

Temporary Shelters and Disaster Resilience in Sustainability: A Case Study of Sigi After The 7.4 M Palu Earthquake 2018

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Published: 31 December 2021

Temporary housing is immediate shelter needed after a disaster for the displaced people. A vast quantity of living quarters is required in a limited time and developed mainly by many different parties. Thus they had produced a wide range of qualities of the accommodation caused due to various considerations. After its initial period, countless transitory houses were still used for years and turned into permanent dwellings, yet others just left empty since the beginning. This paper examines how housing needs recovers and how shelters are resilient to the people in a post-disaster period. One hundred one samples of temporary refuge in Sigi after the 7.4 M Palu earthquake 2018 built by four influential organisations were examined its architectural properties and occupancy. The result shows that safety, comfort, and the expectation for permanent housing significantly determine the houses' success rate. The acceptability level is ensued from top to bottom as follows: the standalone unit with the user involvement; with the local resources; with the fixed package given; and the shared unit package, respectively.

Keywords: *Temporary shelter, Post-disaster housing, Disaster resilience, Mitigation sustainability, Palu earthquake.*

1 INTRODUCTION

The Central Sulawesi earthquake on September 28, 2018, destroyed vast areas, including Palu, Sigi, Donggala, and Parigi Mautong districts. The 7.4 Magnitude with intensity level IX-X MMI shake at 15.00 to 17.02 local time triggered a three to five meter-height tsunami and liquefaction (Kusumah et al., 2018; PuSGeN, 2018). The death toll immediately reached 2,227, and 164,626 people were homeless (REACH, 2019). The final figure shows 4,402 people died, 100,405 houses were damaged, and 172,999 or 53,172 families' lost homes fled in 400 evacuation camps. The Regency of Sigi was the most knocked area with the highest evacuees, up to 93,187, and damaged houses reached 30,538 units (Tandigala, 2019).

The *huntara* or temporary housing program in Sigi was carried out by government and non-governmental agencies (NGOs), both local and international. There were 43 institutions involved in Sigi, each constructed tens to thousands. Governmental actions mostly referred to the National Emergency Prevention Agency (BNPb) Regulations number 7 the year 2008, BNPb number 24 the year 2010, and Law of the Republic of Indonesia (UU) number 24 the year 2007. Meanwhile, in the field, the emergency agencies also referred to the Core Humanitarian Standard, The Sphere Project, Transitional Shelter Guideline (Shelter Centre-IOM), Post-disaster shelter (IFRC), Regulation to Humanitarian Shelter (Ministry of Social Affairs, the Red-Cross PMI Sub Cluster Shelter, and Central Sulawesi governor's decree number 369/476/ DIS.SOS-G-ST/2018 (Klaster PP, 2018). However, the implementation of *huntara* varies depending on each donor's mission and the local contexts.

Three years after, we could easily prove many different physical qualities and various levels of acceptance. Adapting to earthquake hazards, the providers build lightweight houses widely spread using bamboo, plywood, zinc alum, or galvanised metal profiles and sheets, although some still use bricks and concrete. Some houses have been built on a platform to match local building traditions, yet others are on the ground directly (PUPR, 2018). Given that donors also consist of

international organisations, regional aspects were often overlooked (Daswati et al., 2019). Many shelters are not following the number of family members and are socially unsafe, especially in communal shelters (Litha, 2019). Some shelters were left unused because they were not suitable for people's needs (Mulyadi, 2019).

The Indonesian government has officially announced the complete implementation process of the Palu disaster (Klaster PP, 2018; Nugroho, 2018; PUPR, 2018; Tandigala, 2019). However, during the emergency response, the shelter provision was made by inappropriate coordination between the donor and the government. As a result, there are many mismatches in providing temporary housing, such as mistaken targets and inconvenient locations (Daswati et al., 2019). Several post-disaster news headlines supported her finding (Litha, 2019). Thus it is essential to analyse the provider approaches, implementation in the field, and community acceptance as the crucial parts of this study. Although we conducted this research in Sigi, the suitability analysis results would greatly benefit globally because the shelter supply model is relatively similar, especially in developing countries.

