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Pollack Periodica • An International Journal for Engineering and Information Sciences

20 (2025) 2, 153–159

DOI:
10.1556/606.2024.01212

ORIGINAL RESEARCH PAPER

A methodological framework for sustainable housing for displaced populations

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Received: August 13, 2024 • Revised manuscript received: September 15, 2024 • Accepted: September 16, 2024
Published online: November 20, 2024

ABSTRACT

This research highlights the role of sustainability aspects focusing on socio-cultural parameters and environmental performance in designing more comfortable and sustainable shelters. Following a two-mixed method approach, on the one hand, a comparative analysis is presented of IKEA Better Shelter, Rwandan Mud-Brick, and Nepali shelters by examining the cultural integration into their design (traditional layouts and shared spaces), their adaptability, and their environmental performance. On the other hand, a qualitative survey determines the level of satisfaction regarding space, comfort, social interaction, and cultural fit among residents. The results show that traditional building methods with the use of local materials, offer high privacy levels, excellent thermal and acoustics comfort, good cultural appropriateness and minimal environmental impact.

KEYWORDS

sustainable shelter, cultural suitability, environmental impact, refugee satisfaction, socially integrated, Thermal comfort

1. INTRODUCTION

The increased number of conflicts in many countries around the world has resulted in millions of refugees who need secure places to be hosted. Shelters and refugee camps provided by governments and international organizations, including the International Committee of the Red Cross (UNHCR), and other Non-Governmental Organizations (NGOs), often do not meet user satisfaction and are considered unsustainable [1]. Most of them have led to unsuccessful issues. These solutions are often more concerned with the units' technical aspects than with the people who will inhabit them, resulting in culturally inadequate and locally inappropriate designs. Moreover, the implemented solutions have been economically and environmentally unsustainable [2].

Temporary housing, which is provided in post-disaster situations - whether due to natural disasters or man-made disasters like wars - offers a fast solution but not always an effective one, especially when sustainability and cultural adequacy are considered. In most cases, temporary units are designed by specialists from other countries who are not familiar with the contexts where disasters occur or are universal prototypes that do not fit all climate conditions and contexts. As a result, they often fail to meet the needs and culture of disaster survivors or refugees, [3]. Standard solutions tend to ignore the real needs of users, variations in cultural values, climatic differences, family size variations, and the diversity of local housing architecture, among other parameters.

The significance and need for shelters that can last for a long time are increasing globally, as no nation is immune from the effects of natural disasters [4].

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Disasters are resulting in a huge number of displaced populations which in many cases stayed in a shelter with minimum needs for decades and that highlights the need for more permanent dwellings [5].

However, the quality of life within existing shelters and temporary settlements can vary significantly. This study, on the one hand, assesses inhabitant satisfaction in shelters and refugee camps, aiming to identify key factors to improve their quality of life and ensure their comfort within this type of housing [6]. On the other hand, it aims to integrate sustainability aspects focused on cultural appropriateness, social inclusiveness, and environmental impact into the design of shelters and temporary settlements. To achieve this, a comparative analysis examines three case studies: IKEA Better Shelters in the Azraq camp (Jordan), Mud-Brick shelters in Mahama Settlement (Rwanda), and temporary housing units in Nepal after the 2015 earthquake. This analysis focuses on how these projects integrate social and cultural considerations in addition to the use of sustainable materials.

Shelter plays an important role in a sensitive period of people's lives, providing a space to live with dignity, security, and comfort. Therefore, it is essential for people to feel socially integrated and to develop a sense of belonging. A house is also a source of pride and cultural identity; losing a home means more than just physical poverty - it signifies losing dignity, identity, and privacy. In some cases, users frequently abandon or modify the provided shelter, which can in turn affect the safety conditions of the structure [7]. Additionally, since most temporary units are universal prototypes, produced in industrialized countries and requiring importation and transportation to the sites where they will be placed, they can be very expensive when compared to their lifespan. They can cost as much as a permanent house or even up to three times more [8]. Furthermore, the unplanned disposal of units after use makes them unsustainable solutions.

Through the utilization of a questionnaire survey administered to refugees specifically, this study aims to represent their actual needs and experiences. This comprehensive information will reveal existing issues and guide the development of better architectural solutions in time, this will improve the conditions under which displaced people live for years to come, advancing a sense of safety, respect, and well-being.

