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Examining the Sustainability Performance of Post-Disaster Temporary Shelter Units Through Sample Analyses

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Abstract

Temporary shelter units should not only provide a temporary living space for disaster victims, but also support their health and well-being. These structures should provide the necessary facilities for the reintegration of disaster victims into social and economic life. Although the need for post-disaster shelter is critical, the design and implementation of these units often ignore the principles of sustainability, leading to environmental, social and economic problems. This study examines the design and implementation of temporary shelter units in accordance with sustainability criteria. The aim is to evaluate the units used as temporary shelter through sustainability criteria to emphasize their sustainability and to develop recommendations for their sustainability. In this context, the sustainability of temporary shelter units selected from the countries most affected by natural disasters between 1900 and 2024 and used in different disasters were analysed. The findings showed that the temporary shelter units analysed were positive in terms of environmental and economic aspects, but weak in terms of social sustainability. As a result of the study, suggestions were made based on the examined temporary shelter units for post-disaster construction and it is thought that these suggestions will shed light on future design and academic studies. As a result, designing temporary shelter units in accordance with sustainability criteria is vital to support the health, welfare and social integration of disaster victims.

Keywords

Disaster, Sustainability, Temporary Shelter, Post-disaster Shelter

Afet Sonrası Geçici Barınma Birimlerinde Sürdürülebilirlik Performansının Örnek Analizler Üzerinden İncelenmesi

Özet

Geçici barınma birimleri, afet mağdurlarına sadece geçici bir yaşam alanı sağlamakla kalmamalı, aynı zamanda sağlık ve refahlarını desteklemelidir. Bu yapılar, afet mağdurlarının sosyal ve ekonomik hayata yeniden entegrasyonu için gerekli olanakları sunmalıdır. Afet sonrası barınma ihtiyacı kritik olmasına rağmen, bu birimlerin tasarımı ve uygulanması genellikle sürdürülebilirlik ilkelerini göz ardı ederek çevresel, sosyal ve ekonomik sorunlara yol açmaktadır. Çalışma, afet sonrası geçici barınma birimlerinin sürdürülebilirlik kriterlerine uygun tasarım ve uygulamalarını incelemektedir. Amaç, geçici barınma olarak kullanılan birimlerin sürdürülebilirliğini vurgulamak amacıyla sürdürülebilirlik kriterleri aracılığıyla değerlendirmek ve sürdürülebilirliklerine dair öneriler geliştirmektir. Bu bağlamda, 1900-2024 tarihleri arasında doğal afetlerden en çok etkilenen ülkelerden seçilen ve farklı afetlerde kullanılan geçici barınma birimlerinin sürdürülebilirlikleri incelenmiştir. Bulgular, incelenen geçici barınma birimlerinin çevresel ve ekonomik açıdan olumlu olduğunu, ancak sosyal sürdürülebilirlik açısından zayıf kaldığını göstermiştir. Çalışma sonucunda, afet sonrası inşa edilecek yapılarak yönelik; incelenen geçici barınma birimlerinden yola çıkılarak önerilerde bulunulmuş ve bu önerilerin gelecekteki tasarım ve akademik çalışmalara ışık tutacağı düşünülmektedir. Sonuç olarak, geçici barınma birimlerinin sürdürülebilirlik kriterlerine uygun olarak tasarlanması, afet mağdurlarının sağlık, refah ve sosyal entegrasyonunu desteklemek açısından hayati önem taşımaktadır.

Anahtar Sözcükler

Afet, Sürdürülebilirlik, Geçici Barınma, Afet Sonrası Barınma

1. Introduction

Disasters, whether natural or man-made, deeply affect people's lives. Meeting the need for shelter after a disaster is critical for disaster victims to hold on to life again (International Federation of Red Cross and Red Crescent Societies, 2013). In this context, temporary shelters play an important role in post-disaster recovery and reconstruction processes. However, the design and implementation of temporary shelters often ignore sustainability principles (Félix et al., 2013). However, environmentally, socially and economically sustainable temporary shelter solutions can positively affect post-disaster recovery and reconstruction processes. Environmental aspects such as energy efficiency, water management, waste management, material selection; social aspects such as user satisfaction, social cohesion, accessibility; and economic

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aspects such as construction, operation and maintenance costs, local economic contribution, and longevity can be improved by applying sustainability criteria (Arslan & Cosgun, 2008; Félix et al., 2015). The results of post-disaster temporary shelter units, which are evaluated in line with sustainability criteria, are examined in practice, and it is thought that it will be enlightening for future designs or academic studies. Evaluating the post-disaster temporary sheltering process from a sustainability perspective requires a multidimensional approach. Environmental, social and economic elements should be taken into consideration for a holistic sustainable temporary shelter design. In the environmental dimension, it is important that the materials used in temporary shelters are environmentally friendly. In the economic dimension, solutions that are self-sufficient and have low operating costs stand out. In the social dimension, inclusion of users in the process and design approaches that support socialization are envisaged. Evaluating the post-disaster temporary sheltering process in the context of sustainability will not only provide significant gains in environmental, economic and social dimensions, but also contribute to meeting the immediate sheltering needs of disaster victims and long-term recovery processes. In the process of disaster management, the close relationship between pre-disaster and post-disaster periods cannot be ignored. Measures taken and preparations made in the pre-disaster period significantly affect the normalization process after the disaster. Similarly, the organizations and activities carried out after the disaster are reflected back to the pre-disaster period. This cyclical relationship should be addressed in environmental, economic and social dimensions. Decisions taken and investments made in the pre-disaster period can directly affect environmental impacts, economic costs and social outcomes in the post-disaster normalization process. Likewise, recovery and reconstruction activities carried out in the post-disaster period can also contribute to the sustainability of the pre-disaster period. In this context, disaster management strategies should be associated with environmental, economic and social dimensions of sustainability. Decisions to be taken in pre- and post-disaster periods should be planned in a way to observe the balance between these three dimensions.

