

Scenario-Based Evaluation of Sustainable High-Rise Housing for Refugee Communities under Resource Scarcity Using FAHP–TOPSIS: Evidence from Gaza

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Abstract:

The housing problem in conflict-affected areas, especially in Gaza City, is aggravated by a rapid urbanization process, land scarcity, and long periods of humanitarian crisis. Another possible spatial solution is high-rise housing, but its sustainability under extreme resource constraints has not been adequately assessed. This paper proposes a multi-criteria decision-making framework with a scenario-based approach to evaluate sustainable high-rise housing options for refugee communities in contexts with limited energy, water, and material resources. Four architectural situations were developed in accordance with site conditions, community needs, and resource availability. A systematic analysis of the criteria was conducted to assign weights and rank the scenarios using an integrated FAHP to assess environmental performance, resource optimization, indoor environmental quality, and community-centric criteria, and the Fuzzy TOPSIS to rank the scenarios. The outputs of the simulation were added to the decision framework to ensure quantitative rigor, namely, energy demand, CO₂ emissions, thermal comfort (PMV), and natural ventilation performance. Findings indicate that the hybrid scenario achieves optimal performance, with substantial changes in operational energy requirements and carbon emissions, under realistic technological conditions and high social functionality.

1. Introduction

Urban growth, climatic pressures, and prolonged wars have played a major role in exacerbating the housing crisis in the rest of the world, particularly among displaced communities. As per the United Nations High Commissioner for Refugees, more than 108 million individuals have been forcibly displaced across the world by 2023, and an increasing number of them are not housed in temporary camps but in large urban centers [1]. In cities with limited land and conflict zones like Gaza, the housing problem is made complicated due to the extreme population density, broken infrastructure, absence of energy and drinking water, and the lack of building materials. The city of Gaza is the most densely populated in the world, yet it also faces

ongoing power outages and critical water shortages [2].

In this context, vertical residential development is a spatial requirement rather than a planning choice. Nonetheless, traditional typologies of high-rise buildings, which are primarily optimized for density maximization and high cost-efficiency, are ill-suited to fragile, resource-scarce environments because they are highly energy-intensive, rely on centralized infrastructure, and are poorly adapted to social and safety requirements. Recent studies focus on sustainable high-rise buildings, with integrated performance encompassing energy efficiency, carbon reduction, indoor environmental quality, water optimization, and social well-being [3]. However, much of this literature is rooted in technologically advanced settings, offering solutions

that are difficult to establish and sustain, or to achieve, in conflict-stricken areas. In response, researchers and global organizations are further advancing the idea that sustainable solutions should be developed as hybrid systems that integrate passive building design, low-dependence technologies, and local resource loops to enhance resilience and viability [4]. Although this has been done, there remains an urgent gap in the systematic analysis of sustainable high-rise housing options for refugee communities. Recent research either uses a single-domain indicator, such as energy consumption or emissions, or does not consider trade-offs among environmental performance, resource availability, social functionality, and operational reliability. Additionally, the problem of decision-making under uncertainty is not fully addressed, particularly during the initial design phases, where expert judgment and qualitative criteria are key factors.

To address these gaps, the present study proposes a scenario-based evaluation framework that integrates architectural design, building performance simulation, and multi-criteria decision-making (MCDM). Four high-rise housing scenarios are developed for a refugee settlement in Gaza: baseline, passive, hybrid, and active, based on the extent of technological dependency and resource intensity. Simulation quantifies indicators of environmental and indoor performance, including energy demand, CO₂ emissions, thermal comfort, and ventilation effectiveness, whereas resource optimization and community-centric criteria are quantified using expert-based weighting. The assessment model employs the combined Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to prioritize scenarios in an uncertain environment [5,6].

By using Gaza as an exemplary case study of severe resource constraints and socio-political vulnerability, the research will develop a repeatable, evidence-based decision-support model for sustainable high-rise housing in the context of refugee and post-conflict urban settings. The results are designed to assist architects, planners, and humanitarian organizations in making informed choices about design strategies that ensure alignment among environmental performance, social resilience, and practical feasibility.

2. Material and Methods

The evaluation framework for this study is a scenario-based, multi-criteria approach to assess sustainable high-rise housing options for refugee populations under conditions of resource scarcity.