In shelters, people can return to some of their household responsibilities and daily routines, [9]. However, people cannot stay in shelters for a long time, as these environments do not support the full resumption of daily life. Reconstruction work often takes a long time after natural disasters, and in refugee situations, the period for examining asylum applications is usually prolonged. Thus, there is a time gap that needs to be bridged, and temporary housing seems to be the clear solution, [10]. Temporary housing is a space that provides for social, spiritual, and psychological needs. Therefore, solutions should be designed with the users' point of view in mind. The needs and expectations of the user should come first in the design of shelters, not form or aesthetics.

Beyond user satisfaction, the research investigates the integration of sustainability aspects into shelter design. This includes eco-cultural aspects and their environmental impact. This mixed approach aims for the development of more sustainable and socially responsible housing solutions for displaced populations. Most researchers and engineers agree that sustainable settlements are characterized by their ecological efficiency, structural resilience, and social inclusivity. They integrate design strategies that minimize environmental impact, enhance resource utilization, and improve building performance. Moreover, these settlements are designed to resist and recover from natural hazards while providing at the same time access to infrastructure, facilities, and opportunities for all inhabitants.

2. METHODOLOGY

This study uses a mixed-methods approach, first A comparative analysis of three case studies, which are: IKEA Foundation Shelters (Jordan), Mahama Settlement (Rwanda), and Nepal's post-2015 earthquake housing were made based on the architectural form, spatial organization, and sociocultural factors that allows for better understanding the successful strategies used in this projects, in the same time, a structured questionnaire was constructed and shared to collect both quantitative and qualitative data on inhabitant satisfaction in shelters and refugee camps. The survey concentrates on essential aspects including safety, the availability of necessities (food, water, sanitation), the quality of shelters (space, privacy, acoustic and thermal comfort), and opportunities for social interaction. The questionnaire was developed and administrated using Google Forms to include both closed-ended and open-ended questions and distributed to residents using social media tools and a field visit to a refugee camp in Germany. The closed-ended questions were automatically gathered and analyzed by Google Forms while the open-ended questions were carefully reviewed and analyzed by the author. Understanding refugees' personal experiences and suggestions is very important for future designs. The study aims to develop design guidelines that enhance shelter performance, well-being, and community resilience in crisis contexts.

2.1. Technical terms

- *Thermal comfort in shelter*: is the state at which occupants do not feel either too hot or too cold, which plays an important role in occupant's well-being and health;
- *Acoustics Comfort*: means avoiding or minimizing the noise to create a comfortable environment, which is important for the mental health of the occupants in the overcrowded shelter;
- *Cultural integration*: in shelter design means the creation of a shelter that respects the occupants' traditions, customs, and social way of life, therefore, promoting dignity, and cohesiveness.

3. CASE STUDIES DESCRIPTION

Three projects were analyzed in this paper which are:

3.1. The Azraq Refugee Camp "IKEA Foundation Emergency Shelters", The Better Shelter, (Jordan)

The Azraq Refugee Camp in Jordan implements the IKEA Foundation's "Better Shelter" units, which are modular, prefabricated shelters made of durable, lightweight materials and have a life span of up to three years for accommodating over 5,000 refugees. These shelters provide essential protection against harsh weather conditions including insulated panels, solar-powered lighting, and ventilation options [11]. While these shelters are known for their structural resilience and quick response, unfortunately, they are criticized for their limitation of social inclusion and cultural integration [12]. The shelters may not 100% have met the social and cultural needs of the refugees, even though they include features like clotheslines and private courtyards to accommodate some of their customs. Each IKEA shelter has a space of about 17.5 square meters, generally an adequate room for a small family but not suitable for larger families. The shelter includes design features like lockable doors and curtains that allow a moderate level of privacy. However, due to the small size of the shelter, personal space within the unit is usually limited for families, which can affect the overall sense of privacy. While private courtyards are a positive feature, they are not always sufficient for large families. In terms of thermal and acoustics comfort, IKEA Better Shelter provides basic insulation from extreme temperatures, an important feature in these harsh desert environments of Jordan. They possess very limited thermal mass, struggling to maintain extremely hot temperatures during the day and cold at nighttime. They also have ventilation options; these are not always adequate to offer comfort when the temperatures are high. In Addition to that, the few soundproofing properties of the prefabricated plastic and metal walls make it difficult to block out the noise coming either from other shelters or the outside environment.