2 LITERATURE REVIEW

Researches on temporary housing were carried out in various fields of science, from technical to social spheres. The approved references have been widely published globally (IFRC, 2013). After the disaster, the government mostly rapidly carried out emergency shelter and temporary housing programs during the most critical phases. The shelters and houses aim to return survivors to everyday life after the disaster (Barakat, 2003; Félix et al., 2013; The Sphere Project, 2012). The post-disaster programs include the emergency response, the salvage transition, and the recovery (Nugroho, 2018). Many survivors prefer to establish temporary shelter around their previous house or site rather than flee to another place (Chien et al., 2002).

An emergency shelter was done in one to several weeks, followed by a temporary shelter known locally as *huntara* for about three years, and by a

permanent shelter program or *huntap* in the final phase. The *huntara* phase in the transition period has a role in trauma recovery and provides the basis for the rehabilitation process. *Huntara* should have a broader consideration in handling natural disasters rather than merely the accommodation (Forouzandeh et al., 2008; IFRC, 2013). However, these shelters are generally constructed without paying attention to cultural aspects (Barakat, 2003). Technical alternatives for houses have also been attempted with local materials such as wood and bamboo (Utomo et al., n.d.). Recycling objects by proposing containers was also discussed as a new promising alternative (Hong, 2017). Furthermore, the social aspects were fundamental, followed by technical problems (Kotani et al., 2020), and should be based on user habits (Forouzandeh et al., 2008)

To deal with various donors with specific goals such as emphasising sustainability issues, community knowledge and skills, local communities and their spatial habits, resilience to future disasters, and community development (Vahanvati and Mulligan, 2017). Post-disaster shelter frameworks must also consider planning, designing, construction, and occupancy to further stages for the future. The existing infrastructure and accessibility are most of the recommendations (Anhorn and Khazai, 2015). The infrastructure is required both for the basic of the living quarter's functions and to provide future housing itself (Kilci et al., 2015). In the long-term sustainability concerns, the criteria for using a transition house for permanent housing should be well planned (Hindami, Hibatullah NA et al., 2014). Shelters often serve long-term dwellings. Extended use over the estimated time has proven to be a source of the unbearable cost associated with energy consumption in building operations; with this, shelters are not designed to last more than two years (Seike et al., 2019).

Researches on *huntara* are scattered in various areas of coverage. A thorough discussion from planning to occupancy had been carried out to reveal a clear relationship at each stage. Nonetheless, the overwhelming situation following the emergency shelter establishment stage is often undeniably still high. This research

focuses on the supply chains and their relationship with the Sigi community with their specific needs and expectations. Thus providers could recognise *huntara*, which is undoubtedly needed and acknowledge the further step in permanent housing. The results of this study, together with similar studies in different cases, will describe the provision of appropriate shelter.

3. METHODOLOGY

We examine the success rate for transitory shelters from the achievement level of the facility in serving safe temporary accommodation. As its role for accommodating the affected people, a shelter should give adequate physical protection, serve sufficient spaces for daily basics, and offer acceptable room quality to the inhabitants before their permanent house (IFRC, 2013; The Sphere Project, 2012). Thus an examination of the housing types based on the user approval is essential. The 101 samples from four house variants provided by different benefactors were analysed according to the architectural typology and checked by interviews to discover the acceptability level. To link with the disaster resilience, we accessed the expectation of permanent housing, whether the shelter gives learning to the user by the building performance related to earthquake safety.

Four different shelter types were taken from four providers, namely Christian Relief Services (CRS), Habitat for Humanity (HABITAT), KUN Humanity System+ (KUN), and The Ministry of Public Works and Housing (PUPR). They provided temporary housing for 120, 502, 52, and 2652 units, respectively (Shelter sub-cluster up to December 2019). CRS provided brick wall houses combined with wooden panels on top and zinc alum roofing sheets, giving the people a significant level of freedom with the houses' variation. HABITAT builds a lightweight structure by galvalume frame combined with calcium panels and zinc alum roof, which seems quietly fixed. KUN used local materials mainly from bamboo and thatch roofs for cabin-like shelter distinguished from others. PUPR constructed communal house by lightweight

galvanised profiles, gypsum board panel, and the zinc-alum ridge above prepared for a large user, which differs from the others.

4. FINDING AND DISCUSSION

4.1 Shelter typology and properties

CRS has built a single unit for each family, mostly in 4 x 6-meter square consisting of single or double bedrooms and a living room with or without terrace as an additional feature. Some houses stand on stilt others just sit down directly on the elevated ground. Bigger sizes are also found, such as 5 x 7 and 5 x 8-meter square with an additional bedroom. The structural system utilises a small timber frame with wooden walls or a combination of the brick wall below (*figure 1&2*). In some portions, it uses brick walls. The variety of constructional types has resulted from

the freedom of the user to decide. Their involvement was part of the program to elaborate on the people.