The approach combines architectural scenario development, building performance simulation, and fuzzy MCDM to support informed design selection under uncertainty.

2.1 Scenario development

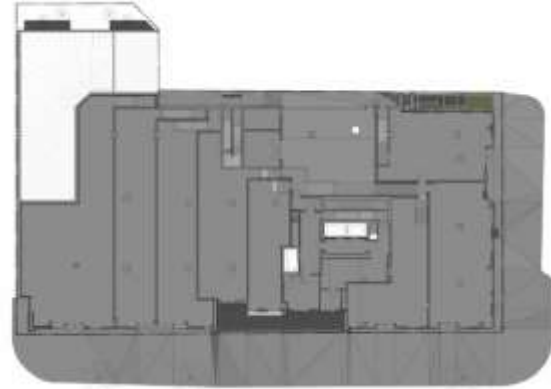


Figure 1. Floor plan.

The proposed scenario plan is shown in Figure 1. Where the area of the site is 1,000,000 m², coverage areas, such as building towers, are allowed 30% (300,000 m²); tower footprint 2,400 m²; the number of towers is 15, and that can be easily accommodated on the site (tower footprint = 36,000 m² = 3.6 of the site). The circulation network and parking structure of the proposed development are specifically intended to facilitate everyday movement and access to services and to serve as a haven and place of refuge during emergencies.

The four high-rise housing scenarios were designed to increase the levels of sustainability integration and technological dependence systematically: a Baseline Scenario (D), an Optimal Passive Scenario (C), an Optimal Hybrid Scenario (A), and an Optimal Active Scenario (B). The scenarios were formulated with recurrent site context, building footprint, height, and functional program so that they were comparable while different architectural approaches, envelope systems, and resource-management technologies. The Baseline Scenario represents a traditional high-rise typology widely used in emergency or speculative developments, which lacks insulation, has a single-glazed facade, central heating and cooling, and does not optimize resource use at the site. The Optimal Passive Scenario will place greater emphasis on architectural shape, orientation, self-shading geometries, thermal mass, and natural ventilation to reduce energy demand and keep it out of reach of active systems. The Hybrid Scenario combines passive design with resilient, low-dependency technologies, such as rooftop photovoltaics, decentralized greywater reuse, and localized waste composting. Active Scenario is a

high-technology practice that will employ advanced facade systems, building management systems, and extensive water-treatment systems. Scenario-based design methods are well known for their utility in exploring sustainability trade-offs under uncertainty, particularly in early-stage decision-making within complex urban systems [7,8].

2.2 Performance metrics and evaluation criteria

To facilitate a broad-level sustainability assessment, performance indicators were organized into a hierarchical criteria system, consistent with best practices in building sustainability assessment. Six criteria were identified: energy performance (C1), embodied carbon (C2), indoor environmental comfort (C3), daylighting and natural ventilation (C4), resource and water efficiency (C5), and community and social resilience (C6). Each of the main criteria was further subdivided into sub-criteria for global standing and prior studies. Figure 2 presents a summary of the multi-criteria sustainability assessment framework to be used in this research, integrating environmental, technical, and social performance within a single hierarchical structure. The framework distinguishes among cost-type indicators (operational energy demand, embodied carbon, overheating, and excessive solar exposure), with lower values indicating better performance. Benefit-type indicators (adaptive comfort hours, daylight availability, ventilation potential, water reuse, and community metrics), where higher values indicate better sustainability outcomes. The framework ensures the consistency of the FAHP-TOPSIS methodology by specifying the directional meaning of each criterion and sub-criterion, thereby enabling comparison of high-rise design scenarios under resource scarcity. Evidence-based decision-making in this integrated organization is informed by trade-offs among energy efficiency, environmental impacts, occupant welfare, resource preservation, and community resilience, within the context of urban development agendas for refugees. Annual energy use intensity (EUI) and life-cycle carbon measures were used to quantify operational energy use and carbon emissions, in accordance with IEA and ASHRAE standards [9,10]. The performance of indoor comfort was assessed using the Predicted Mean Vote (PMV) and ventilation effectiveness indicators, in accordance with ISO 7730 (2025) and ASHRAE 55 (2020) [10,11]. The embodied carbon indicators were based on the principles of life-cycle assessment set out in EN 15978 and ISO 14044. They were associated with increased awareness among individuals associated with high-rise buildings [12]. Based on the literature on urban resilience and social

sustainability, community-based criteria were reflected in accessibility, integration of mixed uses, safety, and spatial legibility.

