Architectural Dimensions and Beyond

www.adb.reapress.com

Arch. Dim. Bey. Vol. 3, No. 2 (2026) 111–122.

Paper Type: Original Article

Mobile and Flexible Architecture: A Sustainable Approach to the Design of Future Residential Apartments

Mostafa Bozorgi[1], **Kimia Nikkhah**[1,*]

[1] Department of Architecture, Hamedan Branch, Islamic Azad University, Hamedan, Iran; bozorgi.mb@gmail.com; kimianikkhah2001@gmail.com.

Citation:

Received:05 November 2025 *Revised: 17 January 2026* *Accepted: 03 March 2025*	Bozorgi, M., & Nikkhah, K. (2026). Mobile and flexible architecture: A sustainable approach to the design of future residential apartments. *Architectural dimensions and beyond, 3*(2), 111-122.

Abstract

Future housing design, with an emphasis on sustainability, flexibility, and mobility, requires a new architectural approach. Climate change, population mobility, and rapid technological developments have rendered traditional housing models increasingly inefficient. As a result, future architecture must be capable of responding effectively to dynamic environmental and social conditions. This research adopts an analytical–comparative methodology, drawing on theoretical studies and a review of international case studies, to extract key principles for the design of sustainable and movable apartment units. The findings indicate that integrating smart technologies, lightweight structural systems, modular housing units, and self-sufficient energy solutions can establish a viable framework for future housing. Such apartments not only achieve environmental sustainability but also provide high levels of flexibility and mobility, enabling adaptation to changing user needs and spatial conditions.

Keywords: Adaptable architecture, Mobile architecture, Future apartments, Sustainable housing, Modular structure, Flexible design, Mobile dwelling.

1 | Introduction

In recent decades, the concept of "home" and "dwelling" has undergone a fundamental transformation. Climate change, population displacement, technological advancements, and energy resource crises have confronted architects with a critical question: What characteristics must future housing possess in order to remain resilient in the face of environmental and social instability? In response to these challenges, future apartment design has emerged as a platform for integrating technological innovation with environmental sustainability [1].

Corresponding Author: kimianikkhah2001@gmail.com

https://doi.org/10.48314/adb.v3i2.60

One of the prominent contemporary approaches in this field is mobile and flexible architecture. Unlike traditional concepts of fixed housing, this approach emphasizes mobility, spatial reconfiguration, and adaptability. Within this framework, buildings are no longer perceived as static objects but as dynamic systems capable of responding to changes in location, climate, and user requirements.

Moreover, the depletion of natural resources and the urgent need to reduce energy consumption have elevated sustainability from a design preference to an unavoidable necessity. In mobile architecture, future housing can achieve sustainability through the use of lightweight and modular materials, recyclable components, and on-site energy generation systems. Consequently, sustainability in this approach extends beyond energy efficiency to encompass the entire life cycle of the building, including reduced construction waste, prolonged functional lifespan, and enhanced spatial efficiency [2].

2 | Problem Statement

Rapid urban transformation, population growth, technological advancements, and climate change have created new challenges in contemporary housing design. Under these conditions, traditional fixed housing models are no longer capable of responding effectively to present and future needs. Apartments designed to remain static over decades lack the flexibility required to adapt to environmental changes, evolving social and economic demands, or unexpected events such as natural disasters [3].

At the same time, the global shift toward sustainable living, characterized by reduced energy consumption, the use of recyclable materials, and environmentally responsive design, has intensified the need to reconsider the concept of housing. Future dwellings must not only minimize environmental impact but also be adaptable, reconfigurable, and, when necessary, mobile. In other words, housing should be capable of adjusting to changing conditions and relocating in response to new spatial, environmental, or social requirements [4].

Despite significant international advancements in modular and mobile architectural systems, comprehensive research integrating sustainability, flexibility, and mobility in residential design remains limited in Iran. The absence of a localized theoretical and practical framework for mobile and adaptable apartment design represents a critical research gap [5].

Therefore, the central research question of this study is as follows:

How can the principles of mobile architecture and modular structural systems be employed to develop a sustainable, flexible, and mobile apartment model for future housing that is environmentally responsible, functionally adaptable, and economically viable?