CRS shelter tries to compensate individual houses by a single standalone construction and seems been planned not only for the short usage of transitory houses. The arrangement of the houses has proved this assumption. They look like a village rather than a shelter complex. Furthermore, the people could access different materials such as brick and concrete for permanent construction. The wooden structural frame and the brick wall were familiar to the people representing the previous existing housing. Thus, though built right after the disaster, CRS shelter can be assumed more likely to be permanent housing than a temporary shelter.



Figure 1. CRS shelters type by wood frame combined with wooden and brick wall on the ground

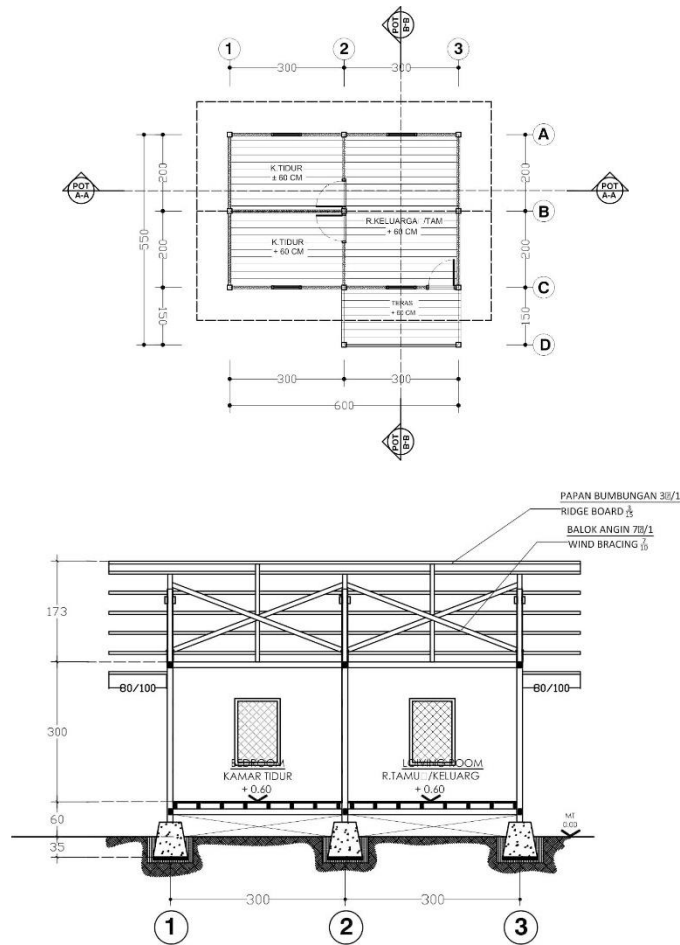


Figure 2. The plan and the section most of CRS shelters

HABITAT has a split approach utilising lightweight galvalume profiles casing, thin calcium wallboard, and light metal sheet for 4 x 5-meter square with a bedroom and a sitting room. The building is commonly positioned on a wooden platform supported by a lightweight metal frame rested in concrete stools (figure 3&4). This typology was built as a fixed package delivered to the community, so the houses were equal.

The HABITAT shelter was built without considering the involvement of inhabitants

because it only provides as much shelter as possible in a limited time. Materials and quality of construction are thus not expected for long term occupancy. The defect can be confirmed by the lower rigidity of the structure when carrying functional loads, and the user can feel high vibrations only from approaching people. The durability of the lightweight metal frame from climate is also another concern for its long-term use. Furthermore, sheathing metal and calcium boards without a proper heat-insulating installation reduce the level of thermal comfort.



