ECOLOGICAL SUSTAINABILITY AND ENHANCEMENT OF RESIDENT WELL-BEING IN THE MODERNIZATION OF HIGH-RISE RESIDENTIAL BUILDINGS IN THE URBAN ENVIRONMENT

Madumarova Marg‘ubaxon Maxkamboy qizi
Assistant Lecturer Andijan State Technical Institute Andijan, Uzbekistan
margubamahkamboyevna@gmail.com
ORCID: 0009-0005-8320-3931

Abstract: The modernization of high-rise residential buildings has become one of the decisive urban policy challenges of the twenty-first century because cities are under simultaneous pressure from climate change, demographic growth, rising housing demand, infrastructure aging, and increasing expectations regarding public health and quality of life. In this context, the question is no longer whether existing vertical housing stock should be upgraded, but how such modernization can be organized in ways that reduce environmental burdens while materially improving the everyday lives of residents. This article examines the modernization of high-rise residential buildings through a dual analytical lens: ecological sustainability and resident well-being. Using an integrative review design grounded in recent international reports, health guidelines, and peer-reviewed studies, the paper synthesizes evidence on the environmental, social, and health dimensions of retrofit and urban renewal. The analysis demonstrates that environmentally oriented modernization cannot be reduced to façade insulation or energy savings alone. Effective modernization requires a systems approach that combines lower operational energy demand, reduced whole-life carbon, water efficiency, resilient landscape design, passive thermal regulation, safe and healthy indoor environments, accessible circulation, functional common spaces, and stronger neighborhood-level social infrastructure. The review also shows that high-rise living is not inherently detrimental to mental or social well-being; rather, outcomes depend on the quality of planning, management, architectural design, maintenance, accessibility, greenery, safety, and opportunities for social interaction. A narrow technocratic retrofit can reduce energy use yet worsen indoor air quality, summer overheating, or social exclusion if ventilation, shading, and everyday human use are ignored. By contrast, a human-centered and climate-sensitive modernization strategy can generate co-benefits in health, affordability, comfort, resilience, and community cohesion. The article proposes that the future of high-rise residential modernization lies in integrated urban governance, whole-life carbon thinking, and resident-centered design frameworks that treat housing as ecological infrastructure and as a social determinant of health.

Keywords

high-rise residential buildings, modernization, ecological sustainability, resident well-being, urban environment, retrofit, indoor environmental quality, urban resilience, social cohesion, housing policy

Introduction

The contemporary urban condition has made housing one of the most decisive arenas where ecological crisis, public health, social inequality, and planning practice intersect. Across the world, urban populations continue to expand while cities confront rising temperatures, infrastructure stress, escalating land values, and widening gaps in access to adequate housing. UN-Habitat has emphasized that the global housing crisis is not a peripheral social issue but a structural challenge affecting billions of people, with more than 2.8 billion lacking adequate housing and urban climate risks compounding this deficit [1]. At the same time, the building and construction sector remains a major source of energy use, carbon emissions, construction waste, and material consumption, meaning that any serious climate strategy must address not only new construction but also the enormous stock of existing residential buildings [2], [3]. High-rise housing occupies a particularly important place within this debate. In many cities, towers and mid-to-high-rise apartment blocks were initially promoted as efficient responses to urban density, land scarcity, and mass housing demand. Yet a large portion of this stock now faces technical obsolescence, thermal inefficiency, inadequate ventilation, outdated engineering systems, inaccessible entrances, deteriorated common areas, and weak integration with green or social infrastructure. The result is a widespread modernization imperative. However, modernization is too often framed in narrow technical terms, as if the replacement of windows, insulation of external walls, or installation of more efficient mechanical systems automatically constitutes success. Such a view is insufficient. Housing is not merely an energy-consuming object; it is a lived environment that shapes bodily health, mental stability, domestic comfort, social relationships, safety, dignity, and everyday routines. The World Health Organization has explicitly treated housing as a determinant of health and has shown that crowding, extreme indoor temperatures, unsafe home conditions, and inadequate accessibility produce measurable burdens on physical and mental well-being [4]. This means that high-rise residential modernization must be examined as a multidimensional urban intervention rather than a simple engineering repair. The ecological side of this challenge is equally complex. For decades, sustainability debates in housing focused largely on operational energy, especially heating and cooling demand. That focus remains important, but it is no longer sufficient. As operational efficiency improves, the relative significance of embodied carbon in materials, demolition waste, and construction processes grows more visible. Recent whole-life carbon frameworks and UNEP assessments have reinforced the principle that retaining and upgrading existing structures can often be preferable to demolition and replacement because it preserves already-invested materials and reduces new material demand [16], [17]. In dense urban districts, modernization also affects stormwater behavior, urban heat accumulation, local biodiversity, ambient air quality, and public-space experience. Green roofs, shaded courtyards, permeable surfaces, water-sensitive landscaping, and solar control systems are not decorative extras; they are elements of ecological performance that influence both urban resilience and everyday comfort. The social dimension is just as decisive. High-rise housing has often been burdened with sweeping generalizations, either celebrated as efficient urbanism or criticized as inherently alienating. The scholarly record is more nuanced. Systematic reviews on