3 | Significance and Necessity of the Research

In today's rapidly changing world, cities are facing unprecedented challenges, including accelerated climate change, land scarcity in dense urban areas, rising construction costs, and the instability of energy resources. These conditions have intensified the need to rethink conventional housing models and to explore alternative approaches to future living environments.

At the same time, technological advancements and the emergence of lightweight, intelligent, and recyclable materials have created new opportunities for innovative architectural solutions. These developments enable the design of responsive, mobile, and adaptable buildings capable of meeting the demands of contemporary lifestyles [6].

Within this context, mobile architecture represents an effective response to emerging challenges in future housing design. By incorporating modular structural systems with the potential for relocation, expansion, and reconfiguration, mobile architecture can simultaneously address environmental, functional, and economic requirements. This approach offers a viable alternative to traditional, static, and resource-intensive construction methods, extending the concept of sustainability beyond energy efficiency to include the entire building life cycle.

The significance of this research lies in its effort to establish a localized and applicable conceptual framework for future apartment design in Iran. By considering regional climatic conditions as well as social and economic contexts, this study aims to bridge the existing research gap and to contribute to the development of sustainable, adaptable, and intelligent housing solutions suitable for the country's future needs.

4 | Research Objectives

4.1 | General Objective

To develop a conceptual and practical framework for the design of future apartment housing based on a sustainable, mobile, and flexible architectural approach, within the context of northern Iran.

4.2 | Specific Objectives

I. To identify key parameters and criteria influencing the design of mobile and transportable architecture.

II. To examine the relationship between modular structural systems and functional flexibility in future housing.

III. To conduct a comparative analysis of successful domestic and international examples of mobile and sustainable architecture.

IV. To investigate the role of emerging technologies, such as lightweight materials, smart systems, and self-sufficient energy solutions, in the realization of mobile architecture.

V. To propose design principles and strategies for the development of future apartment housing in Iran, emphasizing sustainability and adaptability.

5 | Research Methodology

This study adopts an analytical–comparative research approach based on library research, with the objective of extracting design principles for future apartment housing. The methodology involves reviewing international case studies and analyzing architectural diagrams related to mobile, flexible, and sustainable housing.

The research process was conducted in the following stages:

5.1 | Data Collection

A comprehensive review of literature related to mobile architecture, future apartments, and small-scale sustainable housing was carried out. In addition, international case studies were examined to analyze spatial organization, flexibility, and adaptability through diagrammatic analysis.

5.2 | Data Analysis and Spatial Programming

Spatial requirements of residential units ranging from 30 to 40 square meters were identified, with an emphasis on internal flexibility and spatial mobility. Key spaces such as the kitchen, bedroom, living area, and TV room were analyzed to determine how mobile and adaptable design strategies could be implemented within compact housing units.

5.3 | Comparative Analysis and Extraction of Design Principles

Findings from international case studies were compared and synthesized to extract recurring design patterns and principles. This process led to the development of a conceptual framework for sustainable, flexible, and mobile apartment housing suitable for future living environments.

This methodology enables a systematic evaluation of both theoretical concepts and practical spatial and functional requirements of small residential units characterized by adaptability and mobility.

6 | Thematic Studies

6.1 | Adaptable Architecture

Adaptable architecture refers to an architectural approach in which a building is capable of modifying its physical, spatial, or functional characteristics over time in response to environmental, social, economic, and technological changes. In this approach, a building is viewed as a dynamic system that can continuously respond to the evolving needs of its users. Strategies such as movable façades, transformable partitions, smart environmental control systems, and multi-functional spaces are commonly employed to achieve adaptability. In the context of this study, adaptable architecture serves as a fundamental theoretical basis for the design of future residential apartments, as it enables long-term responsiveness to changing lifestyles and housing demands [7].

6.2 | Mobile Architecture

Mobile architecture refers to buildings or building components that possess the ability to be relocated, expanded, folded, transformed, or reconfigured. By utilizing advanced technologies, lightweight structural systems, and modular construction methods, mobile architecture provides opportunities for spatial mobility and flexibility. This approach responds to situations where residential, functional, or infrastructural spaces require physical adaptability and relocation. In this research, mobile architecture is considered one of the primary components of future apartment design, providing a framework for greater flexibility and reducing dependence on permanent and fixed locations [8].