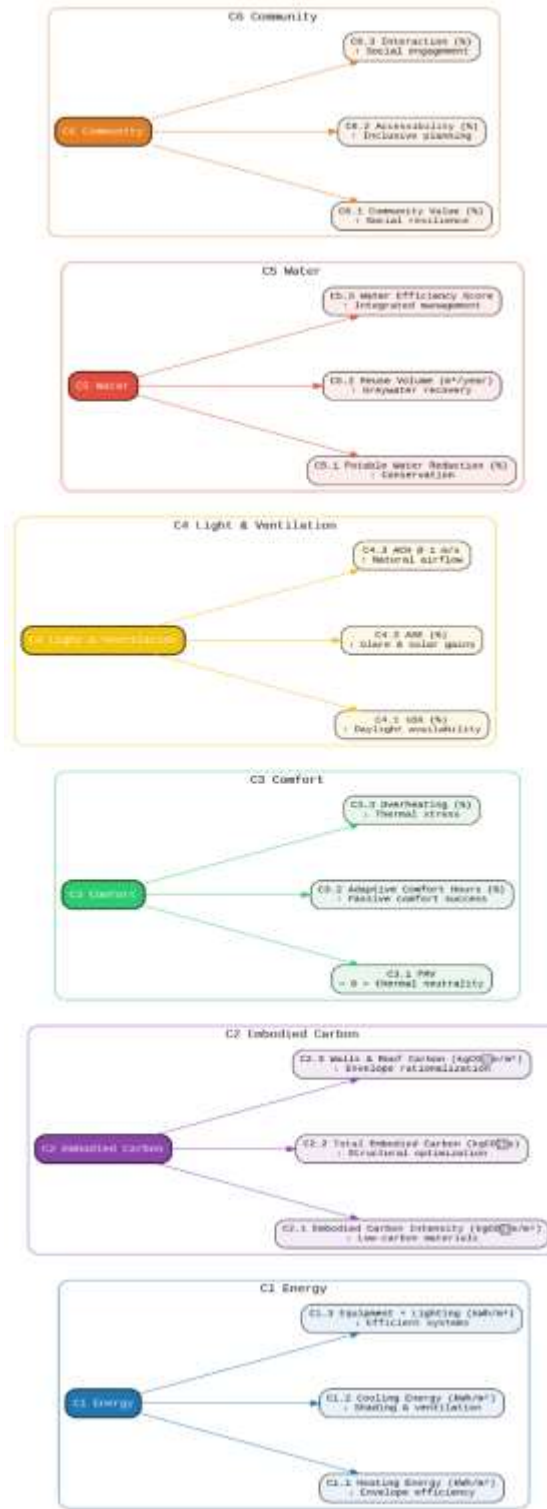


Figure 2. Multi-Criteria sustainability assessment framework.

2.3 Simulation and quantitative analysis

To evaluate the performance of each scenario, a building performance model was used to determine

energy use, thermal comfort, and ventilation behavior under the same climatic conditions. Climatic data applicable to Gaza City, characterized by high cooling demand, low heating demand, and seasonal wind patterns, were used. Annual operational energy use and carbon emissions were given with energy simulations, whereas PMV distributions and ventilation performance indices were given with comfort analyses. It is generally accepted that simulation-based assessment is necessary to predict the environmental performance of high-rise buildings, particularly when facade design and passive approaches are significant factors [13].

2.4 Fuzzy AHP for criteria weighting

Because the sustainability-related judgments were subjective and highly uncertain, the Fuzzy Analytic Hierarchy Process (FAHP) was used to derive the weights of the criteria. The Chang extent analysis technique was used owing to its popularity and computational strength in sustainability analysis [14].

The fuzzy judgments in the pair wise comparisons were represented by triangular fuzzy numbers that could represent the expert judgment (e.g., moderately more important) and convert it into fuzzy number intervals. This technique enhances reliability when accurate numerical judgments are difficult to obtain, particularly in challenging socio-environmental decision-making situations [5].

