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# A Framework for Integrating Vernacular Architecture and Healing Environment Principles for Resilient Post-Disaster Housing

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**ABSTRACT**

Post-disaster housing is typically designed to meet immediate shelter needs, yet it often overlooks environmental adaptability, cultural continuity, and psychological recovery. This study proposes a multi-criteria framework by integrating principles of vernacular architecture and healing environments. A mixed-method approach was used, combining literature synthesis, criteria formulation, expert validation, and TOPSIS-based prioritization. Eight design criteria were assessed: ventilation, natural lighting, transitional spaces, building materials, cultural relevance, flexibility and resilience, sustainability, and psychological support. Expert judgment evaluated each criterion across two dimensions—vernacular and healing principles—followed by normalization, weighting, and ranking using TOPSIS. The results indicate that building materials achieved the highest performance score (Pi = 0.504), followed closely by transitional spaces (0.496), cultural relevance (0.495), and psychological support (0.491). However, the minimal variation between scores suggests that these criteria should not be treated as a strict hierarchy, but rather as an integrated design system. This framework offers a practical basis for developing post-disaster housing that is not only functional but also environmentally responsive, culturally sensitive, and supportive of occupant well-being.

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*Hunian pascabencana umumnya dirancang untuk memenuhi kebutuhan tempat tinggal darurat, namun seringkali mengabaikan aspek adaptabilitas lingkungan, keberlanjutan budaya, dan pemulihan psikologis penyintas. Penelitian ini mengusulkan kerangka kerja multikriteria dengan mengintegrasikan prinsip arsitektur vernakular dan healing environment. Metode penelitian menggunakan pendekatan campuran yang meliputi sintesis literatur, perumusan kriteria, validasi ahli, dan penentuan prioritas menggunakan metode TOPSIS. Delapan kriteria desain dievaluasi, yaitu ventilasi, pencahayaan alami, ruang transisi, material bangunan, relevansi budaya, fleksibilitas dan ketahanan, keberlanjutan, serta dukungan psikologis. Penilaian ahli dilakukan berdasarkan dua dimensi, yaitu prinsip vernakular dan healing environment, kemudian dilanjutkan dengan proses normalisasi, pembobotan, dan pemeringkatan menggunakan TOPSIS. Hasil penelitian menunjukkan bahwa material bangunan memperoleh nilai kinerja tertinggi (Pi = 0,504), diikuti ruang transisi (0,496), relevansi budaya (0,495), dan dukungan psikologis (0,491). Namun, perbedaan nilai yang relatif kecil menunjukkan bahwa seluruh kriteria perlu dipandang sebagai suatu sistem desain yang saling terintegrasi, bukan sebagai hierarki yang kaku. Kerangka ini memberikan dasar praktis bagi pengembangan hunian pascabencana yang fungsional, adaptif terhadap lingkungan, sensitif terhadap budaya, serta mendukung kesejahteraan penghuni*

## 1. Introduction

Natural hazards such as earthquakes, tsunamis, floods, and hurricanes frequently lead to housing loss, displacement, and prolonged disruption of community life (Palanbek Yavaş et al., 2022; Paul et al., 2024). In post-disaster contexts, housing serves not only as physical shelter but also as a means of restoring safety, social stability, cultural continuity, and psychological well-being (Dombo & Ahearn, 2017; Félix et al., 2015). For this reason, post-disaster housing design should address both immediate spatial needs and the broader recovery process experienced by affected communities.

Disaster recovery efforts have increasingly adopted the *Build Back Better* approach, which emphasizes resilience, sustainability, and long-term socio-economic recovery (Noy et al., 2019). In practice, however, many post-disaster housing programs still prioritize speed, standardization, and cost efficiency, often resulting in designs that are less responsive to local climate, cultural practices, and psychological recovery (Perrucci & Baroud, 2020; Rathnasinghe et al., 2021). According to the Indonesian Government's Regulation of the National Disaster Management Agency Number 4 of 2008 (concerning Guidelines for the Preparation of Disaster Management Plans) and Law No. 24 of 2007 (concerning Disaster Management), disaster management is structured around emergency response, transitional recovery, and reconstruction phases. Housing reconstruction still tends to prioritize physical and infrastructural recovery, with limited integration of socio-cultural continuity and psychological resilience.

