University of Pécs
Faculty of Engineering and Information Technology
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PÉCSI TUDOMÁNYEGYETEM
UNIVERSITY OF PÉCS

SUSTAINABILITY IN CRISIS: AN EFFICIENT METHODOLOGICAL APPROACH FOR ENHANCING THE SHELTER DESIGN AND ADDRESSING THE NEEDS OF THE DISPLACED POPULATION

PhD. Thesis Booklet

The degree of Doctor of Philosophy in Architectural Engineering

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"Architecture must not only provide shelter but also the possibility of dignity and hope, especially in temporary structures."

Shigeru Ban "Architect"

"Governments should stop thinking about refugee camps as temporary places, these are the cities of tomorrow. "

Kilian Kleinschmidt" UNHCR 'director of the Zaatari refugee camp"

1.1 BACKGROUND OF THE RESEARCH

In recent decades the number and frequency of natural disasters and man-made disasters such as wars have increased. Due to climate change, Natural Disasters like explosions, earthquakes, floods, hurricanes, storms, or fires have become more frequent [1]. Meanwhile, Wars and conflicts have existed throughout history and remain ongoing like the current conflicts in the Middle East, Africa, and even Europe [2].

Every Year due to the effects of disasters, millions of people face the danger of death or physical injury, they may also lose their homes and properties and become homeless. Disasters may also cause economic and environmental issues and serious damage to structures and infrastructures [3].

The role of architecture in the humanitarian sector has been summarized as delivering quick shelter for the displaced population [4]. However, the challenge is that these shelter solutions do not consider the long-term needs for habitability and sustainability in terms of economic, socio-cultural, and environmental levels.

Sustainable shelter design must follow the three pillars: environmental, social, and economic. [5] Environmentally, shelters shall have low impacts through the use of sustainable materials and efficient construction methods that also offer the potential for reuse or recycling. In the social aspect, shelters should respect the cultural practices, the existence of places to communicate and worship, and the daily routines of the inhabitants. In terms of economics, shelters should be affordable in their construction, transportation, and their maintenance.

Many existing shelter solutions are culturally isolated, environmentally harmful, and economically inefficient. They fail to meet the sustainability goals due to the fact of choosing construction materials and methods for their availability and ease of transport rather than their long-term suitability or environmental impact.

This dissertation focuses on improving and developing a design framework for future sustainable shelter solutions that respond to the needs of displaced populations at the same time while ensuring sustainability in terms of socio-cultural aspects and environmental impact. The framework is then applied to propose a design aimed at enhancing the living conditions of the inhabitants of the Accumoli post-disaster settlement.

1. RESEARCH AIM AND OBJECTIVES

This study aimed to assess the current shelter solutions to identify opportunities for improvements and set strategies for enhancing this type of housing by developing a comprehensive design framework for emergency shelters that addresses the sustainability aspects: economic, Environmental, social, and cultural adaptability, in addition to the real needs of displaced populations.

To achieve the main aim of the study, there was a need to meet the following objectives:

1. To understand the role of temporary houses in post-disaster and refugee scenarios explore the existing shelter solutions, and compare case studies to learn from past experiences.
2. To identify gaps and challenges in existing shelter designs, including issues related to sustainability, durability, assembly, and user satisfaction.
3. To determine the similarities and differences of existing solutions by Comparing prefab modular Global shelters with local traditional shelter types in terms of both quantitative and qualitative factors: Assembly time, capacity, cost, Area, lifespan, Ease of assembly, weather protection, Facilities, comfort, sustainability, cultural and social suitability.
4. To Assess the level of satisfaction among inhabitants living in existing shelter solutions and identify what affects their well-being and comfort.
5. To evaluate existing emergency shelter designs in terms of their ability to meet user needs, including cultural appropriateness, and privacy, in addition to thermal and Acoustic comfort.
6. To Explore architectural strategies in shelters that ensure the socio-cultural needs and comfort of its inhabitants.
7. To Identify materials and construction methods used in shelters that ensure low environmental impact.
8. To Develop a sustainable shelter design framework that considers sustainability principles, including affordability, socio-cultural suitability, environmental impact as well as modularity, structural resilience, and user satisfaction.

9. To apply the design framework principles in Acuumoli by proposing a sustainable shelter design that ensures better living conditions.

2. RESEARCH METHODOLOGY

This research combines both qualitative and quantitative methods for data collection to ensure a better understanding of the humanitarian best and shortcomings strategies alike in existing shelter solutions for the development of more future sustainable shelters.

The methodology is divided into six key phases:

A. **Literature Review**: A critical review of the collected data will be conducted on the existing shelter solutions in humanitarian contexts. The literature review will be based on three themes: shelter typologies, as well as their affordability, sustainability in shelter design, and sociocultural and environmental impacts of the current shelter solutions, in addition to their user satisfaction. This phase is intended to provide a strong theoretical basis, identify gaps in previous studies, and further simplify the following phases of this study.

B. **Comparative Analysis**: This is followed by the comparative analysis of various shelter types. The comparison includes: Global shelters used by UNHCR, prefab modular shelters, and local traditional shelter types that present both post-disasters and refugee shelters used in different regions and contexts. The comparison is made based on quantitative and qualitative criteria. During this phase, an understanding of the various strengths and weaknesses of different shelter solutions will be developed, in addition to determining the main similarities and differences in each type of shelter. This study also helps in identifying which types perform better under different contexts.