The resulting normalized weights indicate the relative importance of each sustainability criterion in the context of resource scarcity and humanitarian constraints.

2.5 Fuzzy TOPSIS for scenario ranking

The four scenarios were ranked using the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), with weights obtained via FAHP. The Fuzzy TOPSIS uses the distances of the alternatives to the ideal positive solution (the best possible solution across all criteria) and the ideal negative solution (the worst possible solution). This approach is also highly applicable to sustainability measurement, as it accounts for trade-offs among contradictory standards and accommodates both quantitative and qualitative data [15]. The result is a closeness coefficient for each scenario, indicating its relative sustainability performance.

2.6 Sensitivity analysis

To verify the soundness of the decision-making structure, a sensitivity analysis was performed by

systematically varying the weight of the community and social resilience criterion (C6) by $\pm 10\%$ and $\pm 20\%$. An alternate ranking of scenarios was used to assess the consistency of the results with the changing stakeholder interests. This is a sound practice in MCDM research because sensitivity analysis is essential for ensuring methodological transparency and the reliability of decisions [16].

3. Results and Discussions

This section presents the results of the multi-criteria decision analysis and scenario-based performance evaluation. The results are presented in a way that initially details the quantitative performance results of the four scenarios, then displays the weights of the criteria produced by the FAHP, the Fuzzy TOPSIS ranking results, and lastly the sensitivity analysis of the results obtained from the robustness of the results with the changing priorities of the stakeholders. The results from simulating the four developed scenarios using Insight 360 are in Appendix 1. The scenario rankings, normalized values, and pairwise matrix are provided in Appendices 2, 3, and 4.

3.1 Scenario performance outcomes

The simulation outcomes indicate that the four scenarios differ significantly across energy, carbon, comfort, ventilation, and social performance indicators. Baseline Scenario (D) had the highest operational energy demand and carbon emissions because it lacked passive design controls, insulation, and mechanical cooling systems. High PV values and low natural ventilation were also indicators of lower indoor comfort under the climatic conditions in Gaza.

Optimal Passive Scenario (C), by contrast, showed a significant decrease in cooling energy requirement and an enhancement in thermal comfort through the architectural solution alone. Formed shapes of self-shading buildings, optimal orientation, extensive balconies, and higher thermal mass had a considerable influence on indoor temperatures and enhanced the performance of cross-ventilation. The findings are in line with past research that has indicated the ability of passive design measures in saving on an operational energy requirement of 20-40% in hot climates.

The Optimal Hybrid Scenario (A) yielded the most balanced results across all indicators. The implementation of rooftop photovoltaic systems minimized electricity demand from the grid for essential services, including lifts and water pumps, and decentralized greywater use, favouring on-site vegetation. The separation of waste and composting also led to resource circularity. Consequently,

Scenario A had the lowest overall operational carbon intensity and one of the highest ratings for comfort and ventilation.

Optimal Active Scenario (B) achieved substantial reductions in operational energy demand through state-of-the-art facade systems, intelligent controls, and extensive water-reuse infrastructure. Nevertheless, the gains are partly offset by the greater embodied carbon of high-performance glazing systems, the complexity of mechanical systems, and the dependence on technology. This trade-off is consistent with recent findings suggesting that, when not optimized, high-tech solutions can redirect operational environmental impacts to embodied impacts.

3.2 FAHP-Derived criteria weights

The analysis of the Fuzzy Analytic Hierarchy Process results shows that community and social resilience (C6) is the strongest criterion, followed by energy performance (C1) and indoor environmental comfort (C3). The weighting reflects the study's humanitarian focus, with social cohesion, safety, accessibility, and long-term resilience as major considerations, alongside environmental efficiency. Embodied carbon (C2) and daylighting/ventilation performance (C4) were assigned moderate weights. In contrast, water and resource efficiency (C5) were assigned lower relative weights because the study focused on architectural and energy-based optimization solutions. The priority hierarchy aligns with sustainability models that focus on the social performance of vulnerable urban environments.

