2021). Residential satisfaction in public and private housing. *Sri Lankan Journal of Real Estate, 15*, 50–72.

Windapo, A., Omopariola, E. D., Olugboyega, O., & Moghayedi, A. (2021). Building technologies in low-income housing. *Sustainable Cities and Society, 65*, 102606. https://doi.org/10.1016/j.scs.2020.102606

Wynn, M. G., Hosseini, Z., & Parpanchi, S. M. (2023). Housing development and the smart city. *Journal of Infrastructure, Policy and Development, 7*(2), 2070. https://doi.org/10.24294/jipd.v7i2.2070