C. **An assessment of socio-cultural aspects and user satisfaction**: The third phase consists of a socio-cultural and user satisfaction assessment done with a survey and interviews for data collection regarding the acceptability and satisfaction among the shelters' inhabitants. There will be questionnaires developed regarding how far the shelters fulfill the cultural and social requirements of their users, in addition to numerous factors that ensure user satisfaction like: the sense of safety, thermal and acoustic comfort, facilities quality, area adequacy, and satisfaction with the time provision of the shelter.

D. **Environmental Impact Assessment**: This phase presents the evaluation of the environmental impact of four existing shelter types using the LCA method, The considered factors include embodied energy and the global warming potential. The result of this phase will highlight the construction methods and materials that have a low environmental impact.

E. **Design Framework Development**: Based on the findings from previous phases, a framework design for future sustainable shelters is developed.

F. **Design Framework Application to Accumoli**: in this part, a proposed shelter design was suggested based on the design framework principles.

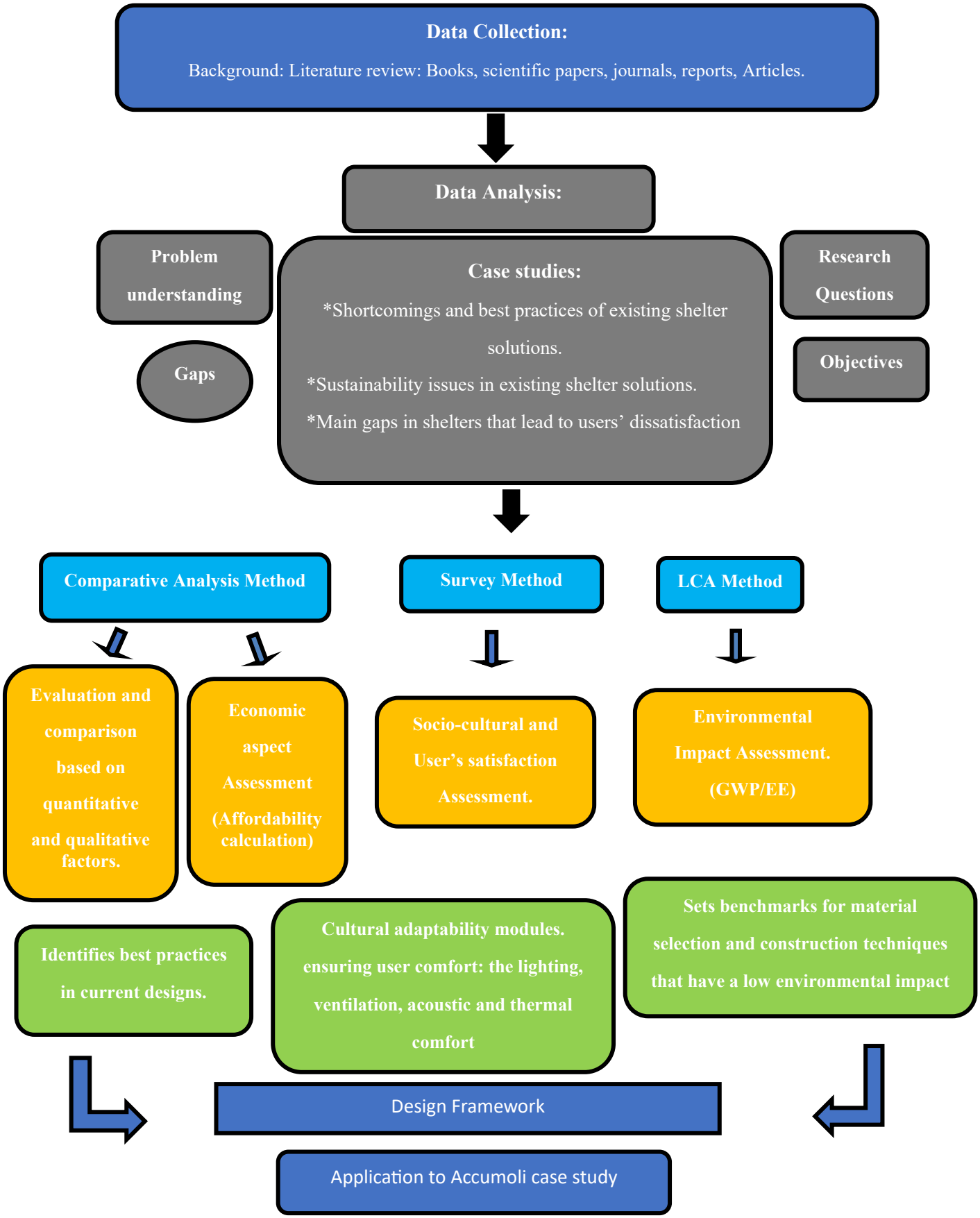


Figure 1: A diagram explaining the Methodology of the research.

❖ 3. Scientific Findings

✓ *1st theory: Sustainability issues of emergency shelters that have a short lifespan*

Thesis I: Prolonged Use of Emergency Shelters Beyond Their Intended Lifespan is a critical issue

Emergency shelters are typically designed for short-term use, prioritizing rapid assembly and basic protection in crises. However, a review of case studies and literature reveals that these shelters are often repurposed for longer periods beyond their intended lifespan. This extended use underlines the wrong thinking of providing emergency shelters with basic needs rather than ones with long-term needs. This highlights the need for more sustainable long-term shelter solutions that can meet prolonged habitation demands without compromising user comfort or harming the environment.