These challenges point to the need for a design framework that is more grounded in local environmental, cultural, and social contexts. Vernacular architecture provides relevant insights, as it reflects long-term adaptation to climate through the use of local materials, passive ventilation strategies, shaded transitional spaces, and spatial patterns that are closely tied to cultural practices and identity (Muqoffa et al., 2025). At the same time, healing environment principles explain how built spaces can reduce stress, improve comfort, and support emotional recovery through natural light, air quality, privacy, safety, access to nature, and user control (Chowdhury et al., 2025; Gaminiesfahani et al., 2020).

Although research on resilient housing, vernacular architecture, and healing environments has grown significantly, these areas are often discussed separately. Their integration into a unified and operational framework for post-disaster housing remains limited. In many cases, studies focus on environmental performance, cultural relevance, or psychological aspects in isolation, rather than translating them into measurable and applicable design criteria. This gap is particularly relevant in Indonesia, where disaster-prone regions are characterized by diverse climatic conditions, cultural backgrounds, and settlement patterns.

This study aims to develop an integrative framework for post-disaster housing by synthesizing principles from vernacular architecture and healing environments. Using a combination of literature synthesis, expert validation, and TOPSIS-based multi-criteria analysis, the study identifies and prioritizes design criteria that support environmental adaptability, cultural continuity, and psychological recovery. The resulting framework is

intended to provide a more systematic basis for designing post-disaster housing that is resilient, sustainable, and responsive to human needs in the Indonesian context.

## 2. Materials and Methods

This study adopted a mixed-method approach that combines qualitative synthesis with quantitative multi-criteria analysis (Figure 1). In the qualitative phase, relevant literature on vernacular architecture, healing environments, and post-disaster housing was reviewed to identify key design criteria related to environmental adaptability, cultural continuity, and psychological recovery. The quantitative phase involved expert judgment to validate the identified criteria, followed by the application of the TOPSIS method to assess and determine their relative priorities.

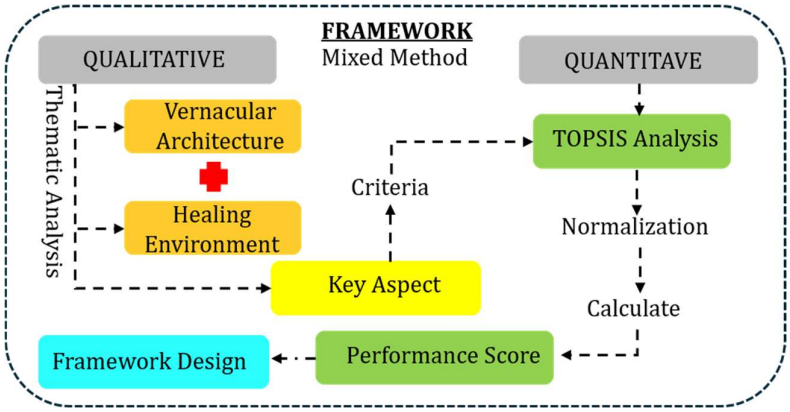



Figure 1. Research framework

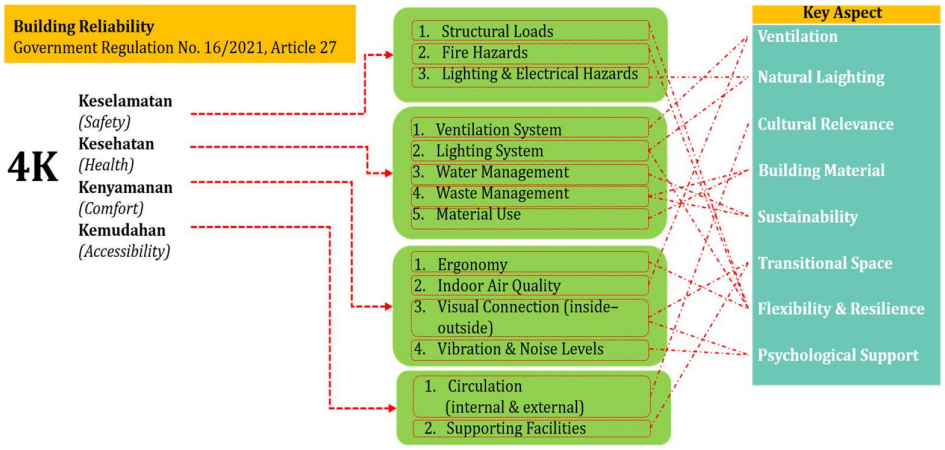



Figure 2. Key aspect building reliability
(Source: Author's analysis (2026) adapted from Government of the Republic of Indonesia, 2021)