6.3 | Future Residential Apartments

Future residential apartments represent a new generation of housing designed around sustainability, smart technologies, spatial flexibility, and mobility. Unlike conventional housing models, these apartments are capable of adapting to demographic shifts, environmental challenges, technological advancements, and changing user requirements. Within this study, future residential apartments are considered the ultimate design objective, emerging from the integration of mobile architecture, flexible design principles, and sustainable strategies [9].

6.4 | Sustainable Housing

Sustainable housing refers to residential environments that satisfy present-day human needs while minimizing environmental impacts and preserving resources for future generations. Key characteristics include energy efficiency, the use of renewable energy sources, resource conservation, environmentally responsible materials, and the enhancement of occupant well-being. In the context of this research, sustainability represents the overarching goal of the design process, while flexibility and mobility are explored as strategies for achieving long-term environmental, economic, and social sustainability [10].

6.5 | Modular Structure

A modular structure is a construction system composed of standardized and independent units that can be assembled, disassembled, expanded, relocated, or reconfigured as needed. Modular systems are widely recognized for their efficiency, reduced construction waste, rapid assembly, and adaptability to changing requirements. In this research, modular structures are considered the technical foundation for implementing both mobile and flexible architectural concepts, enabling the development of adaptable and transportable residential units [11].

6.6 | Flexible Design

Flexible design is an architectural approach that allows spaces and building components to change their functions, configurations, and spatial arrangements over time. Through movable partitions, multi-functional

spaces, and adaptable layouts, buildings can respond effectively to evolving user needs and lifestyle changes. Flexible design enhances the longevity and usability of residential environments while reducing the need for extensive renovations or reconstruction. In this study, flexible design is identified as a core principle for creating future residential apartments capable of accommodating diverse and changing living conditions [12].

6.7 | Mobile Dwelling

A mobile dwelling refers to a residential unit that can be transported or relocated without losing its essential functional and spatial qualities. Such dwellings often incorporate lightweight construction methods, modular systems, and self-sufficient infrastructure, including independent energy and water systems. Mobile dwellings are increasingly viewed as a promising solution for addressing population mobility, environmental crises, temporary housing demands, and evolving patterns of habitation. Within the framework of this research, mobile dwellings represent a practical application of mobile and flexible architecture in future housing design [13].

6.8 | Relationship of the Keywords to the Research Title

The keywords of this study form an interconnected conceptual framework. Mobile architecture and flexible design constitute the primary design approaches that enable buildings to respond to changing environmental conditions and user requirements. Modular structure provides the technical and constructional foundation for implementing these approaches, while mobile dwelling represents their practical application at the residential scale. The integration of these concepts leads to the development of future residential apartments, which are capable of addressing challenges such as climate change, urbanization, resource scarcity, and evolving lifestyles. Ultimately, sustainable housing serves as the overarching objective that unifies all these concepts. Therefore, the title "mobile and flexible architecture: A sustainable approach to the design of future residential apartments" reflects the relationship between mobility, flexibility, and sustainability as the three fundamental pillars of future housing design [14], [15].

The explanation of these keywords serves several important purposes within the article:

I. Establishing the conceptual framework of the research.

These concepts constitute the core pillars of the research topic. By defining them, the study clarifies its perspective on future residential apartments and precisely specifies the meaning of each term within the context of the research.

II. Creating a common understanding for readers.

Terms such as adaptable architecture, mobile architecture, and flexible design may be interpreted differently across various studies and disciplines. Providing clear definitions ensures that readers understand these concepts consistently and in accordance with the theoretical approach adopted in this research.

III. Explaining the relationships among research variables.

In this study, these concepts are not independent; rather, they form an interconnected conceptual chain. For example:

I. Adaptable architecture and flexible design represent the primary design approaches.

II. Modular Structure serves as the technical and operational framework through which these approaches are implemented.

III. Mobile architecture and mobile dwelling are the practical outcomes of applying these approaches at the building and residential-unit scales.

IV. Sustainable housing represents the ultimate objective of the design process.

V. Future residential apartments are the final product resulting from the integration of all these concepts.

IV. Providing the basis for the conceptual model of the research.

Following the introduction of these concepts, it becomes possible to demonstrate how the integration of sustainability, flexibility, modularity, and mobility forms the conceptual foundation for the design of future residential apartments. This framework helps explain the relationships among the key variables and supports the development of a comprehensive model for future housing design.