Figure 3. HABITAT shelters lightweight structure with metal materials on the wooden frame stilt

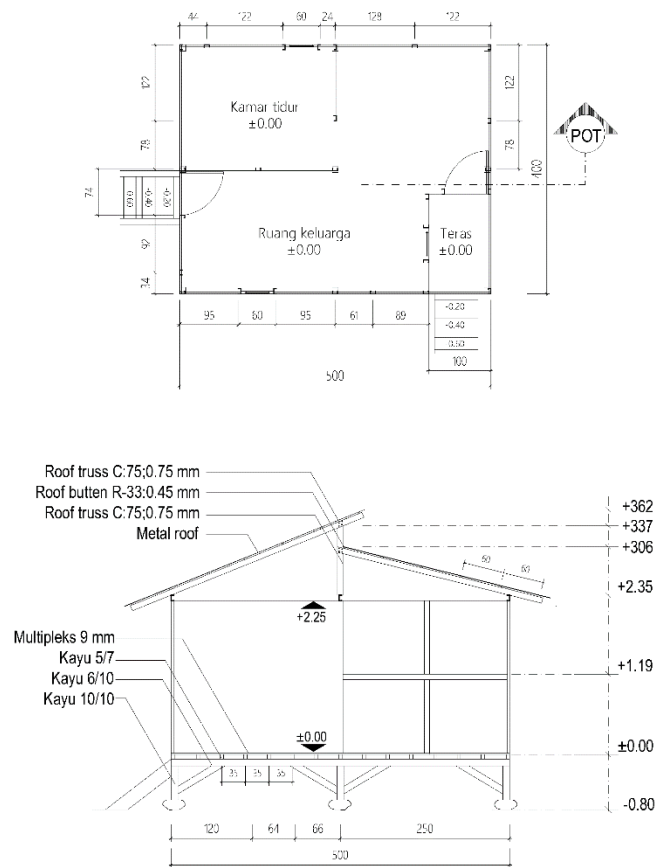


Figure 4. HABITAT shelter plan and section by metal materials and structural system

KUN has an entirely different method of handling materials using local abundance. Instead of using light metal, KUN invited the community to use bamboo as a shelter. This bamboo house has one bedroom and a sitting room measuring 4 x 6.5 square meters. Interestingly, the architecture practices local principles with some improvements to the shape of the windows. The wooden platform floor rests on concrete piles (figures 5&6). The architecture is standard as most of the houses are similar. In addition to accommodating local wisdom by utilising natural

materials, KUN shelter tries to maximise local resources and optimise costs. They have leveraged local knowledge of bamboo construction to provide familiar building types. They also value the capacity of indigenous peoples by providing opportunities for local carpenters and builders to improve the villagers' economy. A complete bamboo shelter is also suitable for climatic conditions where the perforated skin of woven bamboo helps ventilate the air and remove moisture from the air.



Figure 5. KUN shelters distinguished by bamboo structure and multiplex floor on a wooden stilt

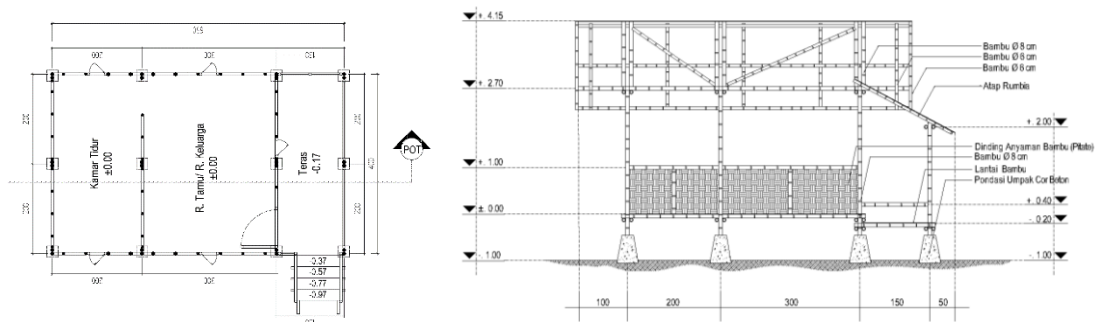


Figure 6. The plan and section of the KUN bamboo shelter

PUPR also has a different approach by serving the community through a shared house consisting of 12 family rooms, four toilets, and one washing zone in each unit. The building area is 25.6 x 9.6 square meters, with 3.6 x 4.8 in each family room. This massive building is built with a lightweight

galvanised frame combined with gypsum walls and zinc roofing sheets. The floor is laid on a concrete base with a galvanised frame covered with multiplex. This one-unit house is designed to accommodate twelve families equipped with an integrated sanitation system (figures 7&8)



Figure 7. PUPR shelters by shared houses with lightweight structures and calcium board lay on concrete poles