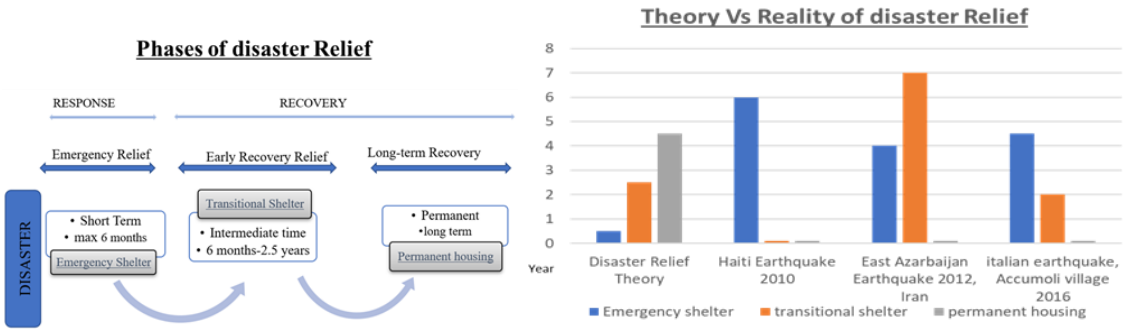


Figure 2: Theory vs Reality in disaster relief (3 case studies).

***Sub-thesis:**

1. **User Dissatisfaction and Abandonment:** 404 Survey responses revealed that many displaced populations find emergency shelters inadequate for extended habitation due to insufficient comfort, area inadequacy, lack of privacy, and the lack of social spaces within the shelter environment, in addition to the unsuitability of their basic and shared facilities. This leads in some cases to the abandonment of these shelters like in the case of Accumoli village, where people preferred to live in their cars or rental apartments in nearby cities than live in the provided tents or containers.

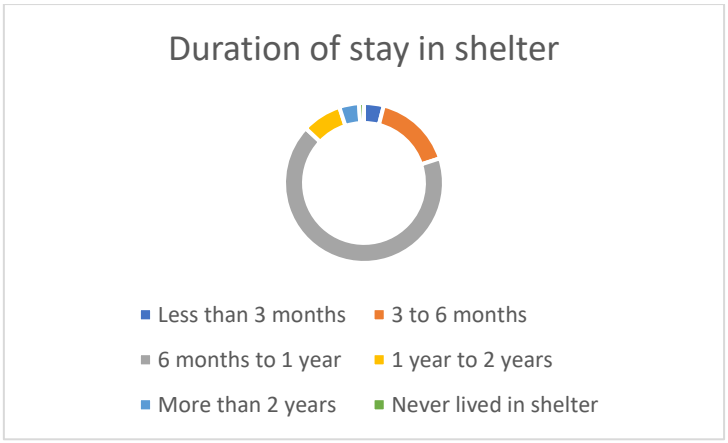


Figure 3: A chart showing the respondents 'duration of stay in shelters

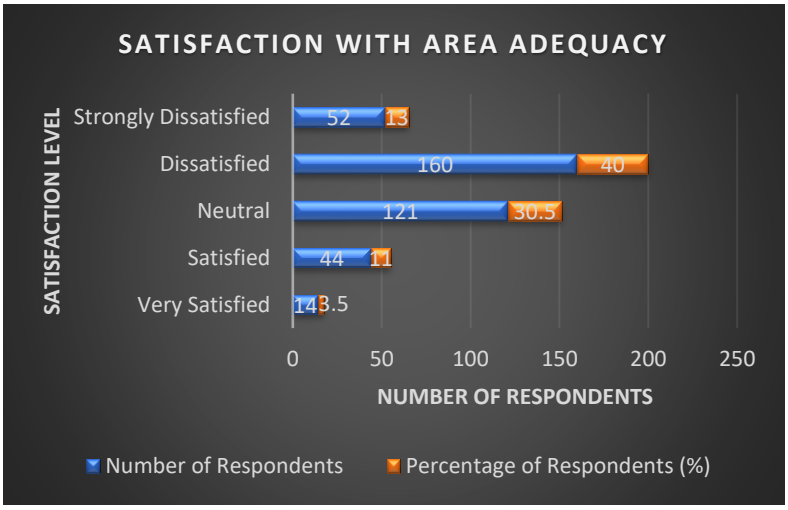


Figure 4: A chart presenting the Respondents' satisfaction with the Area adequacy.

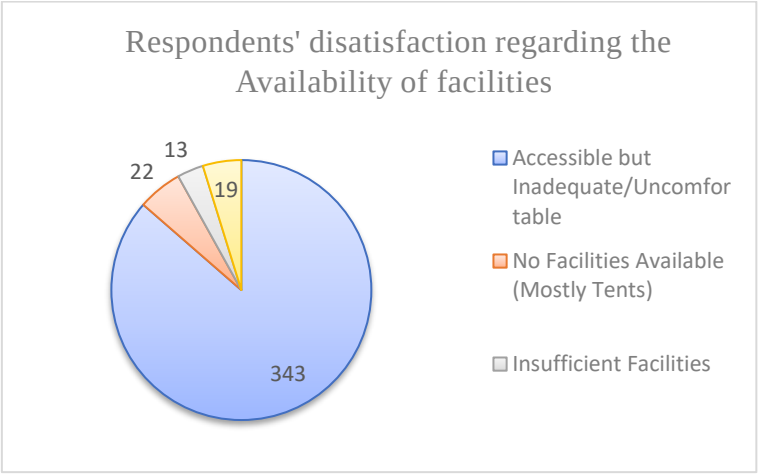


Figure 5: A chart presenting the Respondents' dissatisfaction regarding the Availability and adequacy of provided facilities.

2. **High costs of production and Transportation:** The affordability analysis of 14 different shelters showed that emergency shelters with short lifespans, mainly prefabricated options like Ikea Better shelter, and Azraq T-shelter have a high cost due to their expensive production processes and international long transportation distances compared to shelters constructed on-site that have longer lifespan like Mahama and Eco-dome shelter.