7 | Literature

In this section, the relevant international and domestic studies have been analyzed and are presented below:

Table 1. International research background.

No.	Research Title	Year	Publication Place	Summary/ Abstract	Research Problem	Research Method	Summary/ Conclusion
1	Evaluation of low-impact modular housing using energy optimization and life cycle analysis	2019	Energy, ecology and environment, Vol. 4	Analyzes Life Cycle Assessment(LCA) and energy optimization for container-based modular housing, comparing the Canadian Code (CC) with an improved model (IC)	How to create low-impact modular housing that is energy-efficient and cost-effective throughout its life cycle?	Quantitative method: LCA and Life Cycle Cost (LCC) analysis comparing two scenarios for a 60-year lifespan	Container-based modular design with passive optimization reduces energy/Global Warming Potential (GWP) by 77%, though logistics costs must be managed.
2	A Flexible modular housing system considering user preference, focused on single-family houses for the elderly	2018	International journal of engineering and technology	Designs a flexible modular housing system based on user preferences, specifically for the elderly	How can a flexible modular system meet the diverse needs of the elderly during the aging process?	Analytical method: Literature review and extraction of design elements based on the aging process	Defined flexible elements for elderly living; results are applicable to other age groups
3	Rethinking housing design and architecture for flexible and affordable living	2025	AGATHÓN international journal of architecture	Presents a new approach for social/collective housing emphasizing flexibility, modularity, and affordability	How to shift housing design from fixed/static to flexible, adaptive, and affordable?	Combined method: Case studies of multiple projects and conceptual/behavioral analysis	Collective housing must be an open system allowing for upgrades and reconfiguration; regulations must also permit flexibility.
4	A review of flexibility and adaptability in housing design	2017	ResearchGate	Systematic review of flexibility/adaptability concepts in housing with a matrix of social, economic, and environmental definitions	What is flexibility in housing, and what are the limitations of current research?	Systematic review: Literature review, classification of definitions, and comparison of dimensions	Flexibility is defined as the capacity for change and adaptation; future research needs to cover social and economic dimensions.
5	Research on modularization and sustainable design of temporary housing	2018	Art and design review, vol. 6	Studies temporary modular housing post-disasters, focusing on recycling, pre-fabrication, and reconfigurability	How to design temporary housing that is fast, recyclable, and environmentally compatible?	Analytical: Literature review and analysis of past modular temporary housing projects	Modular design allows for rapid execution and material recycling, but quality of life and service facilities must be prioritized.

Table 1. Continued.

No.	Research Title	Year	Publication Place	Summary/ Abstract	Research Problem	Research Method	Summary/ Conclusion
5	Research on modularization and sustainable design of temporary housing	2018	Art and design review, vol. 6	Studies temporary modular housing post-disasters, focusing on recycling, pre-fabrication, and reconfigurability	How to design temporary housing that is fast, recyclable, and environmentally compatible?	Analytical: Literature review and analysis of past modular temporary housing projects	Modular design allows for rapid execution and material recycling, but quality of life and service facilities must be prioritized.
6	Analysis of costs and benefits of panelized and modular prefabricated homes	2016	Procedia Engineering, Vol. 145	Compares the advantages of panelized vs. modular pre-fabrication methods through cost analysis	Which pre-fabrication method (panelized or modular) is superior in terms of cost and benefits?	Qualitative/quantitative analysis: Comparing the cost per square meter between two practical projects	The modular method was more cost-effective (7-11% savings); contextual and qualitative factors also influence the choice.
7	A study of literature on Modular Integrated Construction (MIC)	2020	Sustainable cities and society	Systematic review identifying trends, challenges, and research gaps in MIC	What barriers limit MIC, and what areas remain open for future research?	Systematic literature review: Identification, analysis, and classification of industrial reports/articles	MIC has high potential for speed, quality, and sustainability, but construction laws and supply chains are major hurdles
8	Modular construction in the digital age: A systematic review on smart and sustainable innovations	2024	Buildings, Vol. 15(5)	Systematic review of modular construction combined with digital and smart technologies	How can digital technologies be integrated with modular construction to enhance sustainability and efficiency?	Systematic literature review: Collection of scientific articles and industrial reports	Combining modularity with digital tech increases quality and sustainability; specific scenarios like student or elderly housing need more study.
9	Motivations and market solutions for flexible housing in Finland	2023	Journal of housing and the built environment	Examines market motivation, challenges, and solutions for flexible housing in Finland	Why is the market adoption of flexible housing limited, and what are the drivers/constraints ?	Mixed methods: Interviews with stakeholders, review of patents, and market solution analysis	Flexibility is vital, but requires cost reduction and increased user awareness; service-oriented systems are proposed.
10	Prefabricated solutions for housing: Modular architecture and flexible living spaces	2025	Buildings, Vol. 15(6)	Proposes a modular concrete housing prototype with three layout hypotheses for flexible living	How to design affordable, flexible, and sustainable modular collective housing?	Design-based: Prototype design, literature analysis, and seismic resistance testing	Prefabricated modular housing offers flexibility and sustainability; seismic resistance is achievable, but initial costs are challenging.