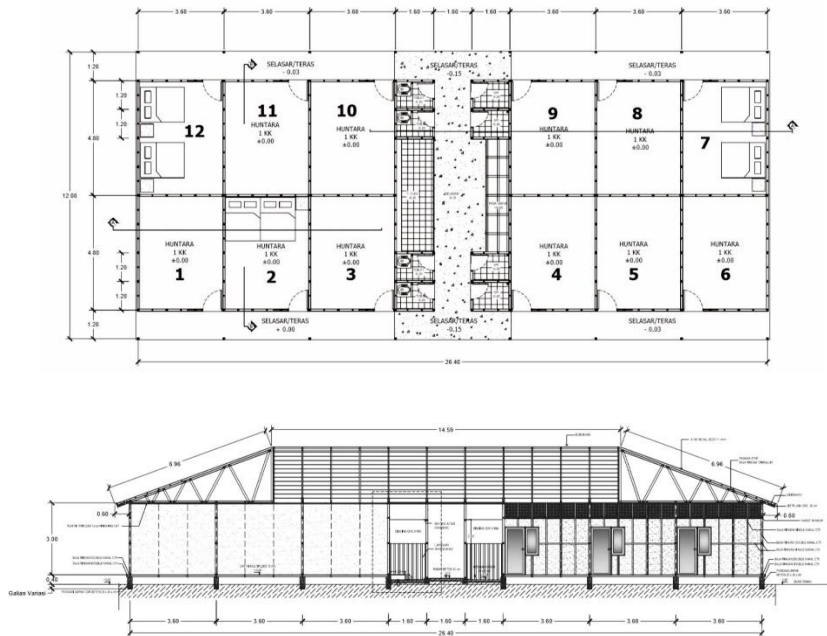


Figure 8. The plan and section of PUPR's shared houses with a service area in the middle

PUPR is targeting shelters primarily for emergency accommodation for the community rather than for further shelter. Thus, design considerations are more on capacity. Each family occupies only 17.3 square meters with no further room separation for daily needs or the possibility of room expansion thereafter. A large unit mass with better-built construction can increase physical and psychological safety precautions. It also results in relatively acceptable room comfort. In terms of emergency response, this shelter complex which accommodates several units and

hundreds of refugees has high effectiveness in serving the community.

4.2 Shelter acceptability level

Examinations were carried out on approximately 25 users in each shelter, with a questionnaire showing wide variations in acceptance. CRS, HABITAT, KUN, and PUPR built four different types with their own goals and reasons. Thus the suitability of performance is also not the same as each other. Shelters from CRS were generally acceptable, followed by KUN, HABITAT, and

PUPR, respectively. If a value of 2 is considered as an acceptable limit of 1 (not accepted) and 3

(strongly accepted), then shelter from HABILAT and PUPR is not recommended (figure 9).

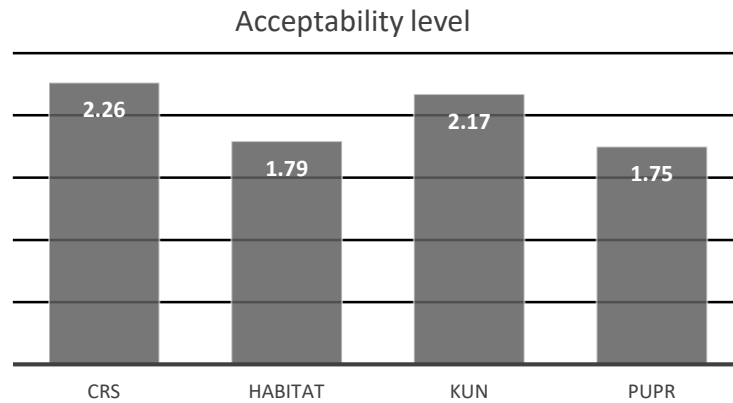


Figure 9. The acceptability levels from the four different shelters

The single standing shelter, projected as permanent post-disaster housing from CRS, is widely accepted because of its relatively better performance. Since people are involved in deciding material preferences and simultaneously getting their work done within budget, the expected quality can be understood even before

they inhabit the house. However, safety precautions are still a significant concern, although most prefer to stay constantly in shelters. Communities will also have relatively clear expectations about further accommodation development in the long term by choosing *huntara* as permanent residences (figure 10).