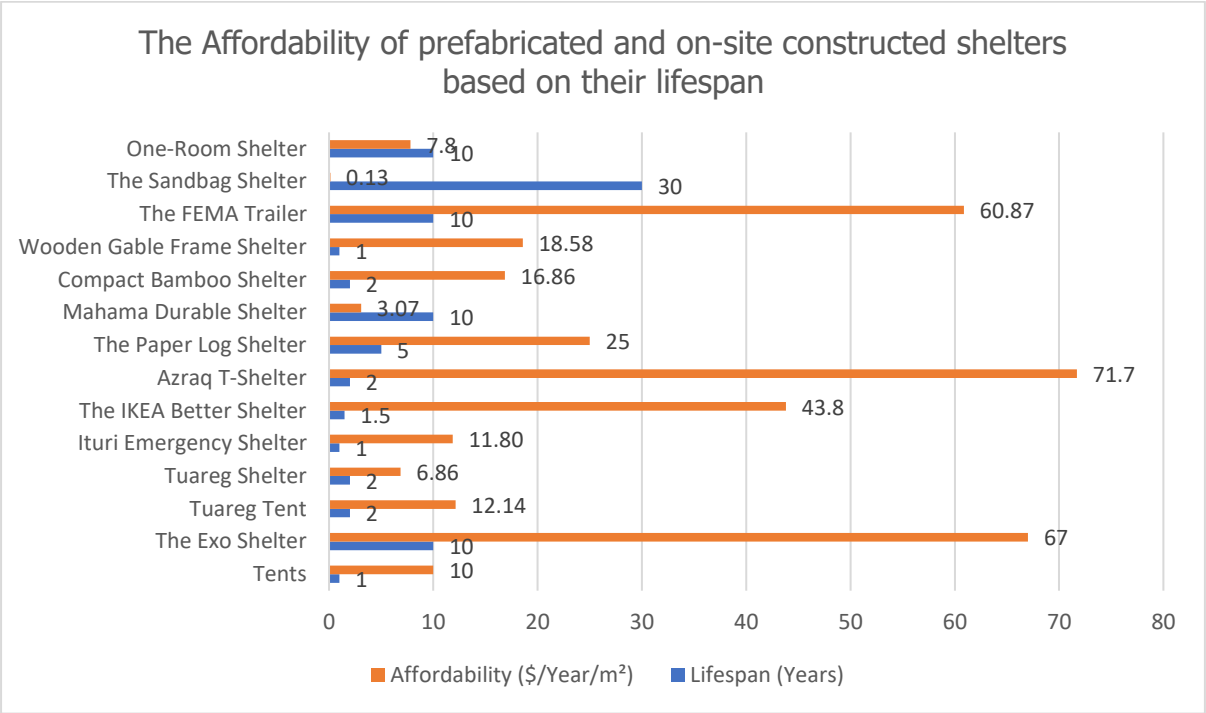


Figure 6: The Affordability Analysis results.

3. **High environmental impact over time:** The comparative study of the total embodied energy and carbon emissions of the 4 shelters assessed considering their lifespan and area shows that Short-term emergency shelters like the IKEA Better Shelter and Tuareg Tent have a higher environmental impact when assessed over time, due to their energy-intensive manufacturing and transportation processes. In contrast, shelters with longer lifespans, including the Eco-Dome and Mahama Durable Shelter, which are locally sourced materials present lower environmental impacts.