In this context, it is important to explain the concepts of disaster, post-disaster shelter and sustainability. Disasters cause multifaceted harm to people. In addition to causing injuries and loss of life, they also cause emotional stress and trauma (Cuny, 1994). Every year, thousands of people around the world are affected by natural disasters. When examining the needs that arise after these disasters, providing safe shelter areas is critical for disaster victims to reorganize their lives (Dayanır et al., 2022). The increase in the number of natural disasters has caused extensive damage to buildings and resulted in many homes being rendered unusable. This has resulted in large numbers of people becoming homeless (Félix et al., 2013). A home is a space where people can live, providing conditions for family life, comfort, protection and privacy. After a disaster there must be a rapid response to shelter needs because losing a home is more than a physical deprivation, it is a loss of dignity, identity and privacy (Barakat, 2003) In other words, providing housing after a disaster is a basic need. This is because housing establishes a sense of normality in the affected community, prevents the spread of death and disease, offers favorable conditions for personal hygiene and provides protection against external influences. Post-disaster housing is a critical requirement for the launch of recovery and reconstruction programs, offering victims privacy, protection and better sanitation. Temporary shelter is needed when disaster victims cannot live in their previous housing and new permanent housing is not yet available. This need is urgent. In disaster management plans, the implementation of temporary shelter takes place simultaneously with recovery and reconstruction strategies in the post-disaster phase. These strategies are implemented to overcome the losses caused by the disaster (Abulnour, 2014). In other words, while temporary shelter is an urgent need in the post-disaster phase, it also forms part of recovery and reconstruction plans. Therefore, temporary shelter is vital for communities affected by disasters and aims to meet the temporary shelter needs of disaster victims. The concept is not simple and requires finding solutions to the emergency and temporary shelter problems created by disasters (Faragallah, 2021). The definition of temporary shelter is not a simple matter. Johnson (2002) uses the term "temporary shelter" to refer to the different types of temporary shelter that people use after disasters until they settle in a permanent home. From another perspective, temporary shelter is a complex component of housing reconstruction that enables people to recover and resume their domestic routines shelter housing is a cumulative system that provides shelter for recovery alternatives for families affected by hazards and disasters (Corsellis, 2012; Faragallah, 2021). Temporary shelter is a type of shelter provided at different stages in post-disaster situations. Shelter serves both as an immediate protection and a function to support the normalization process of disaster victims. Temporary shelter can also be defined in the following ways: (a) as an object, i.e. the physical structure where people live after a disaster. (b) as a process, i.e., temporary shelter is part of the process after a disaster, just as Turner (1972) defines housing as a process, not a product. (c) as a function, i.e. a place that functions to house people from the time of disaster until they have a permanent place (Johnson, 2007a). In conclusion, temporary shelter is a physical structure, a stage in the process and a place that serves a temporary function. According to Quarantelli (1995), temporary shelter is extremely important in the recovery process after disasters. Temporary shelter allows people to return to their normal daily activities such as work, cooking, cleaning, school, socializing (Johnson, 2007b; Arslan & Cosgun, 2008). At this point, Quarantelli (1995) makes a distinction between the concepts of shelter and housing. According to this Shelter is a temporary place to stay immediately after a disaster, where daily activities are suspended. Housing, on the other hand, refers to a return to household responsibilities and daily routine (Johnson, 2002). In other words, while shelter meets immediate needs, housing provides a more permanent solution for life to return to normal. Based on Quarantelli's distinction between shelter and housing, four stages of shelter can be defined in the post-disaster rehabilitation (recovery) process: Emergency Shelter: Temporary places where survivors stay for a short time immediately after a disaster, such as a friend's house or public shelter. Temporary Shelter: Places such as tents, collective shelters, etc. used for longer but still temporary stays a few weeks after the disaster. Temporary shelter: A place where survivors can reside for six months to three years, such as a prefabricated house or rented accommodation. Here, daily activities can be resumed. Permanent Housing: A reconstructed or new house, where survivors can settle permanently. According to this four-stage process, post-disaster recovery and return to normalcy is ensured (Félix et al., 2013). The temporary shelter phase, one of these four phases, cannot be hidden or canceled (Javanforouzande et al., 2020). In summary, the post-disaster process consists of emergency, temporary and permanent phases. At each stage, the need for shelter is tried to be met in different ways. However, there are no specific and decisive strategies for all stages. This deficiency hinders preparedness for disasters. The current post-disaster housing approach fails to meet the needs of disaster victims in a phased, urgent, economic and ecological manner. Therefore, it is important to produce a solution equipped with sustainability criteria to solve the housing problem ecologically, progressively, urgently and economically (Javanforouzande et al., 2020). Temporary shelter solutions have been widely used after the largest-scale disasters. However, these solutions have been criticized as not sustainable and culturally adequate (Félix et al., 2013). In order to achieve sustainability, there are many criteria that a temporary architecture must achieve (Duksi & Küçükali, 2016). These sustainability criteria are an important element to evaluate the sustainability performance of temporary architecture (Duksi & Küçükali, 2016). In this context, it has been observed in the literature studies that the basic elements covering the sustainability criteria of temporary architecture are discussed under different headings in the studies. Duksi and Küçükali (2016): Budget, Operation Time, Use Time, Material, Energy, Water, Flexible Capacity, while Hosseini et al. (2019); Aysan and Davis (1993); Johnson (2002); Barakat (2003); Chandler (2007); El-anwar et al. (2009); Hadafi and Fallahi (2010a) and Wei et al. (2012) categorize them as economic, social and environmental aspects. Javanforouzande et al. (2020) categorizes sustainability criteria in post-disaster temporary shelter as social, cultural, economic and environmental, while Félix et al. (2013) examines cost and environmental aspects. In another study, the sustainability criteria proposed for temporary shelter were determined as economic, cultural and social aspects, environmental aspects, construction systems and materials, site organization and model, components and space design, and some approaches and solutions were developed accordingly (Faragallah, 2021). To summarize from the literature research; it is seen that it is important to explain some issues about determining the sustainability criteria of post-disaster shelter designs. These are;