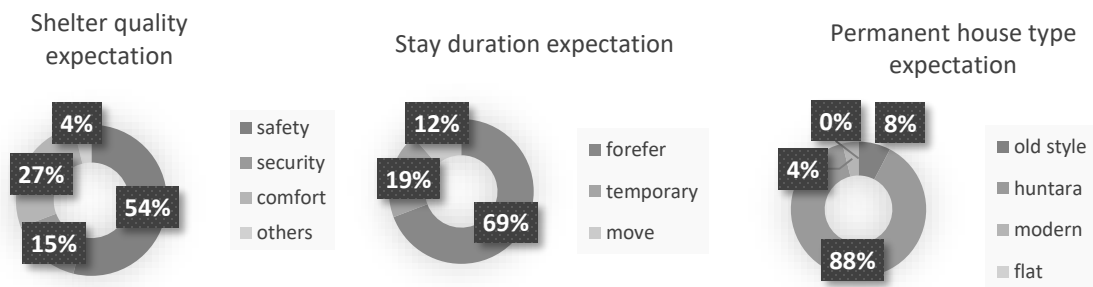


Figure 10. CRS shelters quality, stay duration, and permanent house expectation

The high rates of safety alert and expected duration of stay mean that they understand home security and show acceptance of their place of residence. Meanwhile, they hope that their future home will be like *Huntara* if we read the correlation between length of stay and the number of permanent housing expectations. The CRS *Huntara* model is the most expected, and no one expects to have a flat or multi-storey house for their future home. These facts prove that the

community best accepts the CRS shelter model in Sigi.

Like CRS but under very different circumstances, people know KUN widely because they give people more access to their resources. The bamboo house turned out to be very welcome because it was familiar (figure 11). In a disaster, bamboo is the best alternative that is available in abundance and is technically recognised. Bamboo shelters are built quickly with excellent performance under earthquake shocks. In terms of

climate, even these houses are the best due to their contextual thermal properties, among other options.

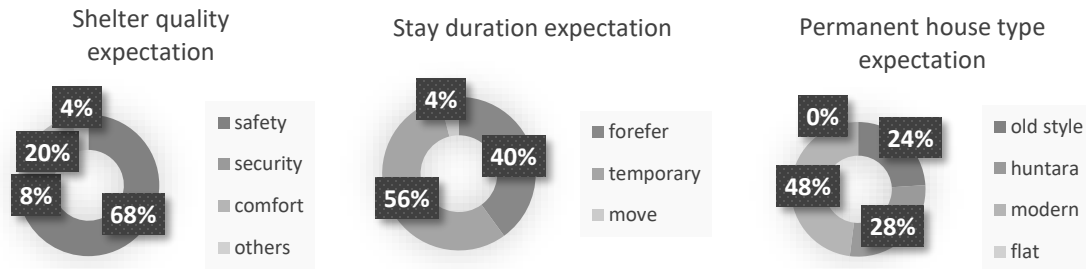


Figure 11. KUN shelters quality, stay duration, and permanent house expectation

From the shelter and stay duration expectation, safety needs even the highest consideration taken from the bamboo houses occupants, yet they preferred to change the house in the future. The third figure supports more expectations than just bamboo (known as non-permanent materials) for future dwellings. Though the people were delighted live in these buildings, modern style houses are still their wish but nothing even thinking about the flat. This finding informs us that bamboo shelter is the best to deal with the earthquake and the living comforts momentarily, but it is not the best answer for permanent housing when disaster is over.

From the expectations of the living place and length of stay, the need for safety is even the highest consideration taken from the residents of the bamboo house. Yet they prefer to move from the house in the future. The third figure supports the hope of living more than just in a bamboo hut

(known as a non-permanent material) for future housing. Although people love to live in this type of dwelling, modern-style houses are still their desire, but no one thinks about the flat. This finding informs us that bamboo shelters are the best for dealing with earthquakes and comfort but not the best answer for permanent housing once the disaster is over.

In contrast to CRS and KUN, the HABITAT shelter, on the other hand, is less acceptable, even though it provides a similar detached house model. Most people still feel that they cannot linger in the building because it is unsafe, less comfortable, and low secure (figure 12). The much-needed housing built in limited time may be one of the reasons for the lack of acceptance of these houses. Many users complain about the rigidity and the comfort of the room due to the heat and cold. The vibrations they experience also reduce the quality of the shelter.