3.3 Fuzzy TOPSIS scenario ranking

Table 1 presents the outcomes obtained using the FAHP-TOPSIS method after weighting all metrics. Scenarios B and C look the same, where scenario C is the worst, and the optimum scenario, which comes in the first rank, is scenario D. The Fuzzy TOPSIS analysis, based on weights derived from the FAHP, produced a clear and consistent ranking of scenarios. The Optimal Hybrid Scenario (A) was closest to the ideal sustainability solution, with the shortest distance and the highest total performance balance. Optimal Active Scenario (B) ranked second, closely followed by Baseline Scenario (D), and Optimal Passive Scenario (C) ranked third.

Table 1. Score and Ranking for the proposed scenarios

Scenario	CC	Rank
A	0.989	1
B	0.334	2
D	0.334	2
C	0.011	3

The high performance of Scenario A could be explained by the integration of low-tech passive methods with targeted, resilient active systems, which reduce operational and embodied impacts and increase community functionality. These findings validate the applicability of hybrid solutions in situations of resource scarcity and systemic instability, consistent with prior high-rise sustainability evaluations of MCDM methodologies [17].

3.4 Sensitivity analysis

The sensitivity analysis assessed the robustness of the ranking outcomes to ±10% and ±20% changes in the weight of the community and social resilience criterion (C6). In all the tested scenarios, the order of ranking did not change, and Scenario A always held the first position, while Scenario C was at the bottom of the ranking. Though the coefficients of closeness were slightly different, especially on Scenarios B and D, no reversal of rank was experienced. This stability demonstrates that the decision framework is not susceptible to changes in stakeholder priorities and that the preeminence of the Hybrid Scenario is not attributable to a particular weighting assumption. Sensitivity analysis has been widely recommended in MCDM research to justify the reliability and transparency of decisions [18]. The sensitivity results are presented in Table 1, and Figure 3 shows the CC curves with C6 varied.

3.5 Interpretation of scenario performance

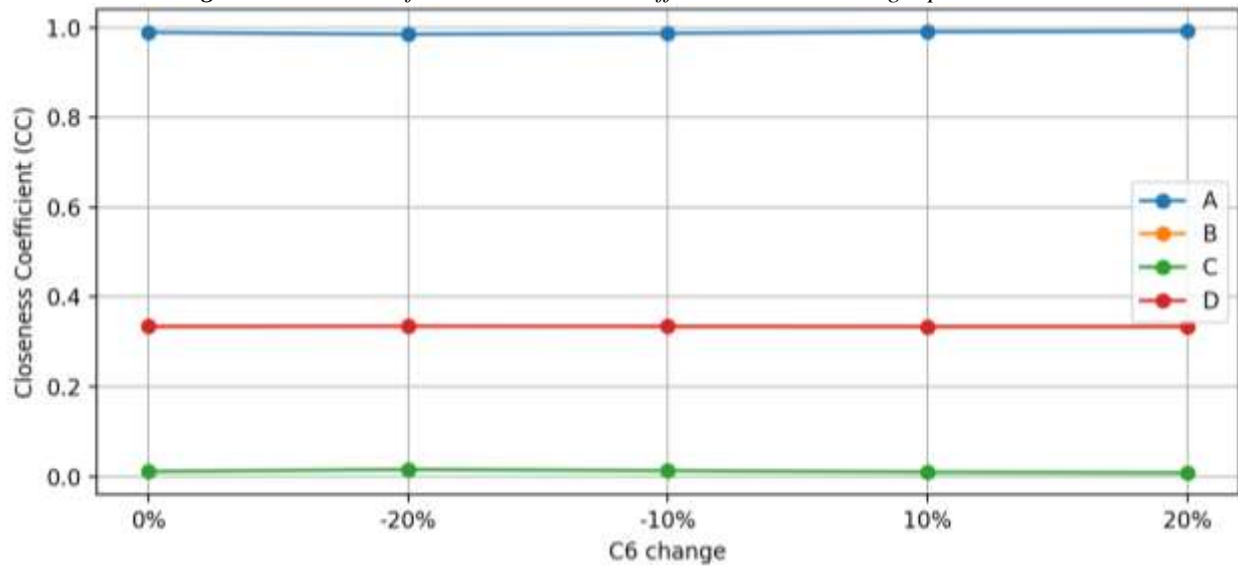
The findings reveal that the sustainability performance of high-rise housing under resource scarcity is not based on a single technological or architectural solution, but rather on a combination of