Firstly, if Environmental Sustainability is considered, the use of renewable energy sources (solar, wind, etc.) is important for ensuring environmental sustainability in post-disaster shelter designs. Researchers such as Arslan (2007), Pourdeihimi (2011) and Alemi et al. (2015) and when environmental sustainability is examined in the section on shelter and settlement standards of the Humanitarian Convention and Minimum Standards in Humanitarian Assistance in the Sphere Guide (Sphere, 2018) emphasized that the use of renewable energy sources such as solar, wind, geothermal and hydroelectricity in post-disaster temporary shelters plays a key role in ensuring environmental sustainability. Solar energy is a low-cost renewable energy source that can be widely used in disaster areas. Arslan (2007) and Pourdeihimi (2011) stated that the installation of photovoltaic solar panels in temporary shelter units and thus meeting the electricity needs is very advantageous from an environmental point of view. Wind energy can also be effectively utilized, especially in rural areas. Alemi et al. (2015) stated that the integration of wind turbines can sustainably meet the energy needs of temporary shelter units. Geothermal energy is a type of energy obtained from underground resources and can be used in the long term. Geothermal energy systems can be used to meet the heating and cooling needs of temporary shelters, especially in disaster areas in hot climate zones (Pourdeihimi, 2011). Hydroelectric power plants can also be used to meet the energy needs of temporary shelter units after a disaster. These renewable energy sources offer clean and sustainable solutions for the operation and lighting of temporary shelters. Water management and recycling are other important criteria under the heading of Environmental Sustainability. Khalili and Amindeldar (2014) state that efficient use of water resources and recycling of wastewater in temporary shelter units are decisive in creating environmentally friendly systems. Patel and Hastak (2013) emphasized that rainwater collection and storage, gray water use and integration of wastewater treatment systems are important for sustainable water management in temporary shelter units. Other environmental sustainability criteria include the use of recyclable, natural and local materials (wood, soil, bamboo, etc.) (Sphere, 2018; Oliver, 2003; Sanderson et al. 2014) and designs that observe ecological balance and support biodiversity (Daneshpour & Mahmoudinejad, 2015; Barenstein, 2006; Hoşkara, 2007). Oliver (2003) stated that the use of traditional, local materials in temporary shelter units will reduce environmental impacts and provide designs that are compatible with the cultural context. Sanderson et al. (2014) also stated that temporary shelter units built using local materials in post-earthquake Haiti are successful examples in terms of environmental sustainability. In the Sphere (2018), Daneshpour and Mahmoudinejad (2015) and Barenstein (2006) emphasize that designs that respect ecological balance and support biodiversity will reduce the long-term environmental impacts of temporary shelter units after disasters.

Secondly, Social Sustainability: In terms of social sustainability, spaces that meet the psycho-social needs of disaster victims are important. Researchers such as Hayles (2010), Dalgish (2013) and Barenstein (2006) have emphasized that meeting the psychological and social needs of disaster victims plays a critical role in the design of post-disaster temporary shelter units. Félix et al. (2013) also drew attention to the importance of providing areas to support the psycho-social well-being of disaster victims in temporary shelter units. Sanderson et al. (2014) stated that the creation of community centers and therapy rooms in temporary shelters after the earthquake in Haiti accelerated the post-traumatic recovery process of disaster victims. Daneshpour and Mahmoudinejad (2015) emphasized that strengthening social networks and community ties in post-disaster temporary shelter units contributed to the increase of psychological resilience of disaster victims. Twigg (2015) states that common areas that meet psycho-social needs enable disaster victims to have a healthier recovery process by reducing stress and anxiety levels. In common areas that support community formation and social interaction, Dikmen (2019) stated that it is also critical for social sustainability to consider the accessibility of disabled and disadvantaged groups to temporary shelter units. Designing shelters to meet the specific needs of these groups supports their daily life activities and participation in social life.

Finally, the criteria under the Economic Sustainability heading are important for the functionality and long-term use of temporary shelter units after a disaster. While meeting the needs of disaster victims, these criteria also support the efficient use of resources and local economic development. Low construction, operation and maintenance costs are critical for the economic sustainability of post-disaster temporary shelter solutions. Sev (2009), Félix et al. (2015) and Arslan (2007) stated that low-cost temporary shelter options are more effective in meeting the short and long-term needs of disaster victims. Alemi et al. (2015) and Sanderson et al. (2014) also emphasized that simple and modular building systems provide advantages in terms of both economic and environmental sustainability. Employment opportunities that will revitalize the local economy are also a prominent criterion under the heading of Economic Sustainability. Patel and Hastak (2013) and Gharaati (2006) argue that employing local people in the construction, operation and maintenance of temporary shelters offers economic opportunities and strengthens social cohesion. Sanderson et al. (2014) stated that the use of local materials and labor in post-disaster temporary shelter programs in Haiti contributed to economic development. Long-lasting and durable building systems are also considered as an important criterion for Economic Sustainability. Arslan and Cosgun (2008), Gharaati (2006) and Alemi et al. (2015) stated that the long-term use of building systems used in temporary shelters provides both economic and environmental advantages. Durable and reusable building elements can also be utilized in the post-disaster reconstruction process. Disaster shelter designs prepared by considering all these elements can both provide quality of life for disaster victims and support environmental, social and economic sustainability. In this way, the post-disaster process will be more resilient and permanent.

2. Material and Method

2.1. Material

One of the most critical needs after a disaster is the need for shelter. Solutions for sheltering needs differ according to the type of disaster, regional characteristics of the geography where the disaster occurred and the time elapsed after the disaster (Baluken, 2023). In this context, the design of temporary shelter units not only provides an immediate solution, but also constitutes a critical step to increase resilience against future disasters. Designing these units within the framework of sustainable principles is important not only to provide an emergency solution but also to increase resilience against future disasters. According to the data in the Emergency Event Database (EM-DAT) database (https://public.emdat.be/), a total of 17,187 natural disasters were recorded between 1900 and 2024. This database includes data obtained from various sources such as the International Federation of the Red Cross, the United Nations, Red Crescent Societies and national governments (Usta, 2023). Among the 19 countries most affected by natural disasters are the United States of America (USA), China, India, Philippines, Indonesia, Japan, Bangladesh, Mexico, Brazil, Iran, Pakistan, Colombia, Afghanistan, Australia, Peru, France, Italy and Russia, while Türkiye ranks 16th with 218 disaster records (Emergency Event Database, 2024; Tarakçı et al., 2024)(Figure 1).

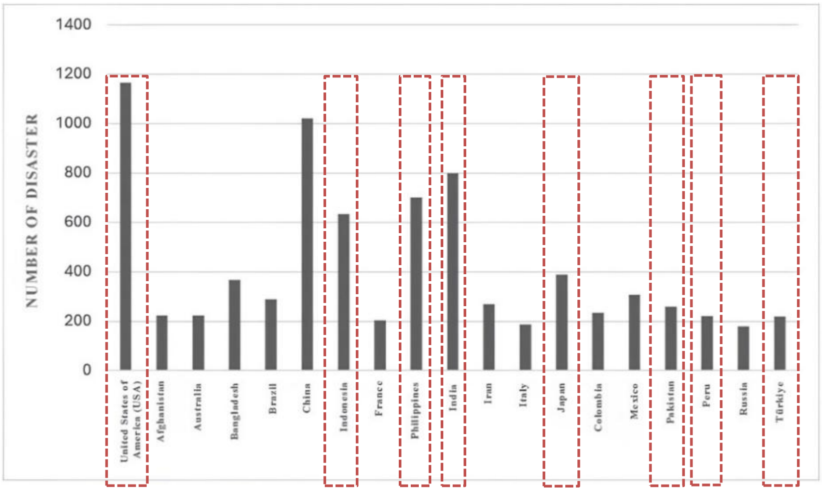

Figure 1: Disasters occurring in countries in the EM-DAT database (Emergency Event Database, 2024; Tarakçı et al., 2024)