high-rise residential living show that adverse mental health or social outcomes are not inevitable consequences of building height alone. Instead, outcomes depend on a matrix of factors that includes dwelling size, maintenance quality, noise control, access to open space, child-friendly environments, security, management, neighborhood services, and the design of transitional and common spaces [10], [11]. Poorly designed towers with dark corridors, broken elevators, hostile ground planes, and isolated surroundings may indeed intensify stress, fear, or social fragmentation. Yet well-managed high-rise environments with daylight, views, greenery, mixed-age usability, safe circulation, and sociable common spaces can support urban living efficiently while preserving quality of life. Recent research further indicates that social cohesion is strengthened not only by social policy but also by the built environment itself: vibrant neighborhoods, accessible public spaces, and quality urban green space contribute to trust, interaction, active mobility, and collective well-being [14], [15]. These findings matter because contemporary modernization programs are often judged by narrow economic metrics, whereas residents judge them through lived experience: whether summer heat becomes bearable, whether the staircase feels safe, whether the courtyard invites use, whether the elderly can access the building independently, whether children have a place to play, whether utility bills fall without trapping stale air indoors, and whether the building still feels like a community rather than a machine for habitation. The central argument of this article is that the modernization of high-rise residential buildings in the urban environment should be understood as an integrated ecological and human-centered transformation. The paper therefore asks three interrelated questions: first, what ecological principles should guide the modernization of existing high-rise housing stock in cities; second, how do modernization strategies influence resident well-being beyond energy savings; and third, what kind of integrated framework can align environmental performance with social and health outcomes? By addressing these questions through an IMRaD-based analytical review, the study aims to contribute a structured conceptual position: that ecological sustainability and resident well-being are not competing goals but mutually reinforcing criteria of successful modernization. A retrofit that lowers energy demand while worsening overheating, noise, indoor air quality, or social isolation is not a fully sustainable intervention. Likewise, a socially popular upgrade that ignores carbon, water, materials, and climate resilience fails to meet the environmental responsibilities of contemporary urbanism. The modernization of high-rise housing must therefore be evaluated through the combined lenses of climate mitigation, adaptation, public health, social cohesion, and everyday usability. Such an approach is especially relevant for rapidly urbanizing and climatically stressed cities, including many inland and post-socialist urban contexts where a large share of the residential stock is aging, infrastructural budgets are constrained, and the need to reconcile density with livability has become unavoidable.

Materials and Methods

This study employed an integrative review methodology designed to synthesize multidisciplinary knowledge on the modernization of high-rise residential buildings from the perspectives of environmental performance and resident well-being. The choice of an integrative review was intentional because the research problem crosses