3.2. Mahama Refugee Settlement," The Mud bricks Shelters" (Rwanda)

The Mahama settlement in Rwanda is the largest refugee camp in Rwanda, which consists of over 6,928 houses, was founded in 2015 with the purpose of housing Burundian refugees. The settlement was created by the UNHCR and Rwandan governments in a way that enables it to change with the requirements of families over time, ensuring long-term needs in environmentally sustainable manner [13]. To reduce negative environmental effects, great consideration has been given to infrastructure, construction materials, and layout [14]. The shelters are built using traditional Rwandan techniques, with materials like thatch and mud bricks. These homes are constructed by the community and provide long-term, durable, semi-permanent housing [15]. The area of Mud-Brick shelters differs but normally they are larger than IKEA units and adapt better to family size. The design and construction of Mud-Brick shelters often afford the household more flexibility in layout, which can involve better partitioning of their space for privacy. Moreover, Mud-Brick shelters have superior thermal regulation because of the thermal mass from the earth's materials used to keep interiors cool during the day and warm at night. In light of that, it would be appropriate in the moderate climate of Rwanda. Acoustically, the thick walls of mud bricks can offer better sound insulation compared to the lightweight material used in IKEA shelters. Therefore, it offers the residents a quieter living environment.

3.3. The Temporary Housing Units and Settlements After the 2015 Nepal Earthquake (Nepal)

After the terrible 2015 earthquake in Nepal, governments and international organizations provided the displaced population with over 1,000 temporary shelters made of lightweight and locally available materials like bamboo, corrugated metal sheets, and tarpaulins [16]. While these shelters offered the displaced population basic protection from the weather, they were frequently criticized for being unstable and unable to accommodate their long-term demands [17]. This type of shelter is good for emergency relief for the affected communities to feel secure and stable. The design considered traditional building techniques and incorporated features like open courtyards for social interaction, respecting Nepalese cultural norms. These temporary housing units have a small area, usually around 15–20 square meters, which is often inadequate for larger families. Also, they do not offer flexibility or modification over time, which makes them suitable only for short time. Moreover, they offer a minimal internal privacy within the unit between the occupants as well as the external privacy, while the units are close to each other in the temporary settlements. In terms of thermal and acoustic comforts the temporary housing units in Nepal have been made from materials that provide a limited level of thermal comfort like bamboos, woods, and tin sheets, while the problem with tin sheets is overheating in sunlight and resultant noise during rainfall. It provides a limited protection against cold, which becomes is problematic in Nepal's mountainous regions during winter.

The acoustic comfort is also compromised, especially with tin roofs amplifying the sound in rain and wind, resulting in uncomfortable living environment.

4. RESULTS AND DISCUSSION

4.1. Case studies, analysis, and results

The results of the Settlement-level analysis reveal significant differences in cultural, social, and sustainable aspects across the three locations. Azraq Refugee Camp in Jordan showcases.

Modular shelters lack cultural integration, whereas Nepal's temporary settlements emphasize community involvement

and traditional architecture. Mahama Refugee Settlement in Rwanda combines cultural validity with local materials.

At the shelter level, the better IKEA shelters perform more on cultural expression, while the shelters in Nepal and Rwanda have a higher cultural level. Sustainable practices are particularly evident in Nepal and Rwanda and focus on local materials and resources. Although IKEA's shelter has a solar panel, it has a greater impact on the environment due to its manufacturing and transportation. This highlights the importance of considering cultural and environmental factors when designing temporary shelters (see Table 1).

The environmental impact of these shelters varies significantly. The Ikea Better Shelter is made of plastic and metal and requires a lot of energy for production and transport. But its solar panels help to eliminate the energy used for operation. However, the shelters in Rwanda and Nepal, which use locally available materials like straw, bamboo, wood, and mud, have lower embodied energy since they require less processing and shipping. Every shelter has simple systems for managing water, and very little is done to conserve it. Despite producing little waste in the building process, the Ikea shelter presents recycling difficulties due to its plastic components. The use of consumable materials in the shelters in Rwanda and Nepal, on the other hand, results in less trash production (see Table 2).

4.2. Survey results

The survey concentrates on social and cultural issues of shelters provided in refugee scenarios, in addition to the essential aspects including area adequacy, privacy, and acoustic and thermal comfort within the shelter, aiming to assess the overall satisfaction within the shelter environment.