In this study, the environmental, economic and social sustainability of temporary shelter units used in case of a possible disaster is analyzed within the framework of determined criteria. Within the scope of the research, structures that are considered as temporary shelter units, whose design information is accessible, used in different disasters, have 2D and 3D drawings with various square meters and interior and exterior visuals of the space, can be constructed in a short time, and maintain their durability until permanent solutions are possible were selected from 19 countries. The 8 countries where the selected buildings are located are marked in red in Figure 1. In this context, temporary shelter units were selected from the United States of America, Indonesia, Japan, Philippines, Pakistan, Türkiye, Peru and India, which have faced the most disasters. Temporary shelter units for which design information, visuals and drawings could not be accessed, which were not used after the disaster or which remained only as pilot designs were excluded from the scope (Table 1).

Table 1: Temporary shelter units determined for the study

Temporary Shelter Units					
	Rapido	Timber Frame	Paper Log House	Container T. Shelter	Transitional Shelter
Disaster Type	Hurricane	Earthquake	Earthquake	Earthquake	Typhoon
Name of Disaster	Dolly Hurricane	Padang Earthquake	Kobe Earthquake	Japan Earthquake	Washi Typhoon
Year	2008	2009	1995	2011	2011
Location	USA	Indonesia	Japan	Japan/Onagava	Philippines
Designer	Rapido	information not accessed	Shigeru Ban	Shigeru Ban	Jason Buensalido
Materials	Stone and wood	Bamboo	Plywood, steel bars etc.	Converted containers	Wood-Metal
Time to build	3 day	2 day	6 hour	1-2 day	12 day
Lifespan	information not accessed	6-12 month	2-5 year	5-10 year	5 year
Number Built	information not accessed	7000	information not accessed	100	250
Square meters	40.15	18	15.7	29	36
Source	Yılmaz (2021)	IFRC (2011)	Rethinking The Future (2024)	Arquitectura Viva (2024)	IFRC (2013)
Temporary Shelter Units					
	Cebu	One Room Shelter	Containers	Timber Frame-2	Paper Log House II
Disaster Type	Hurricane	Flood	Earthquake	Earthquake	Earthquake
Name of Disaster	Hurricane Haiyan	Pakistan floods	Kahramanmaraş Earthquake	Pisco Earthquake	Gujarat Earthquake
Year	2013	2010	2023	2007	2001
Location	Philippines	Pakistan	Türkiye	Peru	India
Designer	Jason Buensalido	information not accessed	AFAD	information not accessed	Shigeru Ban
Materials	Wood-metal	Brick-Tile	Steel	Wood veneer	Paper Log-Wood
Time to build	1-2 week	1-2 week	1-3 day	1 day	1-5 day
Lifespan	5-10 year	10 year	10-20 year l	24 month	5 year
Number Built	100 and above	875	information not accessed	2020	100 and above
Square meters	36	19	20-30 m^2	18	18-20
Source	Özcan vd. (2021)	IFRC (2013)	Tarakçı (2024)	IFRC (2011)	Shigeruban Architects (2024)

While analyzing the 10 selected buildings, many plans, sections, elevations, photographs and videos and data from different sources were examined. However, not all images were included in the study.

2.2. Method

This study, which deals with temporary shelter units within the framework of sustainability criteria, uses the case study method. Case study, as defined by Creswell (2007), is a qualitative research approach in which the researcher examines a limited number of situations or events in a certain period of time by using data collection tools (observations, interviews, audio-visual materials, documents, reports) obtained from multiple sources. In this process, situations and themes related to the situation are identified. In addition, case study is also defined as a qualitative research method in which a situation or event is investigated and the data collected are evaluated in the context of real life conditions (Davey, 1991; Yin, 1984).

This study, which analyses the environmental, social and economic sustainability of temporary shelter units, consists of five stages (Figure 2). The first stage is a comprehensive literature review on disaster, temporary sheltering, post-disaster temporary sheltering units and sustainability. This review formed the general framework of the study and provided the necessary theoretical background for the methodology. In the second stage, the method was designed by categorizing the information obtained through the literature review under environmental, social and economic sub-headings. In the third stage, the sample group to be analysed in the study was determined and detailed information about the buildings in this group was presented. In the fourth stage, analyses were carried out within the framework of sustainability criteria for the selected sample group. Finally, these analyses are evaluated with a table based on the findings of the literature review and recommendations are made about the buildings.