the boundaries of architecture, urban planning, environmental engineering, housing policy, public health, and social sustainability. A single-discipline approach would have narrowed the inquiry and reproduced one of the main weaknesses visible in many modernization programs: the treatment of buildings as either technical shells or social containers instead of socio-ecological systems. The evidence base for the review was assembled from three categories of sources. The first category consisted of international institutional documents that establish the contemporary policy and scientific background of urban housing sustainability, including reports and guidance from UN-Habitat, the World Health Organization, the International Energy Agency, the Intergovernmental Panel on Climate Change, the United Nations Environment Programme, and the Royal Institution of Chartered Surveyors [1]–[7], [16], [17]. These sources were used to define the macro-level context of housing adequacy, climate risk, building-sector emissions, whole-life carbon, urban heat resilience, and healthy housing principles. The second category consisted of peer-reviewed systematic reviews and analytical studies focused on the relationship between urban form, green space, retrofit, indoor environmental quality, fuel poverty, and social cohesion [8]–[15], [18], [19]. These studies were selected because they move beyond purely technical performance indicators and engage directly with human outcomes such as thermal comfort, mental health, respiratory health, walkability, social trust, and subjective well-being. The third category consisted of conceptual and standards-oriented material relevant to indoor air quality and residential health protection, especially where evidence shows that well-intentioned retrofit can produce trade-offs if ventilation or occupancy behavior is neglected [12], [13], [19]. The temporal emphasis of the review was placed on the period from 2018 to 2026, with selected earlier sources retained when they were foundational and still authoritative, particularly WHO evidence reviews and key systematic studies on high-rise housing. Source selection followed four inclusion principles: relevance to existing residential buildings rather than purely new construction, applicability to urban and especially high-density contexts, explicit treatment of environmental and/or well-being outcomes, and sufficient methodological clarity or institutional authority. The analytical process was thematic rather than statistical. After reviewing the source corpus, the evidence was coded into six interrelated analytical domains: operational energy and carbon; whole-life carbon and material retention; indoor environmental quality; outdoor microclimate and green infrastructure; accessibility, safety, and social infrastructure; and neighborhood vitality and cohesion. These domains were then reassembled into a modernization framework in which ecological sustainability and resident well-being are treated as co-dependent outcomes. The method does not claim to provide a meta-analysis with pooled effect sizes, nor does it claim universal quantitative thresholds for all climates and housing types. Instead, it offers a structured synthesis aimed at conceptual clarity and applied relevance. This is suitable for the article's purpose because modernization decisions in high-rise housing are typically made under mixed conditions of technical evidence, policy constraint, social need, and urban context. The study's main limitation is that the evidence base is internationally comparative and not derived from a single city or country case study. Nevertheless, this breadth is also an advantage, because it allows the article to identify convergent principles that remain valid across diverse urban

settings while leaving room for local adaptation in planning, regulation, and design practice.

Results

The review reveals that the modernization of high-rise residential buildings achieves its strongest outcomes when it is organized around integrated co-benefits rather than isolated technical targets. The first major finding concerns the energy-carbon nexus. The literature confirms that the building sector remains one of the largest contributors to energy demand and climate emissions, which means that modernization of existing housing stock is indispensable for national and urban climate goals [2], [3]. Yet the evidence also shows that operational efficiency alone cannot define success. Deep façade retrofits, replacement of glazing, heating system upgrades, rooftop solar integration, improved controls, and enhanced insulation can substantially reduce energy demand, especially in aging buildings with poor thermal envelopes, but these measures become fully sustainable only when they are planned alongside overheating prevention, moisture control, and adequate ventilation [12], [13], [19]. The second finding concerns whole-life carbon and material retention. Comparative carbon frameworks consistently argue that retention and refurbishment of existing building structures can reduce upfront emissions relative to demolition-and-rebuild pathways, particularly because demolition triggers new concrete, steel, and finishing material demand while also generating waste [16], [17]. In practical terms, this means that modernization strategies should prioritize structural preservation where technically feasible, selective replacement instead of wholesale removal, low-carbon materials for envelope and interior upgrades, design for maintenance and durability, and circular procurement strategies that extend component life cycles. The third finding concerns indoor environmental quality as a core mediator between ecological modernization and resident well-being. Evidence from housing and retrofit research shows that residents benefit directly when modernization improves winter thermal comfort, reduces drafts, lowers dampness and mold risk, decreases external noise intrusion, and stabilizes indoor temperatures [4], [12], [13], [18]. These are not minor lifestyle improvements; they are outcomes with implications for respiratory health, cardiovascular stress, sleep quality, domestic productivity, and subjective security. However, the literature is equally clear that poorly sequenced or overly airtight retrofit can trap pollutants, intensify summer overheating, or create humidity imbalances if mechanical or passive ventilation is insufficient [12], [13], [19]. Thus, the results strongly support a “healthy retrofit” model in which insulation, ventilation, shading, filtration, moisture management, and user education are treated as inseparable components. The fourth finding concerns urban heat, green infrastructure, and outdoor microclimate. Both climate and public-health evidence indicate that cities are increasingly exposed to heat-related risks, and that green space, shade, and climate-sensitive public-space design reduce these risks while producing broader co-benefits in mental health, physical activity, and social interaction [1], [5], [6], [7], [9]. For high-rise housing, this finding shifts attention from the tower alone to the entire site and its immediate urban fabric. Modernization therefore needs to include shaded pedestrian approaches, planted courtyards, permeable surfaces, stormwater-sensitive landscape design, roof greening where feasible, façade greening in appropriate maintenance regimes, and the