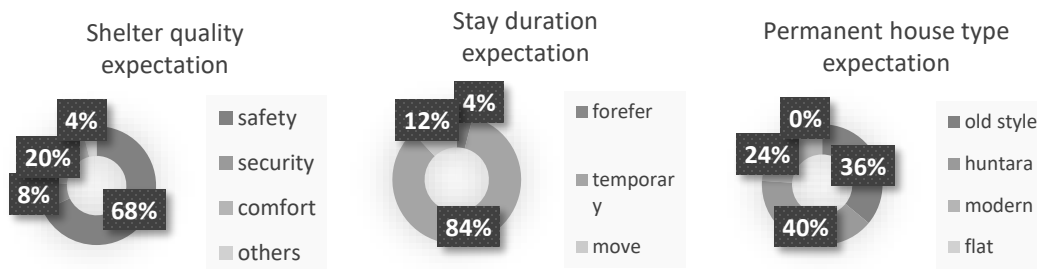


Figure 12. HABITAT shelters quality, stay duration, and permanent house expectation

Shelter safety is the most significant concern. However, the residents' sense of security is low; Therefore, people need safer homes both physically and psychologically. The expected future house is then associated with the third figure, where most of them want to live in another type, modern house. This evidence tells us that people do not desire less built qualities for structural integrity and room comfort. The new kind of house is also the most choice while no one is interested in flats. They only live temporarily in shelters and expect to move as soon as permanent housing is ready. They will leave no matter, even if the unit is prepared to be developed for permanent housing in the future.

Despite being built in a very different style from HABITAT's, PUPR shelters also experience low acceptance of user needs and expectations. In addition, these buildings were never 100% occupied even when the demand for supply of temporary housing was high. Almost all aspects recorded from users are generally accepted as low (figure 13). The much-needed shelter is not even enough to protect and comfort the people. The small-shared room is one of the reasons. A family with more than three members struggled to live with 17.3 square meters of space with all their belongings. Although adequate service facilities such as toilets and washing places complete the shelter, the users hope to leave soon.

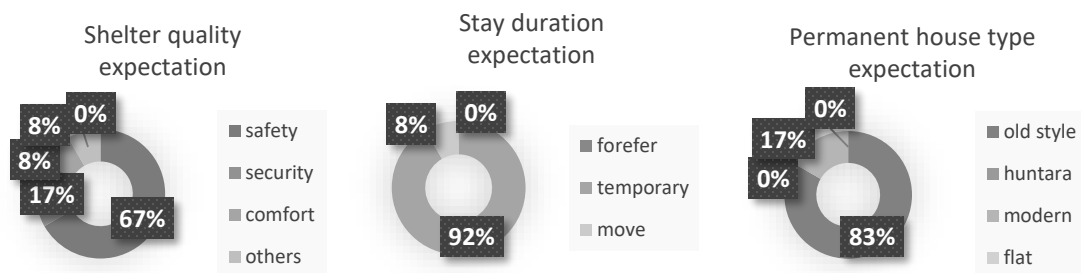


Figure 13. PUPR shelters quality, stay duration, and permanent house expectation

As found in other types, safety expectations are generally high; however, most users only think that life in a shelter is only temporary. No one wants to stay forever, and once they have the opportunity to move, they will. From the field data collection, many people had already moved and left the rest with no choice but to stay. Despite offering a large capacity for many refugees, sharing large shelters is the least successful in user acceptance. We have proof that no one wants to own a house like the PUPR shelter for future housing expectations. Instead, they prefer their old house. The flats type is also undesirable as it offers a shared building.

4.3 Disaster resilience between shelter needs and housing expectation

Living in a temporary shelter after losing your home somehow helps to develop future disaster resilience. Of the four different case groups above, safety is the primary consideration manifested by feelings of security and housing preferences. Variations in the form of shelter bring a level of acceptability based on the needs and expectations of users. However, low acceptance does not mean that there are no positive aspects to post-disaster outcomes. The positive and negative results of disaster resilience based on the above examination are presented in table 1.