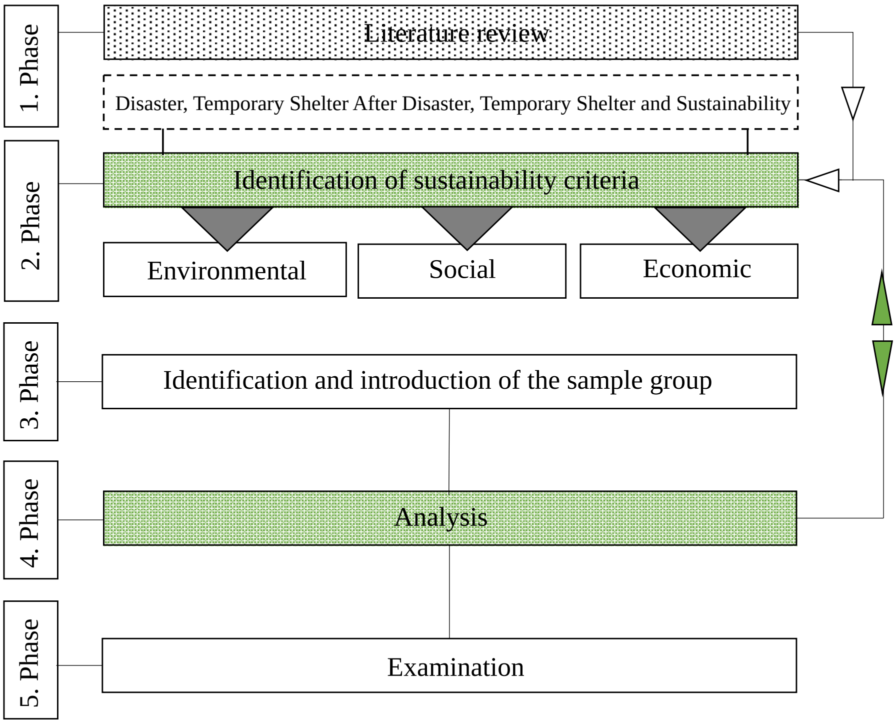

Figure 2: Stages of work

In the study, the sustainability of temporary shelter units is analysed by focusing on 3 sub-headings: environmental, social and economic. The criteria addressed in the literature review were analysed and the similar ones were classified. Table 2 shows the sustainability criteria created for the evaluation of temporary shelter units used after disasters. While creating these criteria; 13 sub-strategies belonging to the environmental, social and economic headings were determined based on the classifications made by Aysan and Davis (1993), Johnson (2002), Barakat (2003), Chandler (2007), Duksi and Küçükali (2016), El-Anwar et al. (2009), Hadafi and Fallahi (2010b), Hosseini et al. (2019), Wei et al. (2012) and Javanforouzande (2020). Each sub-strategy is numbered within its own sub-heading.

Table 2: Sustainability criteria for post-disaster temporary shelter units

SUSTAINABILITY CRITERIA			REFERENCE
Environmental	1	Use of renewable energy sources (solar, wind, etc.)	Arslan (2008); Pourdeihimi (2011), Alemi et al. (2015)
	2	Ensuring water management and recycling	Khalili & Amindeldar (2014); Patel & Hastak (2013); Hoşkara (2007)
	3	Preferring recyclable materials	Oliver (2003); Sanderson et al. (2014)
	4	Use of local materials	Daneshpour & Mahmoudinejad (2015); Barenstein (2006)
	5	Use of materials that do not have a negative impact on human health	Oliver (2003); Sanderson et al. (2014)
	6	Designs that consider ecological balance and support biodiversity	Daneshpour & Mahmoudinejad (2015); Barenstein (2006)
Social	1	Places that meet the psycho-social needs of disaster victims	Hayles (2010), Dalgish (2013), Barenstein (2006)
	2	Common spaces that support community formation and social interaction	Félix et al. (2013); Sanderson et al. (2014); Daneshpour & Mahmoudinejad (2015); Twigg (2015)
	3	Ensuring accessibility for disabled and disadvantaged groups	Dikmen (2019)
	4	Designs that preserve cultural and traditional elements	Barenstein (2006); Lizarralde & Davidson (2006)
Economic	1	Low construction, operation and maintenance costs	Félix et al. (2015); Arslan (2007); Alemi et al. (2015), Sanderson et al. (2014); Halliday (2008); Sev (2009)
	2	Employment opportunities that will stimulate the local economy	Patel & Hastak (2013), Gharaati (2006); Sanderson et al. (2014)
	3	Long-lasting and durable building systems	Arslan & Cosgun (2008), Gharaati (2006), Alemi et al. (2015)
			Aysan & Davis (1993); Johnson (2002); Barakat (2003); Chandler (2007); Duksi & Küçükali (2016); El-Anwar et al. (2009); Hadafi & Fallahi (2010b); Wei et al. (2012), Javanforouzande et al. (2020)

Main objectives of the strategies under the environmental sustainability criteria: Environmental sustainability strategies aim to minimize the environmental impacts of post-disaster temporary shelter solutions, reduce energy, water, waste generation and natural resource use, and ensure efficient use of resources through renewable energy and recycling. It is also important to promote the sustainable use of resources and ensure the long-term sustainability of these solutions by preferring natural and local materials.

Main objectives of the strategies under the social sustainability criteria: Social sustainability goals include supporting the mental health of disaster victims, providing social services and rehabilitation, strengthening solidarity and increasing accessibility. In this context, facilitating access to services for groups with special needs and creating designs that reflect cultural identities are also priorities.

Main objectives of the strategies under the economic sustainability criteria: To ensure that post-disaster temporary shelter solutions are economically cost-effective, to create a sustainable economic model by minimizing operation and maintenance costs in the long term, to support the local workforce and economic activities in the disaster area, to contribute to local employment and economic development, to ensure that post-disaster temporary shelter units are long-lasting and durable, to enable the reuse, conversion or recycling of structures.

3. Findings

3.1. Rapido

General information: In July 2008, Hurricane Dolly made landfall in the Gulf of Texas, causing significant damage along the southern coast of the United States. Hurricane Dolly reached South Padre Island in Texas on 23 July 2008. The hurricane, which was a Category 2 hurricane at the time, produced heavy rains and strong winds in the Texas-Mexico border region (Berg, 2009). Thousands of homes and businesses were damaged or destroyed in the areas hit by the hurricane. This situation brought the need for emergency shelter to the agenda of the local population. Local governments and aid organisations took action to establish temporary shelter units. These temporary shelter units served an important function to solve the immediate and short-term shelter problem until the disaster victims were able to find permanent housing. Thanks to the quick response of the authorities and the co-operation of various stakeholders, thousands of people were able to find safe and appropriate shelter in the aftermath of Cyclone Dolly.

The temporary shelter unit, which was produced to meet the basic needs of the disaster victims after this disaster, has a sleeping area of 13.40 square meters and a bathroom of 6.70 square meters. The other part of the unit, the living space, is 20,05 square meters and has a counter area. Elevations and porches for the entrance made by the disaster victims within their needs have increased the livability of the unit (Yılmaz, 2021), (Figure 3).

Figure 3: Rapido temporary shelter unit figure (Yılmaz, 2021)

Information on sustainability framework: RAPIDO programme is designed to meet the need for temporary shelter after a disaster and to facilitate the process of converting it into permanent housing. In this context; shelter units designed in prefabricated and modular structure can be applied to different terrain conditions and can be installed quickly. Panels and components produced off-site are brought to the disaster area and mounted on concrete foundations. Infrastructure, electricity and installation systems of the units are integrated into the panels. The RAPIDO programme includes the use of environmentally renewable energy sources. Water management and recycling practices ensure the effective use of water resources. Preference of recyclable materials reduces the amount of waste. The use of local stone or wood reduces transport costs. The use of materials such as paints with low VOC emissions and formaldehyde-free wood is observed. From an economic point of view, RAPIDO programme stands out with its low construction, operation and maintenance costs. The use of local labour force accelerates the construction process. It is aimed to increase resilience against future disasters by using long-lasting and durable building systems.