preservation or creation of tree canopy that protects residents from heat stress. Research on urban green spaces further suggests that such interventions are associated with lower heat-related morbidity and mortality and with improved well-being, especially for vulnerable populations [5], [6], [9]. The fifth finding concerns the social meaning of high-rise living. Contrary to simplistic narratives, the reviewed studies do not support the claim that building height itself mechanically produces alienation or poor mental health. Rather, adverse outcomes are associated with neglected management, unsafe circulation areas, lack of child-friendly space, poor access to services, social stigma, noise, and weakly programmed common areas [10], [11]. This is a crucial result because it means modernization must include social architecture, not just building physics. Lobbies, entrances, corridors, elevator zones, shared laundries, rooftop or podium-level community areas, safe play spaces, universal design features, lighting, and visible maintenance all affect how residents perceive belonging and safety. In dense neighborhoods, the vitality of the street edge, the quality of nearby public space, and the visibility of daily life shape social trust and interaction as much as apartment interiors do [14], [15]. The sixth finding is that affordability and well-being are deeply linked through the modernization process. Studies on fuel poverty and social housing retrofit show that energy upgrades can improve subjective well-being when they reduce bill stress and improve comfort, but benefits are diminished or uneven when resident behavior, information access, and post-retrofit use patterns are ignored [13], [18]. Modernization therefore works best when technical intervention is accompanied by resident communication, transparent maintenance systems, manageable operating costs, and protection against displacement or economic exclusion. Taken together, these results point to a six-part modernization model for high-rise residential buildings: reduce operational demand; preserve and optimize embodied resources; ensure healthy indoor environments; create climate-resilient and green external spaces; strengthen social and accessible common infrastructure; and secure affordability through resident-centered governance. This model does not treat ecology and well-being as parallel agendas but as interacting outcomes in one housing system. A building becomes more sustainable not only when it uses less energy, but when it supports healthier indoor air, safer mobility, lower thermal stress, stronger neighborhood ties, and more stable living costs.

Discussion

The implications of these findings are significant for both urban policy and architectural practice because they challenge the conventional division between “green building” interventions and “social housing” interventions. In reality, the modernization of high-rise residential buildings succeeds only when these categories are collapsed into a single planning logic. The first implication is strategic: cities should regard existing high-rise housing stock as a major field of climate action, but one that cannot be governed through carbon metrics alone. Carbon reduction remains essential, especially because urban climate action increasingly depends on the transformation of existing buildings rather than only the performance of new ones [1], [2], [7]. Yet a modernization program that optimizes the energy model while ignoring resident behavior, thermal adaptation, social use of common spaces, or the urban heat burden imposed by barren sites will underperform in both human and environmental terms.