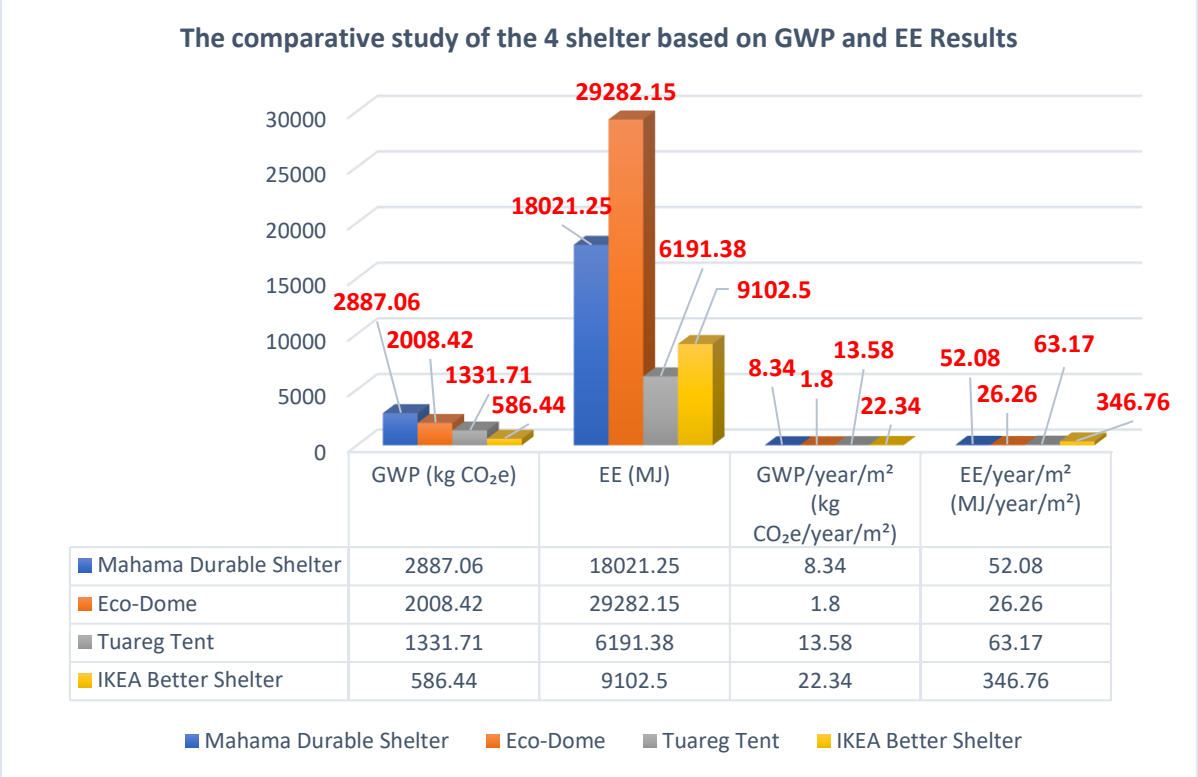


Figure 7: A summary of the environmental impact (GWP and EE) results

Thesis II: Shelters-used materials and construction techniques as well as their transportation process are the main factors that determine their environmental impact.

The results of the LCA show that while prefabricated shelters offer benefits in terms of rapid deployment, they have a high environmental impact in terms of high embodied energy and carbon emissions associated with their production transport and material selection. On the other hand, shelters constructed-on site, and made from local materials, such as the Eco-dome and Mahama Durable Shelter, are more environmentally friendly due to reduced transportation emissions and the use of local and renewable resources.

***Sub-thesis:**

1. **Environmental impact of Renewable materials vs industrial materials:** The GWP and EE analysis of materials used in the construction of the 4 shelters show that renewable materials or local available materials like bamboo and sand have lower environmental impact despite their large quantities compared to smaller quantities of intensive-energy or produced materials like: Steel, plastics.

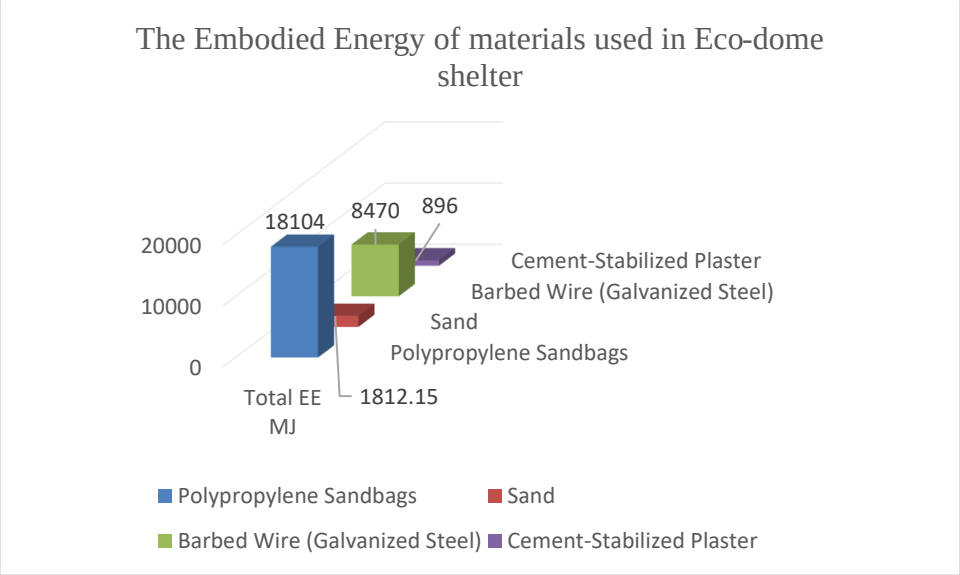


Figure 8: Eco-dome shelter materials 'EE calculation results.

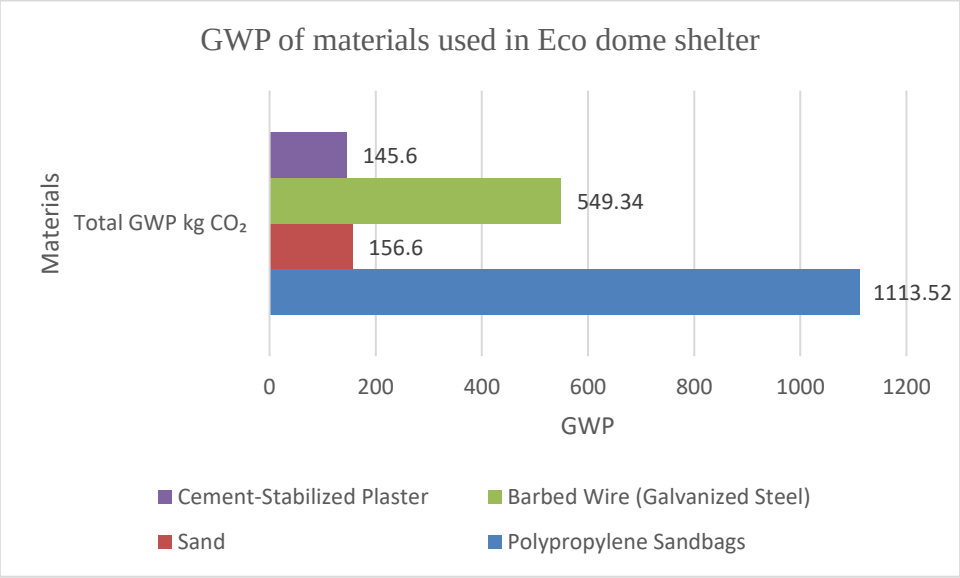


Figure 9: Eco-dome shelter materials 'GWP calculation results.