3.2. Timber Frame

General Information: On 30 September 2009, a series of earthquakes occurred in West Sumatra, particularly near the city of Padang. These earthquakes affected 13 of the 19 districts of West Sumatra province. Approximately 250,000 houses were either destroyed or severely damaged as a result of the earthquakes and landslides (Shelter Projects, 2010). The Government of Indonesia responded quickly with support from the national and international humanitarian community. The government focused on rebuilding provincial government capacity, search and rescue and emergency relief. The emergency phase was concluded within 8 weeks. The temporary shelter units built after the disasters were constructed using local materials. The bamboo tree grown in the Indonesian region constitutes the basic construction systems of the shelter units. In addition, when the materials used are examined; local materials such as terra cota tiles, wooden constructions, palm fibres, galvanised steel frame, steel legs, screws and nuts, nails, wooden planks were used (Ünal, 2017). Timber frame structures were preferred as temporary shelter after the earthquake. This type of structure is lightweight and durable, showing a high resistance to earthquakes and can be constructed quickly. Since the wood material can be sourced locally, it reduces transport costs and supports the local economy. The shelter structure is a timber frame structure with a roof and walls made of palm trees. Its plan dimensions are 4.5 m x 4 m, with a height of 3.35 m to the summit beam and 2.4 m to the eaves level. The roof has a slope of 23.6 degrees (International Federation of Red Cross and Red Crescent Societies, 2011), (Figure 4).

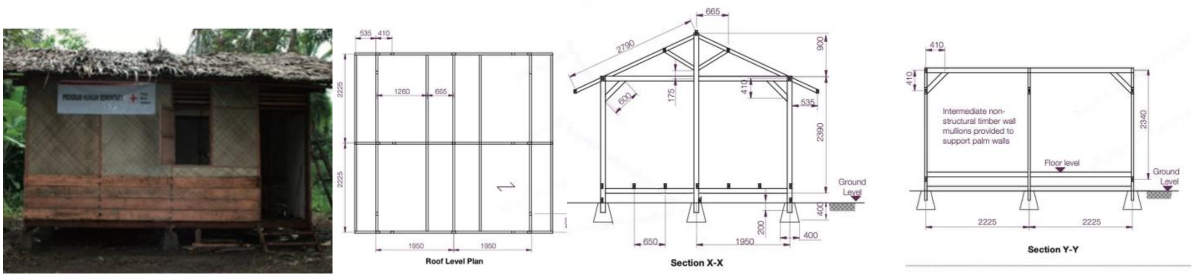

Figure 4: Timber Frame temporary shelter unit figure and drawing

Information in the context of sustainability: There is no bracing in the building; however, a certain stability is provided by the interconnection of the three portal frames with horizontal elements at ground, eaves and summit level. Each portal frame consists of two or three columns and beams supporting the roof and corner bracing elements.

Corner bracing elements in the frames provide horizontal stiffness. Secondary non-structural elements include floor joists, roof beams extending between the beams, and transoms supporting palm wall panels (International Federation of Red Cross and Red Crescent Societies, 2011). The shelter structure has a suspended floor structure, which is assumed to extend between the coconut wood flooring and the floor joists. The columns are embedded in concrete bucket foundations that rest directly on the ground (International Federation of Red Cross and Red Crescent Societies, 2011). The shelter is constructed from locally sourced materials that are familiar to residents and do not require special tools or equipment for assembly. It can therefore be constructed quickly after a disaster and is relatively easy to maintain and adapt over time, depending on the needs of the residents. This shelter offers a good short-term design solution, suitable in areas vulnerable to high seismic and wind loading (International Federation of Red Cross and Red Crescent Societies, 2011).

3.3. Paper Log House

General information: In 1995, the great earthquake in Kobe, Japan, was recorded as one of the most destructive earthquakes in the history of the country. The 7.2 magnitude earthquake, which occurred at 05:46 on 17 January 1995, destroyed the city (Asahi, 1995). After the earthquake, which severely damaged the city, architects and designers started to look for innovative solutions to respond to the urgent housing needs of people. In this process, architect Shigeru Ban developed emergency shelters made of ‘paper logs’, a material that can be used in extraordinary situations. This innovative approach resulted in a lightweight and reusable shelter that can be constructed quickly and economically. Paper logs, being a cheap, easily available and environmentally friendly material, have come to the fore as a solution that can respond to the need for emergency shelter after disasters. Shigeru Ban and his team named this new construction prototype ‘Paper Log House’ and it was an effective response to the need for emergency shelter after the earthquake in Kobe. This innovative approach is recognized as an important development in the field of post-disaster housing (Rethinking The Future, 2024) (Figure 5).

Figure 5: Paper Log House temporary shelter unit figures and drawing (Shigeru Ban Architects, 2023)

Information within the framework of sustainability: The Paper Log House construction method can be realised quickly without the need for any machinery. Each structure, when equipped with the necessary materials, can be built by eight people in just two days (Shigeru Ban Architects, 2023). This quick and simple installation process can quickly respond to the need for emergency accommodation for victims in future disaster situations. Paper Log Houses offer an environmentally friendly shelter option as they are built using natural and renewable materials. Since the design criteria for temporary shelter for the victims of the Kobe Earthquake required affordable structures that anyone can build, have adequate thermal insulation and aesthetic appearance, and can be easily dismantled and recycled, the solution that meets these requirements was found to be a log house hut made of beer cans filled with sand, paper tubes and tent membranes.

3.4. Container Temporary Shelter

General information Container T. Shelter is an emergency shelter solution designed by Shigeru Ban after the major earthquake in Japan in 2011. This building was developed to meet the need for shelter in a fast and effective way after natural disasters. The architectural design was realised by Japanese architect Shigeru Ban. Container T. Shelter aims to provide a safe and habitable living space for post-earthquake victims. Each container dwelling is approximately 29 square meters in size. Depending on how the containers are combined, there are three types of apartments: for one or two persons (19.8 m²), for three or four persons (29.7 m²) and for more than four persons (39.6 m²). To improve the storage systems, the Volunteer Architects Network (VAN), led by Shigeru Ban himself, installed wooden shelves and cupboards in the rooms (Figure 6).

Figure 6: Container temporary shelter unit figures (Özcan et al., 2021)

Information within the framework of sustainability: Converted containers were used in the project. The containers have been transformed into habitable and comfortable spaces through architectural design. The construction time of Container T. Shelter usually varies between 1-2 days. The service life of Container T. Shelter usually varies between 5-10 years. It stands out as a solution that offers advantages such as fast assembly, flexibility and economy. It provided a quick response to the need for shelter after the earthquake. After the 2011 Japan earthquake, approximately 100 Container T. Shelter were built in the Onagawa region. These structures were widely used to meet the need for emergency shelter. Lightweight structural elements, insulation materials and durable cladding materials are used for interior design.