100 persons from different countries (50 persons are Syrian, 9 are Turkish, 8 are Algerian, 8 are Iraqi, 8 are Afghan, 5 are Palestinian, 4 are Ukrainian, 2 are Jordanian, 2 are German, 1 is Yemanian, 1 is Russian, 1 is Sudanese.) have responded to the questionnaire. Most of the respondents are Refugees or Asylum seekers in Germany.

Table 1. A comparative study between three different case studies according to different factors: Type of shelter used, Social and cultural integration, Natural Ventilation and lighting, Water management, and Adaptability

Case study/Sustainable strategies	The Azraq Refugee Camp in Jordan	The Mahama settlement in Rwanda	The Temporary Housing Units and Settlements in Nepal
Type of shelter used	IKEA Better Shelter (Modular Prefabricated Shelter)	Traditional Mud Brick Shelter (Community-Built Semi-Permanent Shelter)	Temporary Transitional Shelter (Locally Constructed Transitional Shelter)
Cultural Integration and Social Spaces Existence (settlement)	- Limited cultural elements and materials. - Organized but initially isolated.	- Uses traditional Rwandan architectural elements and local environmentally friendly materials (mud bricks, thatch). - Community-centric, resident participation.	- Incorporates traditional Nepali designs and locally sourced materials like bamboo, and timber. - Community-driven, resident involvement.
Natural ventilation and lighting	Basic +	++++++	++++++
Water management	Limited, advanced systems but reliant on external supply	Basic system	Basic systems, some greywater reuse
Adaptability	Modular, easy to assemble	Customizable, community-driven construction	Adaptable, community-involved construction

Table 2. Summary table of environmental impact

Aspect/Case study	Azraq Refugee Camp (Jordan)	Mahama Refugee Settlement (Rwanda)	Nepal Temporary Settlements
Material Usage	Prefabricated, high embodied energy	Local materials, very low embodied energy	Local materials, low embodied energy
Energy Consumption (Construction)	Moderate due to modular design	Very low due to traditional methods	Low due to simple design
Energy Consumption (Operational)	Solar panels for lighting	Very low, natural ventilation and lighting	Low, natural ventilation and lighting
Water Usage and Management	Basic systems, reliance on external	Basic systems, potential for rainwater harvesting	Basic systems, some greywater reuse
Waste Generation	Minimal during construction	Minimal, high recyclability	Low, high recyclability

4.2.1. Type and condition of living in the shelter. Out of the 100 survey respondents, 11 indicated that they had never lived in a temporary shelter before. Among those who have experienced temporary shelters, 28 have lived in tents, which are considered a traditional short-term shelter type. Additionally, 19 respondents have lived in prefabricated shelters, which offer a more structured and semi-permanent solution. Another semi-permanent housing alternative that 27 people have mentioned is living in caravans.

Shelters made from local materials, representing vernacular and often culturally relevant solutions, have housed 5 respondents. Furthermore, 9 respondents have lived in semi-permanent or permanent housing, which are typically more organized, long-term shelter solutions. Finally, one respondent has experienced working on these types of housing, providing a unique perspective on their functionality and effectiveness. Table 3 presents a comparative study between the different types mentioned by the respondents according to the area, privacy, thermal and acoustic comfort, social and cultural suitability.

Based on information gathered from the literature review about the above-mentioned shelter types, the comparative study results:

- Tents offer very little comfort and are intended to be temporary structures, suited for the short term, which makes them inadequate for long-term stay.
- Compared to tents, the Prefabricated Shelters and Caravans offer a better structure and insulation, but they also still have very poor cultural integrations and suitability for long-term stays.

While shelters made from local materials show a highly positive performance, both for environmental sustainability and for their cultural fitness. They guarantee better thermal comfort and privacy.

Permanent housing/semi-permanent is the most ideal long-term accommodation for comfort, privacy, as well as cultural integration, but in emergencies, they may not be deployable.

This comparison provides an understanding of the benefits and the issues associated with each shelter type, highlighting the importance of designing solutions that take into consideration shelter and safety priorities, on the one hand, and cultural and social inclusion, on the other.

4.2.2. The duration of stay in a shelter according to the occupants' response. The results show a variety of the duration of occupancy by the respondents, understanding these durations is important for designing shelters that meet both urgent and extended needs (see Fig. 1).