2. **Environmental impact of Materials transportation phase:**

The results of the LCA of the transportation phases indicates that materials imported from long distances have high carbon emissions compared to locally sourced materials like sand or earth.

2nd theory: The importance of considering users' comfort, socio-cultural, and climatic needs in shelter designs that ensure user satisfaction

- **Thesis I: Inadequacy of Standardized Shelters for Local and Gender-specific Needs**

Based on the analysis of case studies and a comprehensive review of the literature, it was noticed that most of the provided emergency shelters are globally standardized solutions, which are usually manufactured in a country and then transported to another country for deployment. While this approach ensures rapid deployment, it often fails to accommodate the specific cultural, social, and environmental requirements of the regions where they are deployed leading to users' unacceptance and dissatisfaction.

***Sub-thesis:**

1. **The sense of unsafety and lack of privacy:** Standardized shelters often fail to align with the Gender-specific needs of displaced populations, leading to dissatisfaction and reduced acceptance among inhabitants. Survey findings show that the concept of prefabricated units with communal sleeping areas and the lack of gender-specific zones within the settlement like outdoor toilets or communal kitchens leads to the feeling of unsafety and lack of privacy, especially among women.

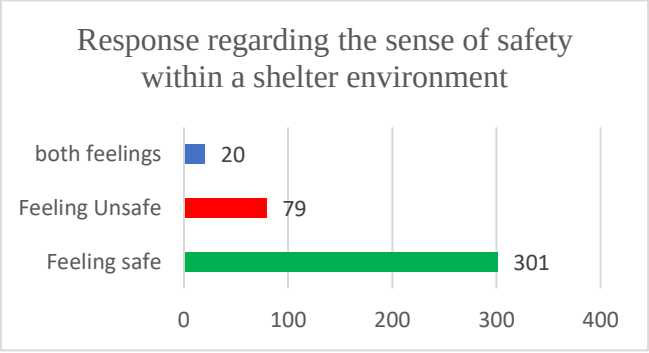


Figure 8: A chart presenting the sense of security between the respondents within the shelter environments.

2. **Inadequate Adaptation to Climatic Conditions:** Standardized shelter designs are frequently unsuitable for diverse climatic conditions, lacking adequate thermal insulation, ventilation, and acoustic comfort which leads to users' dissatisfaction.

✓ **Thesis II: The need for rethinking temporary shelter design and settlement as long-term options by addressing social and cultural aspects in addition to thermal and acoustic comfort.**

Most real-world temporary shelters and settlements in post-disaster or refugee scenarios alike lack social and cultural spaces, as they focus on rapid deployment by providing a quick roof over the head rather than ensuring users' comfort and long-term needs. However as discussed in the literature review, most of the displaced populations lived in these temporary conditions for years or even decades like the case of Tindouf camp, which highlights the need for rethinking these settlements as future cities by addressing the socio-cultural factors and users' comfort in both shelters and settlements scales alike.

***Sub-thesis:**

1. **The relation between the availability of social spaces and community connection and integration:**

   The survey findings underscore the importance of integrating sociocultural factors in shelter design and environment, including the availability of communal spaces and culturally suitable facilities in ensuring the acceptability and functionality of temporary shelters. 77% of respondents reported a lack of social and cultural spaces (communal areas for playing and socializing, religious practices area…) within the shelter environment and 43% among them reported feeling socially isolated in these conditions.

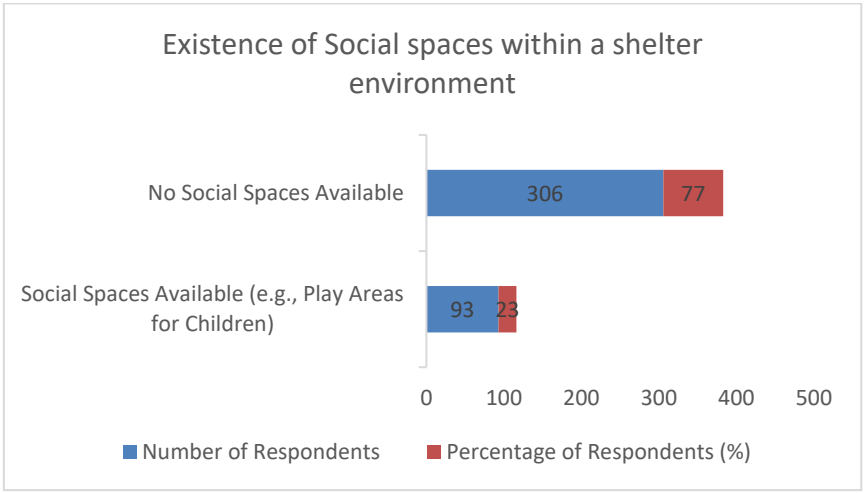


Figure 4: A chart presenting the Respondents' answers regarding the Availability of social spaces.