The second implication is methodological: the relevant unit of intervention is not just the apartment or the envelope, but the building-site-neighborhood assemblage. Many unsuccessful retrofit schemes concentrate funding on external walls and technical systems while leaving access paths, shared spaces, surrounding public realm, ground-floor interfaces, and greenery untouched. The review suggests that this fragmented approach misses some of the most important co-benefits of modernization. Walkable and shaded access routes, usable courtyards, nearby destinations, safe crossings, visible entrances, and community-supportive open space influence physical activity, casual social contact, emotional comfort, and perceptions of security [8], [14], [15]. In other words, the modernization of a high-rise building can alter the ecology of everyday urban life only if it extends beyond the vertical object into the horizontal domain of movement, meeting, waiting, resting, and play. The third implication concerns public health. Healthy housing must be treated as a design outcome, not a secondary benefit. WHO guidance and retrofit reviews consistently show that temperature extremes, dampness, crowding, poor accessibility, and unsafe domestic conditions have direct health consequences [4], while newer retrofit literature shows that energy efficiency measures can either improve or undermine health depending on ventilation, shading, and user adaptation [12], [13], [19]. This makes it necessary to reject the false choice between decarbonization and healthy indoor environments. Modernization packages should be evaluated through integrated health performance criteria: winter comfort, overheating risk, moisture balance, acoustic quality, daylight, air exchange, pollutant control, and accessibility for elderly or disabled residents. Such criteria are especially important in high-rise settings where evacuation complexity, elevator dependency, shared air pathways, and social vulnerability can magnify the consequences of design failure. The fourth implication concerns social equity. Because many aging high-rise buildings are occupied by lower- and middle-income households, modernization is inseparable from questions of justice. The benefits of retrofit are diminished if rent increases, temporary relocation burdens, or maintenance costs effectively displace the residents whom the intervention was supposed to support. This is why affordability must be built into the modernization model as a stabilizing principle rather than an afterthought. Evidence from fuel-poverty and social-housing research suggests that reductions in bill stress, improvements in thermal comfort, and higher resident satisfaction are among the strongest social gains of well-designed retrofits [18]. But the same evidence also suggests that purely technical delivery models can fail if residents are not informed, engaged, or supported in the use of upgraded systems [13], [18]. Therefore, participatory planning, post-occupancy evaluation, and social management capacity should be treated as part of the modernization infrastructure. The fifth implication concerns design language and spatial quality. The review on high-rise living underlines that mental and social outcomes are shaped by the quality of circulation spaces, views, privacy gradients, noise control, child usability, and contact with nature [10], [11]. This means modernization should not be satisfied with making buildings merely more efficient; it should also make them more humane. Ground floors should become more legible and welcoming; stairwells and corridors should feel safe and well-lit rather than residual; shared spaces should encourage interaction without forcing it; roofs and podiums should be reconsidered as social and ecological assets;

and the landscape around towers should be transformed from leftover space into climate-responsive public infrastructure. The sixth implication is epistemic: sustainability assessments for high-rise modernization need broader indicators. Projects are still frequently measured through kilowatt-hours saved, façade U-values, or payback periods. These metrics matter, but they are incomplete. The evidence reviewed here suggests that better evaluation frameworks would combine energy and carbon metrics with indoor environmental quality, summer resilience, water performance, accessibility, resident satisfaction, frequency of common-space use, perceived safety, and neighborhood-level green access [5], [6], [9], [12], [15], [16]. Such an expanded framework is not a luxury. It is the only way to identify whether a building has truly become more sustainable in the lived sense of the term. Finally, the article's findings carry particular importance for rapidly urbanizing and climatically variable cities where high-rise housing is growing under pressure for speed and density. In hot summers, modernization must foreground solar control, cross-ventilation logic, reflective or green roof strategies, and shaded outdoor waiting areas. In cold winters, airtightness and insulation must be paired with moisture-safe detailing and adequate air renewal. In all climates, the challenge is the same: to move from piecemeal repair toward systemic renewal. The modernized high-rise should be conceived as a node of urban resilience, a platform of everyday health, and a long-life material asset within a circular city. The environmental future of urban housing will not be secured by aesthetic renewal alone, nor by energy retrofits that forget the resident. It will be secured when modernization is designed as an ecological-social contract between building, city, and inhabitant.

Conclusion

The modernization of high-rise residential buildings in the urban environment should be understood as a strategic synthesis of environmental responsibility and human flourishing. The evidence reviewed in this article shows that ecological sustainability and resident well-being are most effective when pursued together rather than sequentially or separately. High-rise residential stock can no longer be modernized through isolated technical measures that privilege short-term efficiency while neglecting indoor health, outdoor comfort, accessibility, or social cohesion. A sustainable modernization agenda must reduce operational energy demand, limit whole-life carbon, preserve material value, improve ventilation and thermal stability, mitigate urban heat, strengthen greenery and water sensitivity, support walkability, and produce safer and more inclusive common spaces. Just as importantly, it must protect affordability, acknowledge lived experience, and treat residents not as passive recipients of technology but as central actors in the success of transformation. The main theoretical contribution of this article is to frame high-rise modernization as a socio-ecological project in which the building is both environmental infrastructure and a determinant of health and social life. The main practical contribution is the articulation of an integrated modernization model that can guide architects, planners, municipalities, housing managers, and researchers toward more holistic decision-making. Future studies may deepen this framework through city-specific case studies, post-occupancy evaluations, and comparative analysis of modernization programs in different climatic zones. Even so, one conclusion is already clear: in the era of climate