The design criteria in this study are based on Indonesia's building reliability framework established in Government Regulation No. 16 of 2021, which identifies safety,

health, comfort, and accessibility as the fundamental requirements for buildings (Figure 2). For post-disaster housing, these criteria are expanded to include environmental adaptability, socio-cultural continuity, and psychological recovery. The criteria were validated through expert judgment using purposive sampling (Table 1). Seven experts participated, representing public health, disaster mitigation, engineering and architectural academia, and community-based post-disaster practice. This number is appropriate because the study emphasizes expert validation and criteria prioritization rather than statistical generalization. Methodological guidelines recommend expert panels of at least six and generally no more than ten members for content validation, making seven experts adequate for this study (Lynn, 1986; Yusoff, 2019).

**Tabel 1. Expert judgment respondent profile**

| Field of expertise | Minimum education | Experience | Relevance to the study |
|---|---|---|---|
| Public health | Bachelor's degree (S1) | > 10 years | Environmental health, community health, and post-disaster well-being |
| Disaster mitigation | Bachelor's degree (S1) | > 15 years | Disaster risk reduction, emergency response, and recovery planning |
| Architecture | Master's degree (S2) | > 15 years | Vernacular architecture, housing design, and climate-responsive design |
| Civil engineering | Master's degree (S2) | > 15 years | Building reliability, construction systems, and structural performance |
| Housing and settlement planning | Bachelor's degree (S1) | > 5 years | Settlement planning, housing reconstruction, and spatial development |
| Built-environment studies | Bachelor's degree (S1) | > 5 years | Sustainable design, resilient housing, and environmental performance |
| Community-based disaster recovery | N/A | N/A | Recovery experience |

The validated criteria were analyzed using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), a multi-criteria decision-making method for prioritizing post-disaster housing design criteria. TOPSIS ranks criteria by identifying those closest to the positive ideal solution and farthest from the negative ideal solution based on expert assessments (Thakkar, 2021).

**Step 1:** Normalization of the Decision Matrix

$$rij = \frac{xij}{\sqrt{\sum_{i=1}^{m} \quad xij^2}} \tag{1}$$

**Step 2:** Calculate weighted Normalised Matrix

$$V_{ij} = r_{ij} \times W_j \tag{2}$$

**Step 3**: Calculate the ideal best and ideal worst value, and calculate the Euclidean distance from the ideal worst.

$$S_i^- = \left[\sum_{j=1}^{m} \quad \left(V_{ij} - V_j^-\right)^2\right]^{0.5} \tag{3}$$

**Step 4**: Calculate Performance Score

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (4)$$

In these methods, ($r_{ij}$) represents the normalized value of alternative (i) for criterion (j), while ($x_{ij}$) represents the original score and (m) refers to the number of alternatives. The weighted normalized value ($V_{ij}$), is obtained by multiplying ($r_{ij}$) by the criterion weight ($w_j$). Furthermore, ($S_i^+$) and ($S_i^-$) indicate the distances of alternative (i) from the positive and negative ideal solutions, respectively. Finally, ($P_i$) represents the preference value or relative closeness to the ideal solution, where a higher ($P_i$) indicates a higher priority in the final ranking.