Table 2. Iranian research background.

No.	Research Title	Year	Publication Place	Summary/ Abstract	Research Problem	Research Method	Summary/ Conclusion
1	Active bending and flexible structures: A solution for design in mobile architecture	2022	Journal of Iranian architecture and urbanism	Introduces active bending systems in lightweight structures for mobile architecture	How can active bending structures be utilized in mobile architecture design?	Descriptive-Analytical with case studies	Active bending leads to weight reduction and material savings
2	Analysis of flexible housing capabilities in urban planning	2020	Soffeh Journal, Shahid Beheshti Univ	Analyzes concepts of flexibility in Iranian urban housing design	How to improve spatial flexibility in urban apartment design?	Analytical-comparative	Spatial and structural flexibility increases building lifespan
3	Correlation of modular architecture with interior residential space flexibility	2021	Contemporary architecture research	Examines the relationship between modular design and reconfiguring interior spaces	What is the relationship between modular design and interior flexibility?	Analytical-case study	Modular design with movable components enhances functional flexibility
4	Modular approach and pre-fabrication in flexible housing	2019	Housing and rural environment	Investigates the potential of pre-fabrication in achieving flexible housing	How to use prefabricated systems to create adaptable housing?	Descriptive-applied	Lightweight prefabricated modules increase construction speed
5	Parametric design of a kinetic façade to improve natural lighting efficiency	2018	Journal of Art, Architecture, and Urbanism	Research on kinetic skins using parametric algorithms for light control	How can parametric kinetic façades reduce energy consumption?	Analytical-simulation	Parametric kinetic skins can achieve up to 30% savings in energy
4	Modular approach and pre-fabrication in flexible housing	2019	Housing and rural environment	Investigates the potential of pre-fabrication in achieving flexible housing	How to use prefabricated systems to create adaptable housing?	Descriptive-applied	Lightweight prefabricated modules increase construction speed
5	Parametric design of a kinetic façade to improve natural lighting efficiency	2018	Journal of Art, Architecture, and Urbanism	Research on kinetic skins using parametric algorithms for light control	How can parametric kinetic façades reduce energy consumption?	Analytical-simulation	Parametric kinetic skins can achieve up to 30% savings in energy
6	Mobile architecture technology: review of capabilities and challenges	2022	Civilica	Introduces new technologies in mobile architecture and implementation challenges	What are the barriers to developing mobile architecture in Iran?	Analytical review.	Lack of technical infrastructure is the main barrier in Iran.
7	Analysis of flexibility in traditional Iranian housing and adaptation to today's needs	2017	Hoviat-e-Shahr	Examines flexibility in the structure of traditional Iranian houses	Which elements of traditional houses can serve as a model for flexible design?	Comparative-Analytical	Traditional courtyard-centric houses are valuable models for flexible housing.
8	Evaluation of effective factors in designing small-scale flexible houses	2021	Tarbiat Modares Univ	Identifies factors for designing highly adaptable small-scale houses	How to integrate flexible design in small-scale housing?	Survey-Analytical	Movable furniture systems play the most significant role in flexibility
9	A solution to reduce the functional problems of kinetic skins in buildings	2019	Fine arts journal, Univ. of Tehran	Focuses on the technical problems of kinetic skins in Iran's climate	How to increase the durability of kinetic skins in Iran's climate?	Descriptive-Experimental	Multi-layered design improves the performance of kinetic façades
10	Role of kinetic façades in reducing building energy consumption	2020	Civilica	Research on the relationship between skin mobility and energy consumption	How can kinetic skins help reduce energy consumption in hot climates?	Energy Simulation-Analytical	Kinetic façades can create up to 25% savings in cooling energy