risk and urban housing pressure, the most successful high-rise modernization will be the one that makes the building simultaneously lower-carbon, healthier, more resilient, more affordable, and more livable.

References

[1] UN-Habitat. (2024). World Cities Report 2024: Cities and Climate Action. Nairobi: UN-Habitat.

[2] UNEP & GlobalABC. (2025). Global Status Report for Buildings and Construction 2024/2025. Nairobi: United Nations Environment Programme.

[3] International Energy Agency. (2024). Buildings – Breakthrough Agenda Report 2024; Buildings – Energy System. Paris: IEA.

[4] World Health Organization. (2018). WHO Housing and Health Guidelines. Geneva: WHO.

[5] World Health Organization Regional Office for Europe. (2016). Urban Green Spaces and Health: A Review of Evidence. Copenhagen: WHO Regional Office for Europe.

[6] Hunter, R. F., Cleary, A., Cleland, C., & Braubach, M. (2017). Urban Green Space Interventions and Health: A Review of Impacts and Effectiveness. Copenhagen: WHO Regional Office for Europe.

[7] IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Chapter 6: Cities, Settlements and Key Infrastructure. Cambridge: Cambridge University Press.

[8] Cerin, E., Sallis, J. F., Salvo, D., Hinckson, E., Conway, T. L., Owen, N., et al. (2022). Determining thresholds for spatial urban design and transport features that support walking to create healthy and sustainable cities: Findings from the IPEN Adult study. The Lancet Global Health, 10(6), e895–e906.

[9] Nazish, A., Abbas, K., & Sattar, E. (2024). Health impact of urban green spaces: A systematic review of heat-related morbidity and mortality. BMJ Open, 14, e081632.

[10] Barros, P., Ng Fat, L., Garcia, L. M. T., Slovic, A. D., Thomopoulos, N., de Sá, T. H., Morais, P., & Mindell, J. S. (2019). Social consequences and mental health outcomes of living in high-rise residential buildings and the influence of planning, urban design and architectural decisions: A systematic review. Cities, 93, 263–272.

[11] Larcombe, D.-L., van Etten, E., Logan, A., Prescott, S. L., & Horwitz, P. (2019). High-Rise Apartments and Urban Mental Health—Historical and Contemporary Views. Challenges, 10(2), 34.

[12] Lozinsky, C. H., Casquero-Modrego, N., & Walker, I. S. (2025). The health and indoor environmental quality impacts of residential building envelope retrofits: A literature review. Building and Environment, 270, 112568.

[13] Hashemi, A., & Dungrani, M. (2025). Indoor Environmental Quality and Health Implications of Building Retrofit and Occupant Behaviour in Social Housing. Sustainability, 17(1), 264.

[14] Jennings, V., Rigolon, A., et al. (2024). The dynamic relationship between social cohesion and urban green space in diverse communities: Opportunities and challenges to public health. International Journal of Environmental Research and Public Health, 21(6), 800.

[15] Mouratidis, K., & Poortinga, W. (2020). Built environment, urban vitality and social cohesion: Do vibrant neighborhoods foster strong communities? Landscape and Urban Planning, 204, 103951.

[16] Royal Institution of Chartered Surveyors. (2023). Whole Life Carbon Assessment for the Built Environment. London: RICS.

[17] United Nations Environment Programme. (2023). Building Materials and the Climate: Constructing a New Future. Nairobi: UNEP.

[18] Shwashreh, L., Taki, A., & Kagioglou, M. (2024). Retrofit strategies for alleviating fuel poverty and improving subjective well-being in the UK's social housing. Buildings, 14(2), 316.

[19] ASHRAE. (2023). Position Document on Indoor Air Quality. Peachtree Corners, GA: ASHRAE.