## 3. Results and Discussion

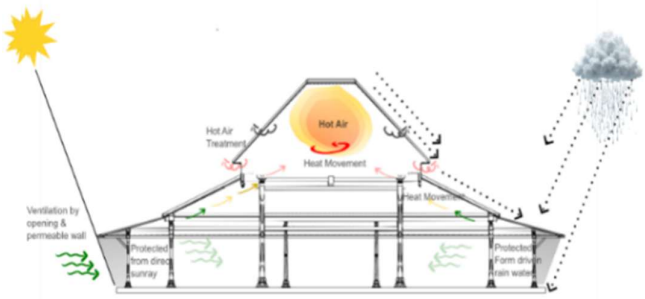
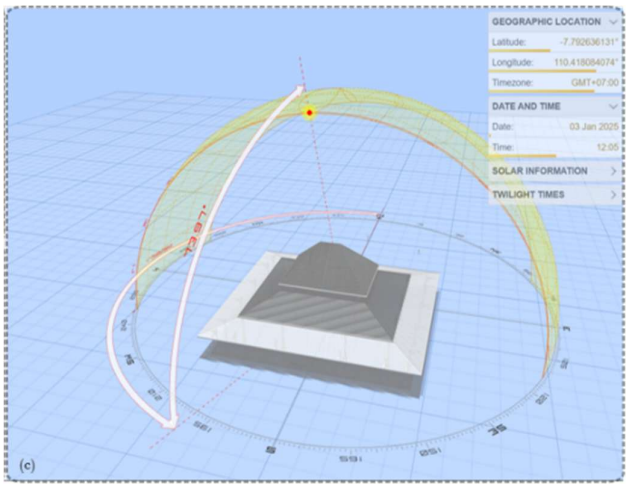
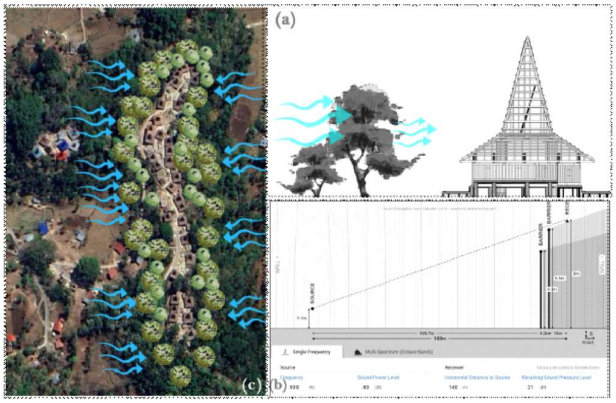
The design criteria were derived through a synthesis of vernacular architecture principles, healing environment variables, and building reliability requirements (Table 2). The resulting framework consists of eight operational criteria, which were then used for expert validation and TOPSIS-based assessment.

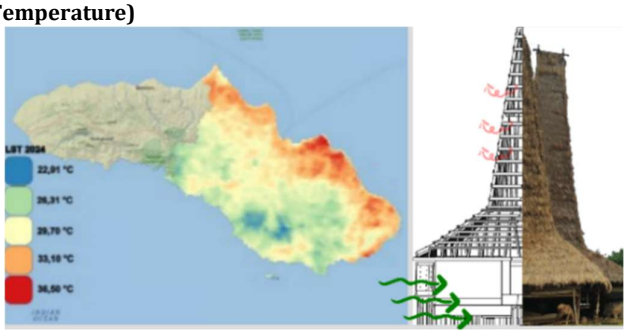
**Table 2. Selected and operational indicators**

| Code | Selected criterion | Vernacular architecture basis | Healing environment basis | Operational indicator | References |
|---|---|---|---|---|---|
| **C1** | Ventilation | Cross-ventilation, porous walls, and climate-responsive openings | Fresh air circulation and indoor air quality | Airflow path, openings, porous envelope, and passive ventilation | (Abdollahi Rizi et al., 2023; Zhang et al., 2024) |
| **C2** | Natural lighting | Building orientation and large openings | Daylight exposure and visual comfort | Daylight access, glare control, orientation, and circadian support | (Achsani et al., 2025; Nasrollahi & Shokry, 2020) |
| **C3** | Transitional spaces | Veranda, serambi, shaded terrace, and semi-outdoor space | Access to nature and stress-reducing spatial transition | Shaded semi-open areas, green buffer, social edge, and recovery space | (Yildirim et al., 2023) |
| **C4** | Building materials | Local, natural, and climate-adapted materials | Non-toxic, warm, and psychologically comforting materials | Local availability, durability, thermal comfort, and safety | (Almusaed et al., 2020) |
| **C5** | Cultural relevance | Local identity, symbolic forms, and participatory construction | Sense of belonging and community engagement | Local spatial identity, *gotong royong*, cultural familiarity, and social attachment | (Procentese & Gatti, 2023; Titisari et al., 2023) |
| **C6** | Flexibility and resilience | Adaptable vernacular typologies and modular forms | Ergonomic and adaptable spatial planning | Spatial flexibility, expandability, and post-disaster adjustment | (Doğan et al., 2026; Mehdizade & Ayoobi, 2026) |
| **C7** | Sustainability | Passive design, material efficiency, and climatic adaptation | Low-energy design and biophilic elements | Energy efficiency, local resources, passive cooling, and ecological response | (Anand et al., 2023; Mehdizade et al., 2026) |
| **C8** | Psychological support | Symbolic meaning, privacy gradients, and community rituals | Safety, control, and emotional well-being | Perceived safety, privacy, user control, personalization | (Hagerup et al., 2025; Sui et al., 2023) |