A review of both domestic and international studies indicates that contemporary architectural research has increasingly shifted toward the development of sustainable, flexible, and environmentally responsive approaches. At the national level, the primary focus of research has been on optimizing environmental performance through the application of movable façades, smart building envelopes, flexible structures, and nature-inspired design strategies. These studies demonstrate that the integration of advanced technologies, intelligent control algorithms, and modular systems can play a significant role in reducing energy consumption, improving thermal comfort, lowering construction costs, and enhancing overall building efficiency. Furthermore, several studies have highlighted the capacity of traditional Iranian architecture to provide spatial flexibility and emphasized the importance of incorporating these principles into contemporary design practices.

At the international level, research has focused on more advanced dimensions of adaptive architecture, extending beyond energy efficiency and environmental performance to encompass cultural, social, and technological aspects. The findings suggest that flexible and kinetic architecture, supported by intelligent systems, innovative materials, and digital technologies, enables the creation of dynamic, reconfigurable, and user-responsive environments. Moreover, responsive and smart buildings serve as interactive platforms between users and the built environment, contributing to enhanced spatial experience and improved functional performance.

Overall, the existing body of literature underscores the simultaneous importance of three key components: environmental sustainability, functional flexibility, and technological intelligence. Nevertheless, there remains a need for the development of integrated and localized frameworks that effectively combine these three approaches in housing and contemporary architectural design, particularly within specific regional contexts.

8 | Conclusion

The findings of this research demonstrate that future apartment design must move beyond traditional housing models and adopt a dynamic, responsive, and user-centered approach. Climate change, population mobility, limited resources, and evolving lifestyles have transformed housing from a static physical entity into an adaptable system. Within this context, the integration of environmental sustainability with spatial flexibility and mobility emerges as one of the most effective strategies for future residential architecture.

Site analysis and diagrammatic studies conducted in the city indicate that the regional climatic and environmental conditions provide a suitable foundation for implementing flexible housing models. The results reveal that even within compact residential units ranging from 30 to 40 square meters, it is possible to design efficient, adaptable, and multi-functional spaces. In such units, spaces such as the kitchen, bedroom, and living area are no longer fixed elements but are defined as transformable components capable of changing function in response to user needs.

The review of international case studies and theoretical frameworks related to mobile architecture highlights the critical role of lightweight modular systems, recyclable materials, and self-sufficient energy technologies in achieving sustainable and mobile housing. These strategies not only reduce energy consumption and environmental impact but also extend the functional lifespan of buildings and decrease construction and maintenance costs.

In this research, sustainability is approached as a multidimensional concept encompassing environmental, economic, social, and functional aspects. The findings emphasize that future architecture should not be limited to material sustainability but must also prioritize adaptability, spatial reconfiguration, and mobility as fundamental design principles. The ability to relocate units, modify internal layouts, and adapt to changing environmental and social conditions transforms housing into a living, responsive system aligned with long-term user needs.

Ultimately, this study proposes a conceptual framework for future apartment design that integrates mobile architecture principles with sustainability and flexibility. This framework can serve as a foundational reference

for architects and designers addressing future housing challenges in Iran. However, a key limitation of this research is the lack of on-site field studies. Future research is recommended to incorporate empirical evaluations, environmental simulations, and user behavior analysis to further assess and optimize the performance of mobile housing models.