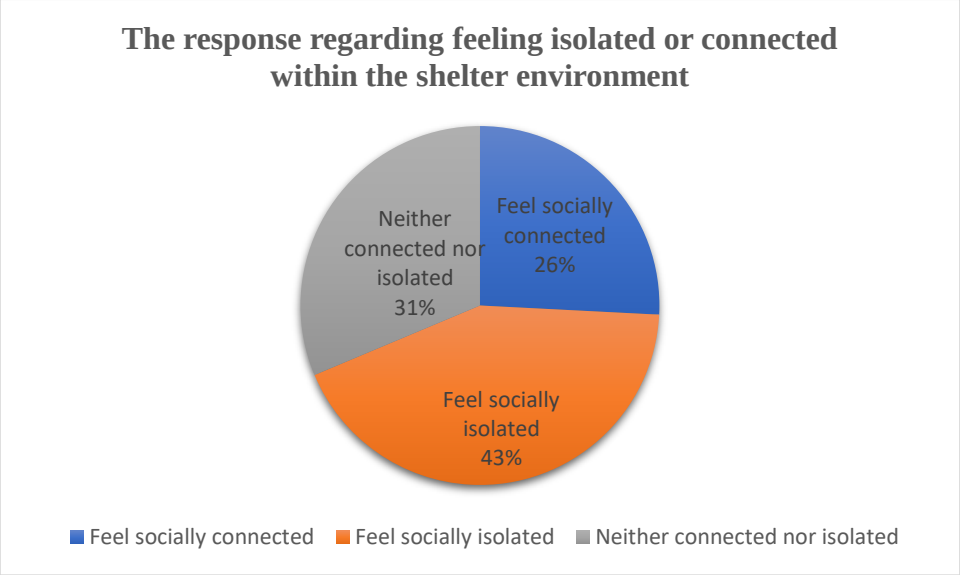


Figure 5: A chart presenting the response regarding feeling isolated or connected within the shelter environment.

2. **The relation between the construction method and cultural suitability:** The evaluation of 14 global shelter prototypes indicated that while prefabricated shelters are effective as quick emergency response due to their rapid deployment, they are often criticized for lacking cultural and climatic suitability. In contrast, locally constructed shelters with simple construction techniques may take longer to assemble but offer improved cultural integration.
3. **Thermal and acoustic comfort are crucial aspects to ensure users' well-being and satisfaction:** They are primary aspects of shelter design that affect the daily well-being and user's comfort, which unfortunately not considered in temporary shelter solutions. The results of the survey indicate that 55% of respondents reported extreme heat in summer and 37.5% reported poor heating in winter. While over 90% of respondents reported disturbing noise levels, especially in the afternoon and evening. These results show that existing shelter solutions failed to ensure the user's thermal and acoustic comfort due to inadequate insulation, poor ventilation, and a lack of soundproofing measures.