The synthesis of vernacular architecture and healing environment principles suggests that post-disaster housing requires an integrated design approach that brings together multiple dimensions rather than treating them in isolation (Table 3).

**Table 3. Design synthesis and related criteria**

| Visual evidence | Key design synthesis | Relevant design criteria |
|---|---|---|
| **Construction form and acclimatization of Javanese houses**   | Illustrates shaded roof forms, cross-ventilation, protected openings, and passive climatic adaptation in traditional Javanese houses. | Ventilation **(C1)**; natural lighting **(C2)**; transitional spaces **(C3)**; thermal comfort |
| **Solar Spherical in the majority of the Central Java region of Javanese houses**   | Indicates how orientation and solar exposure can be used to reduce heat gain while maintaining daylight and airflow. | Natural lighting **(C2)**; ventilation; climate-responsive orientation |
| **Traditional settlement of *Prai Ijing* Sumba and Simulation of noise level reduction**   | Shows clustered settlement, native vegetation, and vegetative barriers that support microclimate, visual quality, and environmental comfort. | Transitional spaces **(C3)**; access to nature; psychological support **(C8)**. |

| Visual evidence | Key design synthesis | Relevant design criteria |
|---|---|---|
| **Traditional East Sumba building features a thatched roof and a cross-ventilation system responding to high LST (Land Surface Temperature)**   | Shows porous local materials, thatched roof, high roof form, and cross-ventilation as responses to hot and dry climatic conditions. | Building materials **(C4)**; ventilation **(C1)**; sustainability **(C7)**; thermal comfort |
| **House Lingga in the Batak Karo House**   Adapted from Indonesia House, 2008 **(Schefold & Nas, 2008)** | Highlights local structural knowledge, hardwood elements, palm fiber roofing, durability, and cultural meaning in construction details. | Building materials **(C4)**; cultural relevance **(C5)**; durability; local knowledge |

The TOPSIS analysis produced performance scores ranging from 0.474 to 0.504, indicating that all criteria contribute meaningfully to post-disaster housing performance (Table 4). The relatively narrow range of scores suggests that these factors should not be interpreted as a rigid hierarchy, but rather as a set of interrelated priorities within an integrated design framework.

Building materials (C4; Pi = 0.504) ranked highest, highlighting the central role of material selection in overall performance. This can be understood through the direct influence of materials on construction feasibility, thermal comfort, local resource availability, cultural familiarity, and long-term maintenance. In post-disaster contexts, the use of locally available and climate-responsive materials is particularly important, as it reduces dependence on external supply chains, accelerates reconstruction, lowers transportation costs, and supports community-based building processes. This finding aligns with previous studies emphasizing that post-disaster housing should not rely solely on rapid, standardized construction, but also consider local building traditions, environmental conditions, and residents' capacity to maintain their homes over time (Wang & Ng, 2023). In practical terms, this suggests that material selection should be approached as a strategic design decision rather than merely a technical one. Designers and policymakers need to prioritize materials that are accessible, durable, climate-appropriate, familiar to residents, and compatible with local construction knowledge.