Table 1. Shelter forms and positives/negatives aspects resulted

Shelter forms:	Pros (+)	Cons (-)
Single unit house with the user involvement	High acceptability High provision for permanent housing User empowerment	Lower speed of shelter delivery Fewer safety performances The wide variety of the shelters
Single unit house with the local resources	High acceptability Lower budgeting High climatic comfort	Lower speed of shelter delivery Limited material durability Not expected for permanent housing
Relatively fixed single-unit house.	Faster construction Simple construction Relatively cheaper construction Regular shelter form	Lower acceptability Less provision to permanent housing Less structural integrity Less climatic comfort
Communal-shared temporary housing	A high number of shelter availability Fast construction High structural integrity	Lower acceptability Impossible requirement for permanent housing Less inhabitancy comfort

Single unit shelters with user involvement have the highest acceptability because they belong to the community. Living in a shelter that looks like a permanent home provides an optimistic future for relieving the trauma of the disaster. Carrying out economic activities developed with social empowerment also strengthens community resilience in dealing with disasters. However, people have their preferences related to their place. Thus benefactors cannot avoid longer delivery times. The choice that is not strict will also bring about uneven quality due to the large variety of houses. On the other hand, unfortunately, it brings significance in reducing disaster resilience.

Single units with local resources have high acceptability because they provide benefits both socially and economically. Using local materials lower the budget due to less cost and technical application problems. It also offers structural integrity that is ideal for dealing with earthquakes. The need for local components automatically triggers supply and demand to encourage the economy that involves local carpenters. Bamboo provides an appropriate climatic response to warm and humid tropical air with low heat capacity and allows for more ventilation. At the same time, the distinguished structures may

The communal unit instant package is the least acceptable despite its advantages. Shared units

reduce the distribution of dwellings due to the need for a limited number of local carpenters. The lack of durability of bamboo also discourages people and is socially linked to lower incomes. So although it is very welcome as a temporary shelter, a bamboo house is not yet preferred for permanent residence.

However, the single unit packages with less user involvement have lower acceptance, although they offer further development for permanent housing. Uniformity of structure benefits massive delivery programs and budget optimisation. Prefabricated house modules simplify construction. Not only speeding up construction but also inviting residents to participate. However, the rapid 'as is' development somehow degrades the acceptability and decreases the room's structural integrity and quality. The simple structure with light materials has discouraged people from going any further for their future homes. This situation can reduce disaster resilience in the future. Although the structural system may be strong enough to withstand an earthquake, the shaking of the building from daily activities interferes with feelings of security. Room discomfort caused by the material's thermal properties both day and night is also a concern for the shelter.

offer large shelters in quick supply to accommodate large numbers of people. The unit

construction can be carried out in a certain place with all the necessary aspects, including structural quality and functional facilities. However, this type of shelter is not designed for further permanent housing. Despite following the standard of three square meters per person, limited space for the whole family and their belongings is the main reason for the low reception. Massive shared shelters are only for emergency purposes, which are very useful in disaster emergency response but not subsequent housing. This type of shelter will increase disaster resilience in quick response to provide accommodation, but not for future life. Unfortunately, this type may not offer lessons for dealing with other earthquake disasters in the future.

5. CONCLUSIONS

Sigi's temporary shelter shows a variety of the survivor accommodation and housing transitions for post-disaster safety measures. The choice of structure has specific purposes and reasons depending on the organization's mission, budget, and local context. However, in the case of Sigi, most of the stakeholders' performance is still below expectations to provide a level of acceptability about housing needs and expectations for future disaster resilience.

Shelters provided mainly for temporary accommodation are not well accepted by the community and do not provide better disaster resilience. On the other hand, the projected occupancy for permanent housing with a certain degree of freedom will help residents immediately start the safe house they need. User safety in the future as part of disaster resilience should be the first consideration; thus, safe structures become the most critical issue in which shelters must provide experience. Unfortunately, the shared unit experience has ruled out the possibility for other large housing estates in the future, such as flats or apartments where earthquake problems are relatively better handled in engineered buildings. However, each type can be a decent dwelling if the architecture removes its negative aspects. As part of disaster resilience in Palu or Indonesia in general, temporary shelters should not be seen as

temporary accommodation. Instead, it should play a role in transitional homes where people can learn how to deal with disaster-related issues such as building houses properly, what materials are appropriate, and what qualities are to be achieved. Thus, future disaster resilience will increase.

6. ACKNOWLEDGEMENT

This paper is result of collaborative research on Department of Architecture Universitas Islam Indonesia (UII) related to building safety and disaster resilience under the scheme of internal research by Directorate of Research and Social Services (DPPM UII) 2019-2020.

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