The findings about the area adequacy show a variability of response and this means that shelter designs may not be universally effective in meeting the diverse needs of residents. Re-evaluating designs focusing on providing sufficient space could significantly improve living conditions by enhancing comfort and reducing stress for shelter occupants (see Fig. 2).

4.2.3. Social sustainability in shelters. In a survey assessing social connectivity within shelters on a scale from 1 to 5 (with 1 being strongly agreed), the responses were as follows: 33 respondents rated their sense of social connection as 3, 29 rated it as 2, 21 rated it as 4, 9 rated it as 1, and 8 rated it as 5.

Results show that the shelter environment is characterized by a huge range of considered social connections and

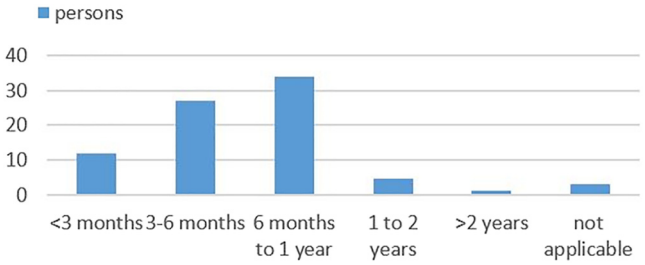

Fig. 1. A chart explaining the duration of stay of the respondents in the shelter

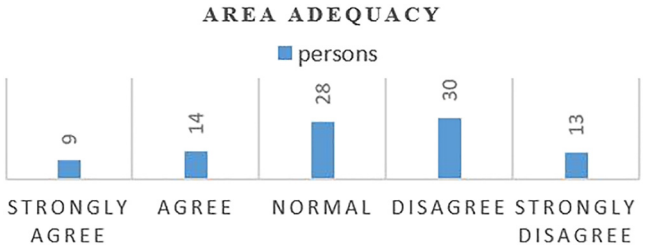

Fig. 2. The respondent's satisfaction with the area adequacy

Table 3. A comparative study of the shelter types provided across different factors crucial for refugee comfort and well-being

Shelter Type	Tents	Prefabricated Shelters	Caravans	Shelters made from local materials	Heims/Permanent Housing
Area	Minimal space	Moderate space, semi-permanent	Moderate but compact space	Flexible, can be extended	Large, organized spaces
Privacy	Very low	Moderate	Moderate	High	High
Thermal and Acoustic Comfort	Minimal insulation and soundproofing	Moderate, improved insulation but still limited	Moderate; some insulation, but can overheat	High; good insulation and soundproofing	High; well-insulated, good soundproofing
Social and Cultural Suitability	Low	Often limited, standardized designs	Low; culturally neutral design	Very high; reflects local culture and traditions	High; long-term cultural integration possible

available common areas. Many respondents reported having some social interaction opportunities but showed relatively low levels of connection which could obstruct stronger community formation. On the other hand, a considerable number experienced a lack of connection, probably due to a lack of communal spaces. They imply that spatial design is crucial in creating social cohesion in shelters. To promote a strong community carry-off among inhabitants, there should be a proper delineation of communal spaces for various purposes.

4.2.4. The noise levels assessment in shelters. The survey evaluates noise levels at different times of the day (see Fig. 3).

- In the morning, 16 respondents find the noise level very high, 24 find it high, 33 find it low, 17 find it very low, and 9 find it almost non-existent;
- In the afternoon, 17 persons report very high noise levels, 44 find it high, 27 find it low, 3 find it very low, and 2 find it almost non-existent;
- In the evening, 30 respondents experience very high noise levels, 35 find it high, 19 find it low, and 10 find it very low;
- At night, 16 respondents report very high noise levels, 16 find it high, 45 find it low, 16 find it very low, and 4 find it almost non-existent.

The results present significant variations in the noise levels throughout the day. The majority of respondents report that the noise increases in the afternoon and evening, At night, while many respondents (45) find noise levels low, there is still a group of 32 who experience high to very high noise levels, causing some trouble to the inhabitant comfort and bothering their sleep and rest period.

The research underscores the critical role of acoustic design in enhancing shelter environments. Excessive noise levels, particularly during evening and nighttime hours, negatively impact resident well-being. To mitigate these issues, architectural strategies should prioritize sound insulation through careful material selection and construction techniques. The spatial organization of shelters should incorporate dedicated quiet zones, separate from high-traffic or noisy areas. By optimizing acoustic performance, shelter environments can significantly improve resident comfort and quality of life.