**Table 4. TOPSIS performance score and ranking**

| Rank | Code | Design criterion | VA principles | HE principles | (Si+) | (Si-) | Performance score (Pi) |
|---|---|---|---|---|---|---|---|
| | | **Weight** | **0.51** | **0.49** | | | |
| 1 | C4 | Building materials | 0.40 | 0.30 | 0.072 | 0.073 | 0.504 |
| 2 | C3 | Transitional spaces | 0.33 | 0.37 | 0.073 | 0.072 | 0.496 |
| 3 | C5 | Cultural relevance | 0.39 | 0.31 | 0.063 | 0.062 | 0.495 |
| 4 | C8 | Psychological support | 0.34 | 0.37 | 0.068 | 0.066 | 0.491 |
| 5 | C2 | Natural lighting | 0.38 | 0.33 | 0.055 | 0.050 | 0.478 |
| 6 | C1 | Ventilation | 0.36 | 0.35 | 0.055 | 0.050 | 0.475 |
| 7 | C6 | Flexibility and resilience | 0.36 | 0.35 | 0.055 | 0.050 | 0.475 |
| 8 | C7 | Sustainability | 0.37 | 0.34 | 0.054 | 0.049 | 0.474 |
| | | **V+** | 0.33 | 0.30 | | | |
| | | **V-** | 0.40 | 0.37 | | | |

Transitional spaces (C3; Pi = 0.496) ranked second. Semi-open areas such as verandas, shaded terraces, and communal edges play an important role in supporting passive cooling, encouraging social interaction, and facilitating gradual psychological recovery. These spaces also offer functional flexibility, as they can be adapted during emergencies into evacuation areas, temporary shelters, emergency kitchens, or distribution points (Celentano et al., 2019; Wang et al., 2023).

Cultural relevance (C5; Pi = 0.495) and psychological support (C8; Pi = 0.491) also ranked highly, reinforcing the idea that post-disaster housing should restore not only physical safety but also a sense of identity, belonging, and emotional security. Cultural relevance may be expressed through familiar spatial patterns, local construction practices, symbolic forms, and participatory design processes (Lazar & Chithra, 2022). Psychological support, on the other hand, can be addressed through perceived safety, privacy, user control, opportunities for personalization, and access to calming environmental features.

Although natural lighting, ventilation, flexibility, resilience, and sustainability received relatively lower scores, the difference between the highest and lowest values is only 0.030. This small gap indicates that these aspects should not be considered less important. Rather, the findings point to the need for a balanced approach, where material, spatial, cultural, environmental, and psychological considerations are integrated to achieve resilient post-disaster housing.

The findings are consistent with previous studies emphasizing that housing after disasters should address not only immediate shelter needs, but also environmental, cultural, and psychosocial recovery (Wang et al., 2023). The high ranking of building materials reinforces earlier research highlighting the importance of using local, durable, and climate-responsive materials to accelerate reconstruction, reduce dependence on external supply chains, and support long-term maintenance (Celentano et al., 2019). Similarly, the prominence of transitional spaces aligns with both vernacular and healing environment principles, which underline the role of semi-open areas, ventilation, access to outdoor spaces, and opportunities for social interaction in supporting comfort and recovery.

At the same time, these results need to be interpreted with some caution. The use of expert judgment introduces a degree of subjectivity, as the assessment is shaped by the experts' backgrounds, experiences, and disciplinary perspectives (Lynn, 1986). Although the selected experts represent relevant fields, their evaluations may still reflect specific contextual preferences. For this reason, the TOPSIS ranking should be understood as a structured indication of relative priorities rather than a fixed or absolute hierarchy.