C6 Change	A-CC	B-CC	C-CC	D-CC	A-Rank	B-Rank	C-Rank	D-Rank
0% (baseline)	0.989	0.334	0.011	0.334	1.000	2.000	3.000	2.000
-20%	0.985	0.335	0.015	0.335	1.000	2.000	3.000	2.000
-10%	0.987	0.334	0.013	0.334	1.000	2.000	3.000	2.000

0.100	0.990	0.334	0.010	0.334	1.000	2.000	3.000	2.000
0.200	0.991	0.334	0.009	0.334	1.000	2.000	3.000	2.000

Table 2. Sensitivity of topsis closeness coefficients to c6 weights shifts

Figure 3. Variation of TOPSIS closeness coefficients under c6 weight perturbations.



active and passive design and community-focused planning. The prevalence of the Optimal Hybrid Scenario (Scenario A) indicates that neither purely passive nor fully high-tech modes can be applied effectively to the multidimensional problems of post-conflict, infrastructure-constrained settings, such as Gaza.

Although the Optimization Passive Scenario (C) minimized cooling requirements and enhanced thermal comfort through its form, orientation, and envelope design, it lacked the capacity to sustain essential services during power outages, thereby limiting its overall performance. This observation confirms earlier studies that, although passive strategies are necessary, they must be complemented by robust energy and water infrastructure to make extreme environments habitable in the long term.

On the other hand, the Optimal Active Scenario (B) achieved marginal efficiency in energy conservation through advanced facade technologies and smart building management systems. Still, these advantages were offset by increased embodied carbon and technological reliance. Such a trade-off supports the recent literature's view that high-tech sustainability directives may not be well suited to contexts characterized by supply-chain disruption, maintenance constraints, and economic instability.

3.6 Significance of community-centric weighting

The FAHP results, which prioritize community and social resilience, are consistent with contemporary sustainability models that value human-centered performance and environmental efficiency. Spatial arrangements that ensure safety and social interaction, accessibility, and psychological well-

being are major factors in the long-term success of humanitarian and post-conflict housing.

The better performance of Scenario A in community-related sub-criteria in terms of shared service floors, mixed-use functions, and decentralized facilities (Scenario A) supports the notion that architecture decisions have direct impacts on social sustainability. Such results are consistent with previous empirical research indicating that housing initiatives that prioritize shared areas and multifunctional designs lead to higher levels of social cohesion, less expended behavioral energy, and improved maintenance outcomes.

3.7 Energy, carbon, and lifecycle trade-offs

The lifecycle perspective used in this paper emphasizes that operational energy remains the primary contributor to total carbon emissions in high-rise warm-weather houses. However, embodied carbon values were comparable across scenarios; disparities in cooling demand, ventilation performance, and adaptive comfort produced quantifiable differences in operational carbon intensity.

These results are consistent with global assessments indicating that construction accounts for nearly 36% of global final energy consumption and 39% of energy-related CO2 emissions, with operational energy consumption predominating in hot climates [9].

The passive approach to cooling loads in the Hybrid Scenario, combined with the passive support of key systems through localized photovoltaic generation, demonstrates an efficient balance of carbon

reduction between low-tech resilience and technological support. This aligns with recent calls to adopt appropriate technological methods in sustainable architecture, particularly in areas experiencing chronic energy insecurity.

3.8 Methodological implications of fahp–topsis integration

FAHP and TOPSIS integration proved effective for managing uncertainty and expert judgment, as well as heterogeneous performance indicators. FAHP enabled the translation of linguistic evaluations of relative importance into quantitative weights, whereas TOPSIS provided a clear method for ranking alternatives based on their distances to ideal solutions.

The consistency in the sensitivity analysis indicates the strength of the decision framework in addressing a common criticism of multi-criteria methods: the subjectivity and sensitivity of weights. Hybrid MCDM methods of this type have been successfully applied to analyze facade systems, HVAC designs, and city planning strategies for high-rise buildings. Notably, the zero-weighting of water efficiency indicators does not imply that they are irrelevant; it simply reflects the methodological fact that criteria that are not varied across alternatives cannot affect ranking results. This fact supports best practices in MCDM, in which differentiation rather than absolute importance determines the weighting.