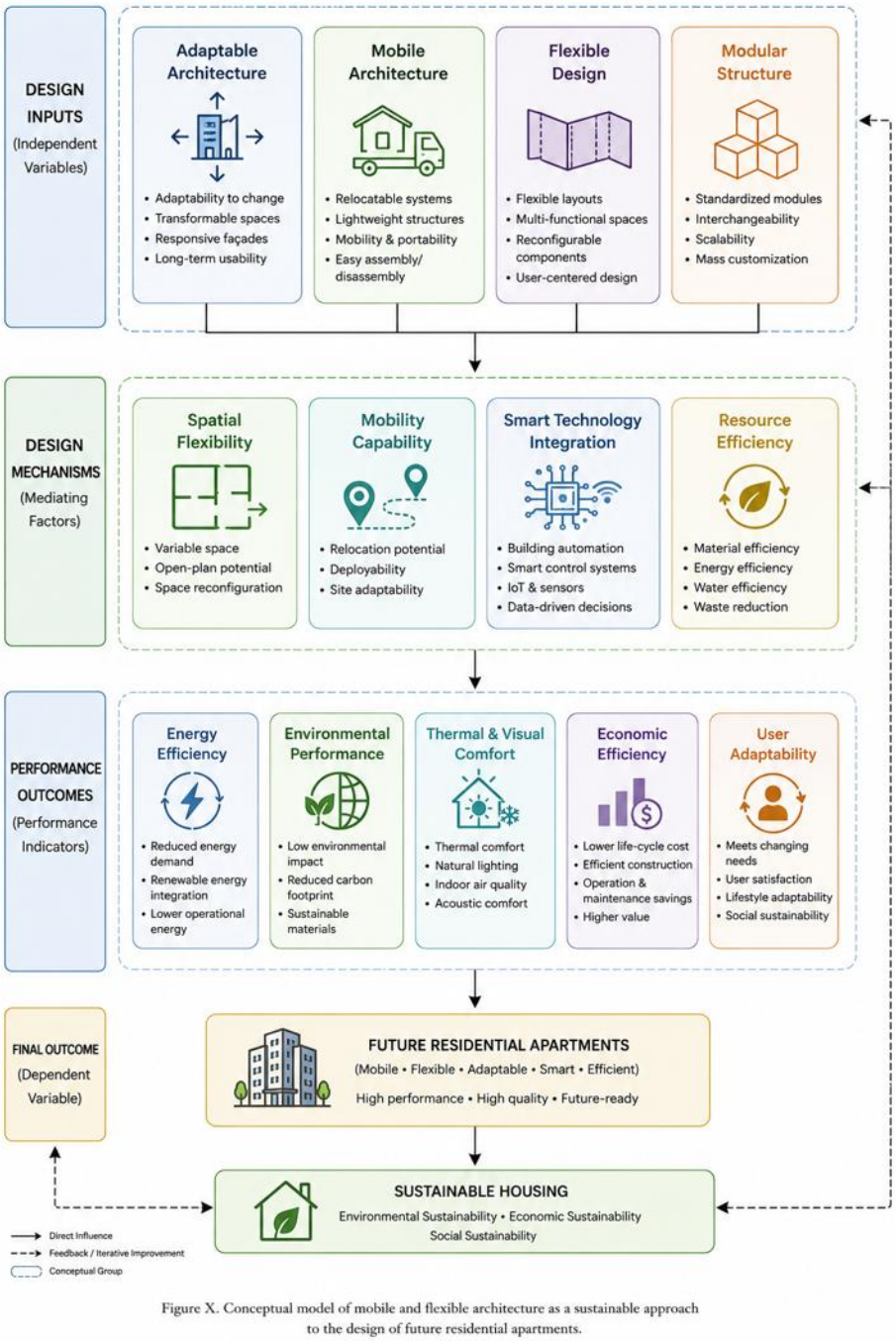

Fig. 1. Conceptual model of mobile and flexible architecture for sustainable future residential apartment design.

This diagram illustrates the integrated conceptual framework of the study, showing the relationships between design inputs (adaptable architecture, mobile architecture, flexible design, and modular structure), mediating design mechanisms (spatial flexibility, mobility capability, smart technology integration, and resource efficiency), and performance outcomes (energy efficiency, environmental performance, thermal and visual comfort, economic efficiency, and user adaptability). These interconnected layers ultimately lead to the

development of future residential apartments as the final outcome, contributing to the realization of sustainable housing.

Authors' Contributions

All aspects of the research and manuscript preparation were carried out by the author. The author has read and approved the final version of the manuscript.

Data Availability

All data supporting the reported findings in this research paper are provided within the manuscript.

Funding

Not applicable.

Conflict of Interest

The author declares that they do not have any conflict of interest.

Consent for Publication

The author confirms consent for the publication of this work

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants performed by the author.