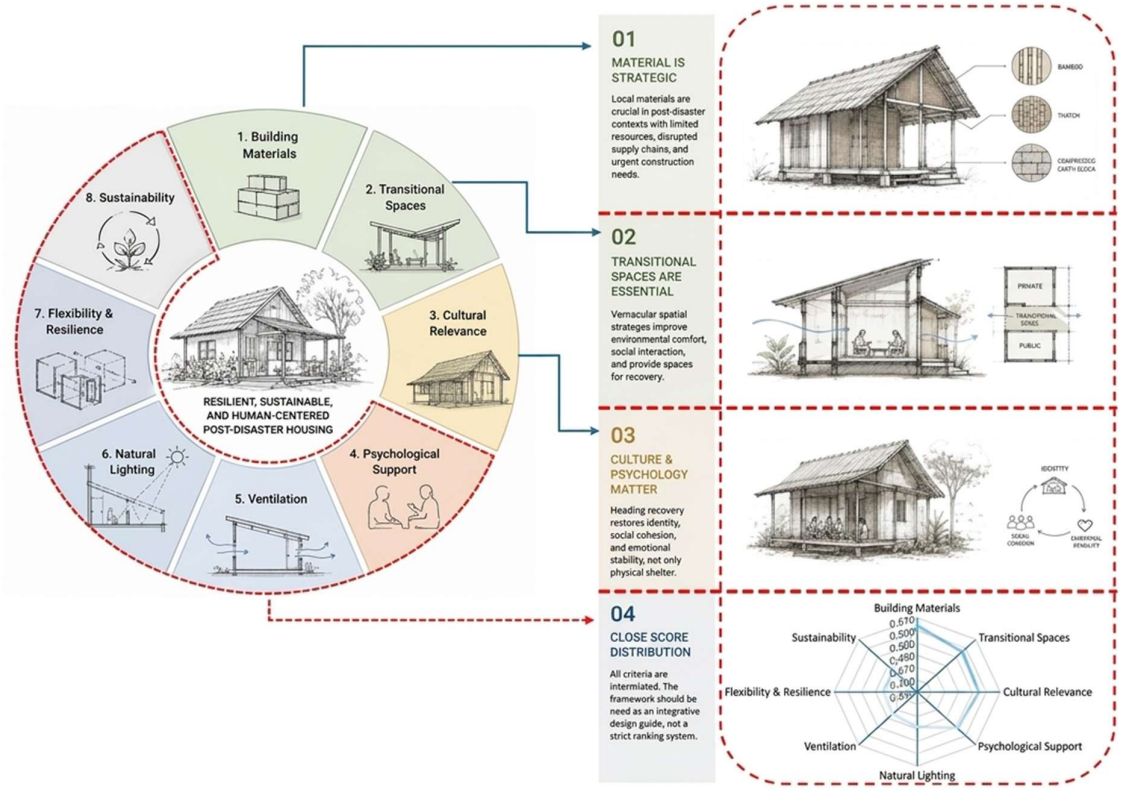



Figure 3. Integrated design framework for post-disaster housing

This study also has several limitations. The number of experts is relatively limited, the framework has not yet been tested in a real post-disaster housing context, and the TOPSIS method itself cannot fully capture complex interactions between criteria. Future research should focus on applying this framework in actual housing projects, involving residents as end users in the evaluation process, and comparing the results with other multi-criteria decision-making methods.

## 4. Conclusion

This study shows that housing design after disasters requires an integrated framework that brings together principles of vernacular architecture and healing environments. Its main contribution lies in translating environmental adaptability, cultural continuity, and psychological recovery into measurable and operational design

criteria. Through expert validation and TOPSIS analysis, eight key criteria were identified: ventilation, natural lighting, transitional spaces, building materials, cultural relevance, flexibility and resilience, sustainability, and psychological support.

The findings highlight building materials, transitional spaces, cultural relevance, and psychological support as the most influential factors. At the same time, the relatively small differences among the TOPSIS scores suggest that no single criterion should dominate the design process. Instead, effective housing solutions should balance local materials, passive environmental strategies, semi-open spatial configurations, cultural identity, and restorative spatial qualities within a cohesive approach.

The proposed framework contributes to the field by offering a structured way to prioritize design considerations that are technically reliable, environmentally responsive, culturally grounded, and supportive of occupant well-being. In practice, it can assist architects, planners, and disaster recovery stakeholders in developing housing strategies that address both immediate shelter needs and longer-term community recovery.

Future research should focus on validating this framework through comparative case studies across different disaster-prone regions in Indonesia, including coastal tsunami-prone areas, earthquake-affected rural settlements, volcanic relocation sites, and flood-prone communities. Field-based validation and post-occupancy evaluations will be important to assess how these criteria perform in real reconstruction contexts and how they can be adapted to specific socio-cultural and environmental conditions.

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