3.9 Implications for post-conflict high-rise housing

The results indicate that a sustainable high-rise dwelling to accommodate the refugee and post-conflict populations cannot be limited to the generic green building designs. Instead, more context-sensitive hybrid approaches that prioritize social resilience, passive climatic adaptation, and low-dependency active systems are the most promising way forward. Scenario A shows that the concept of sustainability in the Gaza area is not determined by technological advancement but by the community's ability to endure, adapt, and empower itself. It is consistent with international reconstruction principles that emphasize locally manageable systems, circular resource flows, and social infrastructure as sources of sustainable recovery [19].

4. Conclusions

4.1 Conclusions

This research presents a case study assessing sustainable high-rise housing for refugee

populations under severe resource constraints, using Gaza as a model of a post-conflict setting. The study, by incorporating environmental performance indicators, architectural design variables, and community-based criteria into an FAHP-TOPSIS decision-making system, revealed that hybrid sustainability strategies invariably outperform single-approach solutions.

The findings affirm that passive design elements such as optimal orientation, compact massing, natural ventilation, and envelope efficiency cannot be ignored in minimizing cooling requirements and energy use for building operation in hot climates. Nevertheless, the results also demonstrate that passive-only strategies cannot be adopted when infrastructure reliability is impaired. On the other hand, technology-focused solutions offer performance benefits at the expense of embodied carbon, maintenance requirements, and system dependence. The best-case scenario is a hybrid moderation scheme in which the passive approach serves as the basis for both schemes and is selectively strengthened by decentralized renewable energy systems and vital active technologies.

Most importantly, the results of the weighting demonstrate that the community and social resilience criteria are as important as, or more important than, the energy performance. Safety, privacy, mixed-use service floors, proximity to essential amenities, and socializing areas play a major role in overall sustainability ratings. This confirms the current theory of sustainability, which recognizes resilient housing not only for its energy efficiency but also for its capacity to foster dignity, stability, and long-term social cohesion in vulnerable communities.

Methodologically, the study substantiates the strength of hybrid FAHP-TOPSIS models in architectural decision-making processes, particularly when qualitative factors, ambiguous information, and numerous performance objectives are present. The reliability of the scenario ranking, as assessed under sensitivity analysis, supports the framework's external validity for early-stage design and policy evaluation.

4.2 Policy and design implications

From a policy perspective, the results undermine the prevalence of generic green building rating systems in addressing humanitarian and post-conflict housing. Although these systems can provide useful benchmarks, they typically do not capture context-specific priorities, particularly social resilience, infrastructure vulnerability, and resource scarcity. Context-adaptive sustainability models that integrate social, environmental, and operational requirements,

rather than focusing solely on energy metrics, should thus be incorporated by policymakers and reconstruction authorities.

In the case of Gaza and in a related context, the research proposes policies that should encourage:

Hybrid passive and active design solutions as the minimum of high-rise housing;

Decentralized renewable energy resources, especially the integration of photovoltaic, to provide continuity in the vital services;

Spatial planning that is mixed-use and community-oriented in that it lowers the levels of mobility, increases safety, and strengthens social networks.

Carbon assessment is a lifecycle-based assessment that accounts for both embodied and operational emissions during design approval.

These recommendations align with international reconstruction and climate-action agendas, including the UN Sustainable Development Goals (SDGs 7, 11, and 13) and emerging Zero-Emission Building policies promoted by the International Energy Agency and the U.S. Department of Energy [20].

At the design practice level, architects and planners are asked to use evidence-based scenario evaluation in the early stages of design, employing multi-criteria decision-making tools to assess trade-offs among performance, resilience, and social impact. These methods enable clear design decisions and enhance the alignment of architectural intent, policy goals, and user requirements.

4.3 Contribution to knowledge

This study is a contribution to the body of literature as it:

Providing evidence of the relevance of scenario-based MCDM models to the urban design of post-conflict housing; empirically proving the practicality of the community-based approach to sustainable high-rise assessment; offering a transferable methodology framework which can be repurposed to other resource-deprived and humanitarian challenges.