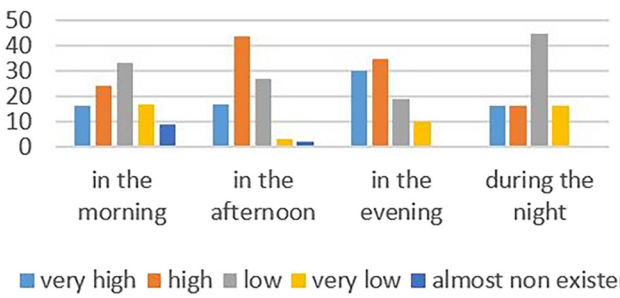

Fig. 3. A chart representing the respondent's perception about the noise level within a shelter

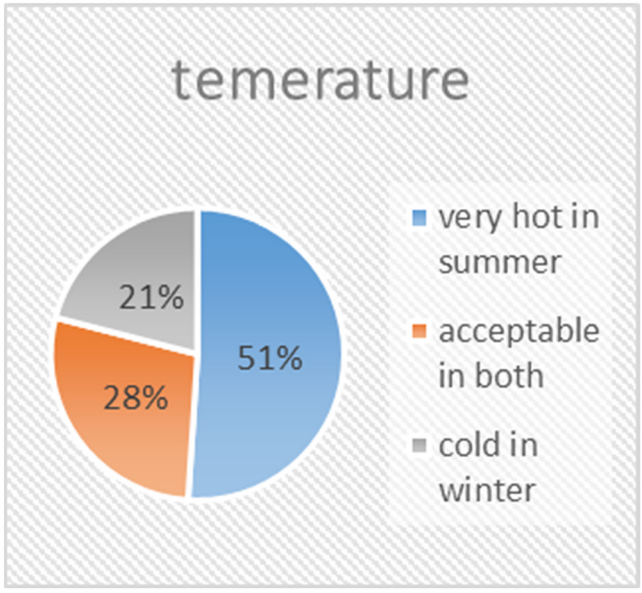

Fig. 4. The temperature level within a shelter

4.2.5. Temperature and thermal comfort in shelters. The data from the survey shows that there is a lot of thermal discomfort inside shelters. Overheating conditions dominated, with more than half of the respondents complaining about overheating during summer. It is noteworthy, however, that during winter, a considerable number were cold, so neither type of required amount of thermal control was met. These results demonstrate a need for shelter designs with far better thermal performance.

These problems should be resolved by using architectural interventions aimed at enhancing passive and active climate control strategies. Passive design principles concerning ideal orientation, shading devices and natural ventilation will prevent overheating during the summer. The incorporation of thermal mass materials and insulation may compensate for both cold and hot seasons. Appropriate active systems - like energy-efficient heating and cooling technologies - may be used to support additional comfort. Some focus points for generally enhancing occupant well-being and the performance of the shelter through better design for thermal comfort (see Fig. 4).

5. CONCLUSION

The purpose of this study is to further propose the complexities that these temporary shelter arrangements are supposed to address by considering three shelter types: IKEA Better Shelters, Mud-bricks shelters in Rwanda, and temporary housing units in Nepal. In this light, the findings emphasize the critical interplay between cultural, social, and environmental factors of whether these solutions work in practice.

Cultural and Social Integration: Traditional building methods and the use of local materials, like as in the Mud-Brick shelters in Rwanda, offer a greater level of cultural appropriateness, and result in closer social ties among the

inhabitants. The IKEA Better Shelter and other modern prefabricated and modular designs often offer lower levels of cultural resonance, which might limit social integration.

Environmentally Sustainable: The use of locally sourced materials and the adoption of traditional construction techniques are seen in the Mud-Brick shelters and to some extent in the Nepali housing units. They significantly reduce the ecological impact of shelter construction and operation but it still has issues related to waste management and water conservation.

Living Conditions: The quality of life within the shelter space is determined by aspects of comfort, privacy, and noise. Inadequate insulation, ventilation, and soundproofing generate stress and discomfort among the occupants of shelters.

Recommendations for the proposed challenges include that future shelter designs shall be in a way that they are culturally appropriate, environmentally sustainable, and friendly to the occupant's concerning well-being. It needs incorporation and balancing of both passive and active design strategies to optimize thermal comfort. Most importantly, there needs to be special attention toward spatial organization, sound insulation, and waste management so that results in healthy and resilient living environments for the displaced population.

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