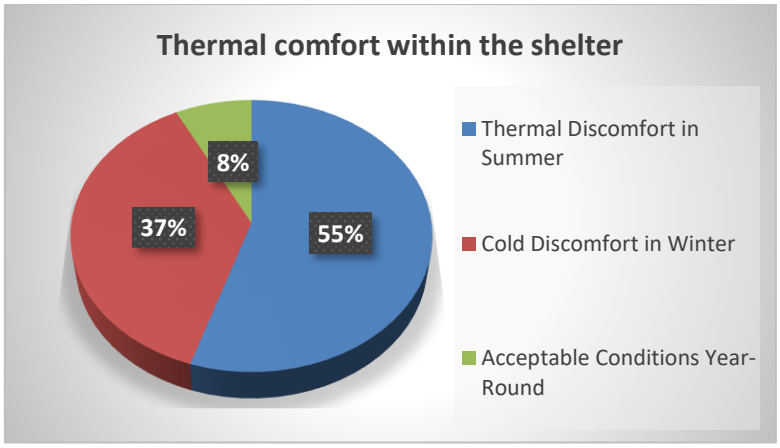


Figure 6: A chart presenting the thermal comfort within a shelter

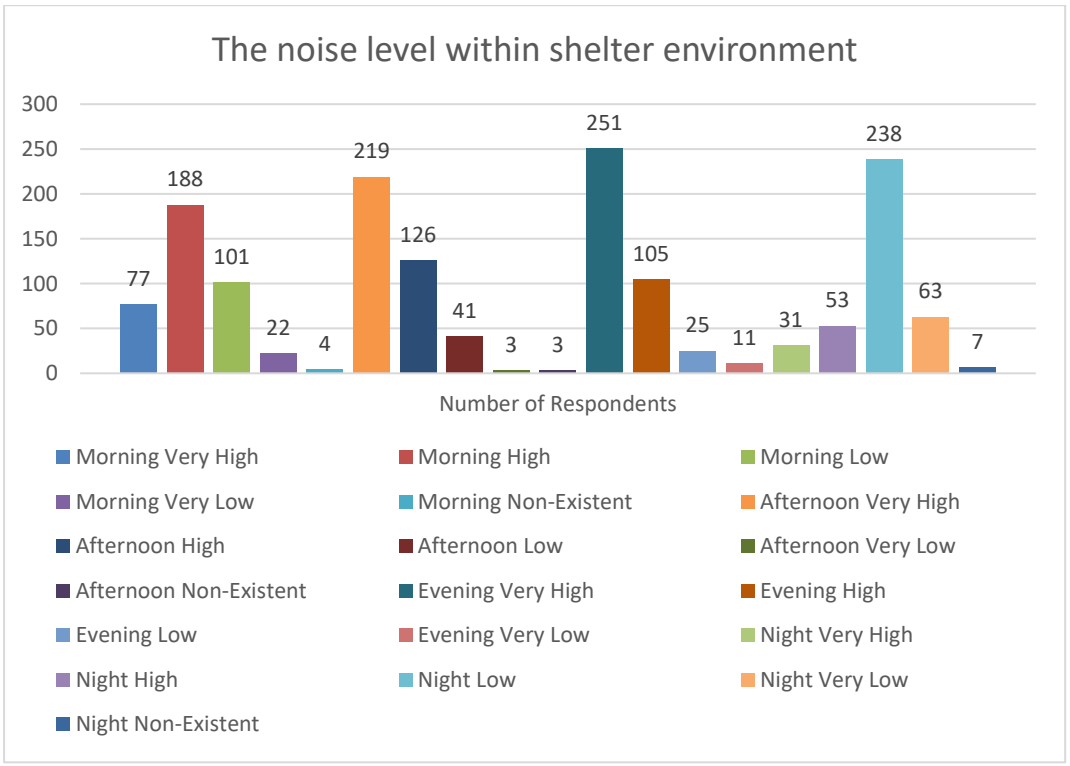
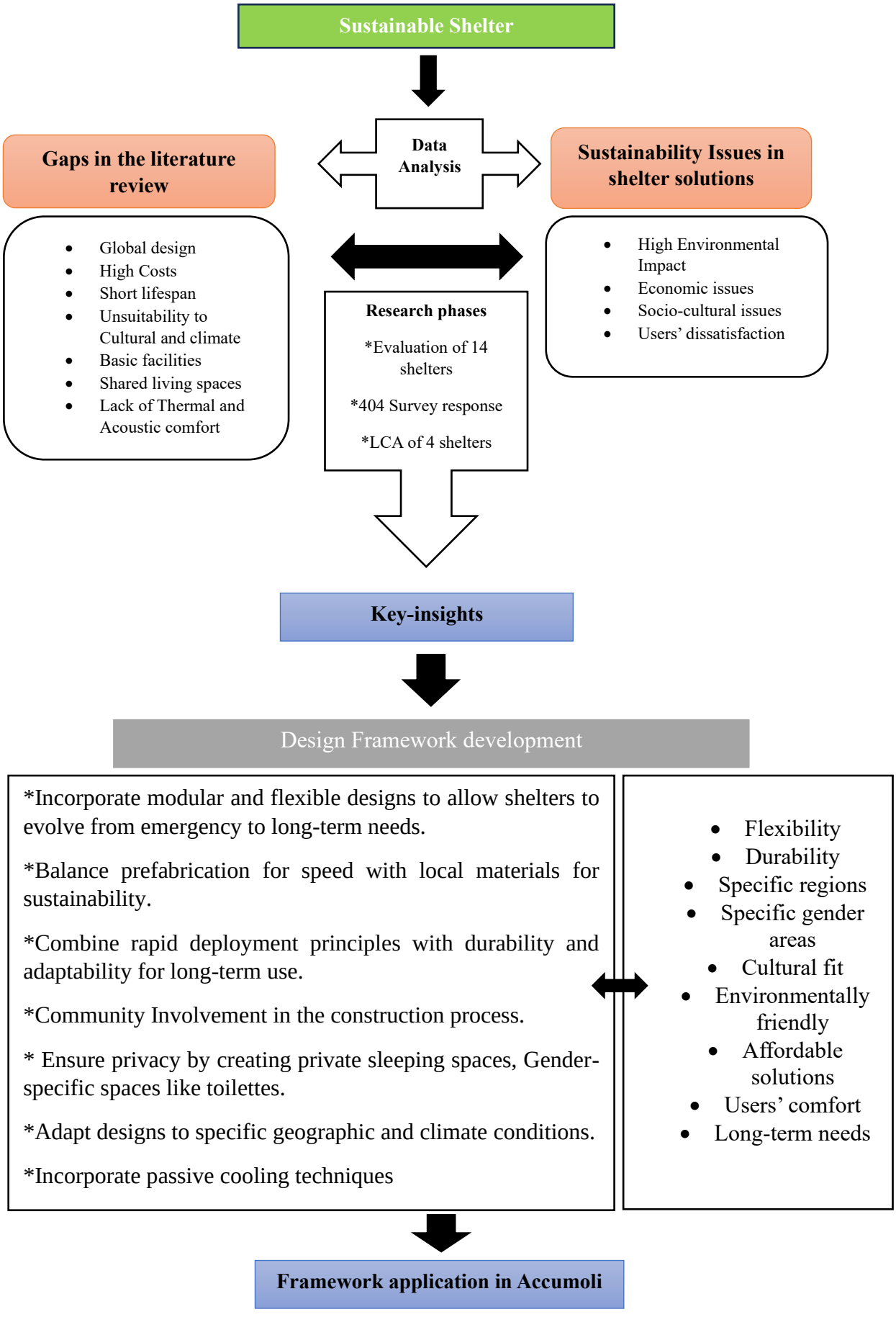


Figure 7: A chart presenting the noise levels a different times of the day within a shelter

❖ 4. Design Framework

Based on the thesis main findings previously mentioned, A design framework that integrates sustainability with all its dimensions, including economic, social, environmental aspects with considering cultural suitability and users' comfort was suggested for creating future shelter designs that ensures long-term needs and users' satisfaction.


Sustainable Shelter
Data Analysis
Gaps in the literature review
Global design
High Costs
Short lifespan
Unsuitability to Cultural and climate
Basic facilities
Shared living spaces
Lack of Thermal and Acoustic comfort
Sustainability Issues in shelter solutions
High Environmental Impact
Economic issues
Socio-cultural issues
Users' dissatisfaction
Research phases
*Evaluation of 14 shelters
*404 Survey response
*LCA of 4 shelters
Key-insights
Design Framework development
*Incorporate modular and flexible designs to allow shelters to evolve from emergency to long-term needs.
*Balance prefabrication for speed with local materials for sustainability.
*Combine rapid deployment principles with durability and adaptability for long-term use.
*Community Involvement in the construction process.
* Ensure privacy by creating private sleeping spaces, Gender-specific spaces like toilettes.
*Adapt designs to specific geographic and climate conditions.
*Incorporate passive cooling techniques
Flexibility
Durability
Specific regions
Specific gender areas
Cultural fit
Environmentally friendly
Affordable solutions
Users' comfort
Long-term needs
Framework application in Accumoli