The work contributes to a comprehensive perspective on sustainable high-rise housing as a social-technical system rather than a purely technological one.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or

personal relationships that could have appeared to influence the work reported in this paper

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References

- [1] UNHCR, Global Trends: Forced Displacement in 2024. Geneva: *United Nations High Commissioner for Refugees*, 2025.
- [2] World Bank Group, Gaza and West Bank Interim Rapid Damage and Needs Assessment. *Washington, DC: World Bank*, 2025.
- [3] IEA, Annual Report 2023. Annex 49 Energy Efficient Communities, *International Energy Agency*, 2023.
- [4] UN-Habitat, "Housing," United Nations Human Settlements Programme, 2024. [Online]. Available: <https://unhabitat.org/topic/housing>
- [5] A. Mardani, A. Jusoh, K. Md Nor, Z. Khalifah, N. Zakwan, and A. Valipour, "Multiple criteria decision-making techniques and their applications – A review of the literature from 2000 to 2014," *Econ. Res.-Ekon. Istraživanja*, vol. 28, no. 1, pp. 516–571, 2015, doi: 10.1080/1331677X.2015.1075139.
- [6] M. M. A. Bhuiyan and A. Hammad, "A hybrid multi-criteria decision support system for selecting the most sustainable structural material for a multi-storey building construction," *Sustainability*, vol. 15, no. 4, p. 3128, 2023, doi: 10.3390/su15043128.
- [7] R. Reitberger, N. Palm, H. Palm, and W. Lang, "Urban systems exploration: A generic process for multi-objective urban planning to support decision making in early design phases," *Build. Environ.*, vol. 254, p. 111360, 2024, doi: 10.1016/j.buildenv.2024.111360.
- [8] G. Abou Jaoude, O. Mumm, and V. M. Carlow, "An overview of scenario approaches: A guide for urban design and planning," *J. Plan. Lit.*, vol. 37, no. 3, 2022, doi: 10.1177/08854122221083546.
- [9] IEA, "Buildings – Analysis," International Energy Agency, Sep. 2022. [Online]. Available: <https://www.iea.org/reports/buildings>
- [10] ASHRAE, Standards and Guidelines. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2009.
- [11] ISO, ISO 7730:2025: Ergonomics of the thermal environment. Geneva: *International Organization for Standardization*, 2025.
- [12] ISO, ISO 14044:2006: Environmental management—Life cycle assessment—

Requirements and guidelines. Geneva: International Organization for Standardization, 2006.

- [13] G. Elshafei, "Passive building model guidelines for Minia City based on psychometric chart & CBE tools," *J. Appl. Eng. Technol.*, vol. 43, no. 2, p. 384, 2024.
- [14] D.-Y. Chang, "Applications of the extent analysis method on fuzzy AHP," *Eur. J. Oper. Res.*, vol. 95, no. 3, pp. 649–655, 1996, doi: 10.1016/0377-2217(95)00300-2.
- [15] N. Liladhar Rane and S. Choudhary, "Fuzzy AHP and fuzzy TOPSIS as an effective and powerful multi-criteria decision-making (MCDM) method for subjective judgements in the selection process," *Int. Res. J. Mod. Eng. Technol. Sci.*, vol. 5, no. 4, pp. 2582–5208, 2023, doi: 10.56726/IRJMETS36629.
- [16] G. Demir and R. Arslan, "Sensitivity analysis in multi-criteria decision-making problems," *Ankara Hacı Bayram Veli Univ. J. Econ. Adm. Sci.*, vol. 24, no. 3, pp. 1025–1056, 2022, doi: 10.26745/ahbvuibfd.1103531.
- [17] M. A. Vaziri Rad, H. Forootan Fard, S. Tajedini, and D. Aghajani, "Integrating multi-criteria decision making and game theory approaches to identify sustainable power supply solutions grounded in economic optimization: A case study in the abundant climates of Iran," *Energy*, vol. 338, p. 138909, 2025, doi: 10.1016/j.energy.2025.138909.
- [18] E. Triantaphyllou and A. Sánchez, "A sensitivity analysis approach for some deterministic multi-criteria decision-making methods," *Decis. Sci.*, vol. 28, no. 1, pp. 151–194, 1997.
- [19] UN, World Cities Report 2024: *Cities and Climate Action*. New York: United Nations, 2024.
- [20] UN, Policy Briefs in Support of the High-Level Political Forum: *Leveraging Energy Action for Advancing the Sustainable Development Goals*. New York: United Nations, 2021.