3.5. Transitional Shelter

General Information: In 2011, after Typhoon Washi (Sendong) hit the Philippines, the Cebu Transitional Shelter Project was initiated to provide a fast and permanent shelter solution for disaster victims. The prefabricated and modular shelter units are each approximately 36 m2 in size. The units are constructed with timber frame, concrete wall, corrugated metal roof system and have a compact plan scheme. Each unit has a bathroom and an entrance hall. This structural system provides easy assembly, flexibility and conversion to permanent housing. It is also designed according to the needs and expectations of disaster victims. Prefabricated production was applied for fast installation after the disaster. Temporary shelter was provided until the return of the disaster victims and the ground was prepared for permanent housing planning. Improvements were made for the units with user participation. The architectural design of the Transitional Shelter Project was realised by Filipino architect Jason Buensalido. Each prefabricated shelter unit is approximately 36 square meters in size. The shelter is a rectangular building with a gable roof and a covered floor area of approximately 4.0 m x 5.0 m, with an indoor bathroom and an entrance hall of approximately 4.0 m x 1.5 m (Figure 7).

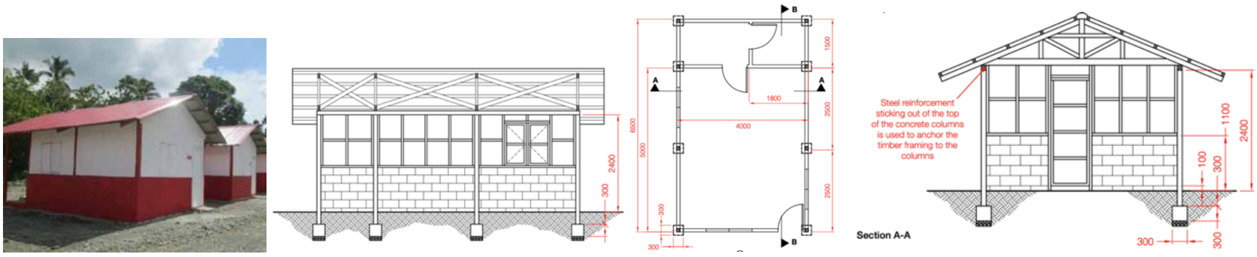

Figure 7: Transitional temporary shelter unit figures and drawing (International Federation of Red Cross and Red Crescent Societies, 2013)

Information in the context of sustainability The external walls have a semi-high concrete masonry structure supported by a timber frame extending to the eaves, while the roof consists of timber beams and purlins carrying corrugated metal sheets; this roof frame is supported by eight prefabricated concrete columns located inside the external walls. The concrete columns and masonry walls are embedded in the ground and do not require a special foundation. The floor is covered with a poured concrete slab and a septic tank is located in the bathroom. Thanks to its modular design, the shelter can be expanded and relocated with minor changes to the main structure. The materials used offer a reasonable design life by increasing durability; the concrete and masonry materials are very robust and the wooden components are made durable by the necessary treatments. The prefabricated concrete columns allow the roof to be constructed quickly to provide a closed shelter during the construction of the external walls, while the shelter can perform adequately against lateral wind and seismic loads thanks to the appropriate anchorages of the timber frame.

3.6. Cebu

General Information: The Philippines is a country that is affected by many tropical cyclones every year. In 2013, after Hurricane Haiyan hit the Philippines, this unit was developed to meet the need for emergency shelter. The project was designed by Jason Buensalido and was created for a quick and effective post-disaster solution.

In this context, it was prepared as a project similar to the RAPIDO programme. Prefabricated and modular shelter units were designed. Thus, solutions that are suitable for different terrain conditions and can be installed quickly have been produced (Figure 8).

Figure 8: Cebu temporary shelter unit figures and drawing (Özcan et al,, 2021)

Information within the framework of sustainability: Wall, roof and floor panels produced off-site in the factory were brought to the disaster area and assembled. This shortened the construction period. Disaster victims were involved in the design process by determining their needs. Thus, user satisfaction was tried to be ensured. Paper tubes were used in the corners of the design and woven bamboo sheets were applied as connection material between them. The foundations are made of beverage crates filled with sandbags and the floor is made of plywood made of coconut wood. Students at Sen Carlos University were also involved in its construction (Özcan et al., 2021). The construction time of the Cebu Hurricane structure usually varies between 1-2 weeks. In terms of its social impacts, Cebu Hurricane increases social resilience by allowing communities to rebuild quickly and supports economic revival through the employment of local labor. Economically, the fast construction time and use of local materials reduces costs, which is important for communities working with limited resources. In the long term, the resilience and reusability of the structure increases the capacity to respond quickly to future disasters.

3.7. One Room Shelter

General information: The 2010 floods across Pakistan had a major impact due to heavy rainfall that exceeded forecasts. The impact of the flood disaster was greater than the previous disasters of 2005 (earthquake), 2005 hurricane (Katrina), 2008 hurricane (Nargis in Myanmar), 2010 Haiti (earthquake) and 2004 Indian Ocean tsunami (Kuzucuoğlu & Başbuğ Erkan, 2020). One Room Shelter was developed to meet the urgent need for shelter after the major flood disaster in Pakistan in 2010. This shelter is a rectangular structure with dimensions of approximately 4.8m x 3.9m and has a flat roof (Figure 9).

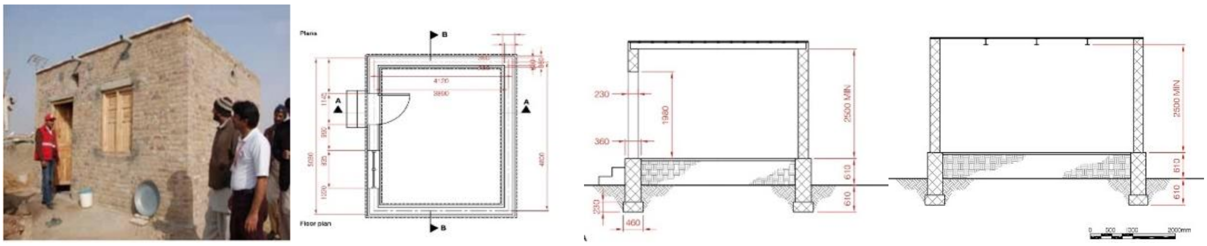

Figure 9: One Room temporary shelter unit figures and drawing (International Federation of Red Cross and Red Crescent Societies, 2013)