References

[1] Hyderabadi, H., Haqparast, F., & Ahmadnejad, F. (2022). Active and flexible bending structures: A design solution for mobile architecture. *Green architecture quarterly*, *8*(1), 43-54. (**In Persian**). https://www.ensani.ir/file/download/article/1663567221-10121-1401-1-43.pdf

[2] Seydian, S. A., & Razani, F. (2021). Explaining the influential components of flexibility on the dynamics of interior space (case study: Movable wall in a residential garden tower). *Architectural quarterly*, *3*(17), 11. (**In Persian**). https://www.magiran.com/paper/2224166

[3] Einifar, A. (2003). A model for analyzing flexibility in traditional Iranian housing. *Fine arts magazine,1* (13), 64-77. (**In Persian**). https://www.sid.ir/paper/419235/fa

[4] Matini, M. (2015). Using nature's patterns to design flexible, flexible structures in architecture. *Fine arts - architecture and urban planning magazine*, *20*(1), 67-80. (**In Persian**). https://doi.org/10.22059/jfaup.2015.56372

[5] Azimi, M. (2025). Smart moving facades: A dynamic solution for energy optimization and daylight management in sustainable architecture. *The 27th national conference on urban planning, architecture, civil engineering and environment*. Shirvan, Iran. Civilica. (**In Persian**). https://civilica.com/doc/2265801

[6] Amirshahi, H., & Salami, Z. (2023). Studying the parameters of flexible houses with a sustainable and smart architecture approach. *The 5th international congress of engineering, technology and applied sciences*. Auckland, New Zealand. Civilica. (**In Persian**). https://civilica.com/doc/1982065

[7] Yar Mahmodi, T., & Nasr, T. (2023). Using a variable pattern to design the building shell to control daylight (case study: Monkey flower). *Quarterly journal of architecture and sustainable environment*, *1*(1), 73-92. (**In Persian**). https://ecc.isc.ac/showJournal/40923/293815/3719330

[8] Zandiyeh, M., Eghbali, S. R., & Hessari, P. (2011). Flexible housing design methods. *Naqsh-e jahan magazine-theoretical studies and new technologies of architecture and urban planning*, *1*(1), 95-106. (**In Persian**). https://dor.isc.ac/dor/20.1001.1.23224991.1390.1.1.4.7

[9] Taghizadeh, K., Matini, M. R., & Kakoei, E. (1398). Flexible structures: A solution to reduce the performance problems of moving shells. *Fine arts - architecture and urban planning magazine*, *24*(2), 39-48. (**In Persian**). https://doi.org/10.22059/jfaup.2019.258891.672029

[10] Barozzi, M., Lienhard, J., Zanelli, A., & Monticelli, C. (2016). The sustainability of adaptive envelopes: Developments of kinetic architecture. *Procedia engineering*, *155*, 275–284. https://doi.org/10.1016/j.proeng.2016.08.029

[11] Jagannath, S., Gatersleben, B., & Ratcliffe, E. (2024). Flexibility of the home and residents' psychological wellbeing. *Journal of environmental psychology*, *96*, 102333. https://doi.org/10.1016/j.jenvp.2024.102333

[12] Lee, J. H., Ostwald, M. J., & Kim, M. J. (2021). Characterizing smart environments as interactive and collective platforms: A review of the key behaviors of responsive architecture. *Sensors*, *21*(10), 3417. https://doi.org/10.3390/s21103417

[13] Lyu, H., Herring, D., Chen, H., Zhou, S., Zhang, J., & Wang, L. (2025). A data-driven multi-objective optimisation framework for energy efficiency and thermal comfort in flexible building spaces. *Energy and buildings, 346*, 116100. https://doi.org/10.1016/j.enbuild.2025.116100

[14] Magdziak, M. (2019). Flexibility and adaptability of the living space to the changing needs of residents. *IOP conference series: Materials science and engineering* (Vol. 471, p. 72011). IOP Publishing. https://doi.org/10.1088/1757-899X/471/7/072011

[15] Parra Martinez, J., Gutiérrez Mozo, M. E., & Gilsanz Diaz, A. (2021). Inclusive higher education and the built environment. A research and teaching agenda for gender mainstreaming in architecture studies. *Sustainability*, *13*(5), 2565. https://doi.org/10.3390/su13052565