Information in the framework of sustainability: The walls are constructed of 230 mm thick, unreinforced, fired bricks supporting the roof. The roof is covered with ceramic tiles, supported on steel beams, and a cement render coating is applied on top of the tiles. The foundation consists of unreinforced brick piers and foundation walls. The part of the floor covered with plaster is located at least 610 mm above the surrounding floor surface. The design of the structure includes a door and a window, as well as air vents at the top of the walls (International Federation of Red Cross and Red Crescent Societies, 2013). This structure was designed to enable flood-affected communities to quickly regain a safe living space. Its main materials are bricks and tiles; the bricks increase the durability of the structure, while the tiles play an important role in providing waterproofing and longevity of the roofing. The expected lifespan of One Room Shelter is approximately 10 years, but this can be extended with regular maintenance and repair. The construction time usually varies between 1-2 weeks, which contributes to the reconstruction of communities by providing a quick solution in emergency situations. A total of 875 of these structures have been built, providing safe shelter for many people affected by the floods. One Room Shelter aims to minimize environmental impact by using local materials. Materials such as bricks and tiles are sourced locally, reducing construction costs and supporting the local economy. In addition, these structures are designed in accordance with local climatic conditions and are structured in a way to provide energy efficiency.

3.8. Containers

General Information: Türkiye is located on the Mediterranean-Alpine Himalayan earthquake belt, which is one of the most critical earthquake belts on earth, and earthquakes occur frequently in the country due to this geological structure. After various disasters such as earthquakes in Türkiye, public institutions have solved emergency and temporary shelter units. Container structures were rapidly established to meet the need for emergency shelter, especially after the major earthquake in Kahramanmaraş in 2023. These structures are designed to ensure that individuals affected by the earthquake have a safe living space. Containers can be placed quickly after the disaster thanks to their portable structures and can be used immediately in the areas where they are needed (Figure 10).

Figure 10: Containers temporary shelter unit figures and drawing (Tarakçı, 2024)

Information within the framework of sustainability: Container structures have various characteristics in terms of the comfort and security provided in temporary accommodation centres. The average indoor area per person varies between three and a half and four and a half square meters. In hot and humid climates, air flow is provided in the containers to prevent direct sunlight, while in cold climates the materials are intended to provide optimum insulation. The height of the containers should be at least 30 centimeters from the ground and necessary infrastructure connections should be made if there are areas such as toilets or kitchens in the interior (Afet ve Acil Durum Yönetimi Başkanlığı, 2015). In addition, the containers have an installed power capacity of 15 kilowatts per hour. All connections in insulation and electrical installations must comply with Turkish Standards Institute (TSE) norms. The floor of the containers, which are built using fire-resistant materials, are made of materials that do not break and will not be damaged in case of contact with water. Sealing is ensured by using waterproof material on the upper parts of the ceiling. Kitchen worktops in the interiors are designed from unbreakable materials and equipped with ventilation systems over the stove (Afet ve Acil Durum Yönetimi Başkanlığı, 2015).

3.9. Timber Frame II

General Information: Developed to address the urgent shelter needs following the Pisco Earthquake, this structure features a wooden frame construction that offers significant advantages in terms of lightweight and durability, allowing for rapid assembly in emergency situations. The construction time is merely one day, with plans for the structure to be utilized for up to 24 months. The interiors are designed to meet basic needs and can accommodate up to 18 individuals. Built on a 3m x 6m plan, it utilizes Bolaina wood-supported framing and features a single-pitched roof with a slope of four degrees (Figure 11).

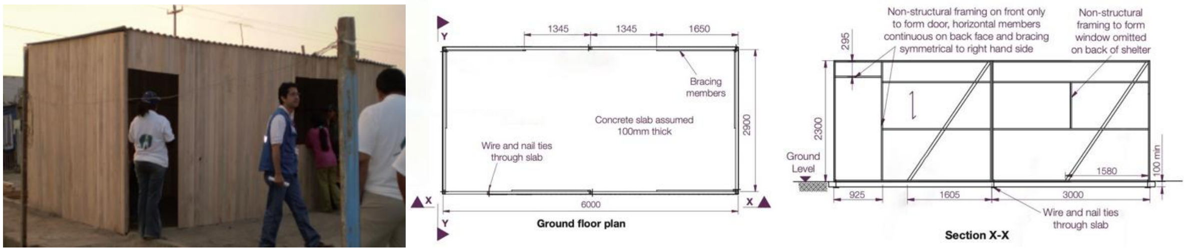

Figure 11: Timber Frame II temporary shelter unit figures and drawing (International Federation of Red Cross and Red Crescent Societies, 2011)

Information within the framework of sustainability: The shelter features walls constructed with solid wood panels covered by a tongue-and-groove system, and a roof made of corrugated fiber cement sheets. Standing at a height of 2.4 meters, the structure is positioned on either a new or an existing concrete slab. When a new slab is utilized, wire ties wrapped around nails embedded in the ground provide resistance against upward lifting at all column points of the frame. In cases where existing slabs are used, the shelter is anchored to external posts for stability. The shelter consists of six panels that are assembled using connecting wooden elements, connection plates, and plastic straps. A central ridge beam is added to the panels, with additional beams nailed on top to support the roof. This lightweight and simple box shelter presents a good design solution for areas sensitive to seismic loads; however, its performance under wind loads is deemed insufficient. The structure utilizes locally sourced materials and does not require specialized tools or equipment for assembly. The panelized construction method offers advantages in terms of construction speed and quality control.

3.10. Paper Log House II

General Information: The Paper Log House project, designed by Shigeru Ban, was implemented following the earthquake in Gujarat, India, in 2001, to provide shelter for those who lost their homes. The architectural design of the project is recognized for its pioneering work in disaster relief shelters by the Japanese architect Shigeru Ban. It was specifically conceived to address the urgent shelter needs after the Gujarat Earthquake in 2001. Ban aimed to offer a rapid solution by utilizing environmentally friendly and sustainable materials in this structure. Paper tubes form the foundation of this building due to their lightweight and ease of transport, while also providing a cost-effective option. Each Paper Log House has an approximate size of 18-20 square meters (Figure 12).

Figure 12: Paper Log House II temporary shelter unit figures and drawing (Shigeruban Architects, 2024)

General Information: The project utilizes inexpensive and readily available materials. Paper tubes (logs) and plastic coverings have been chosen as the primary construction materials, providing a rapid and economical solution. The structure features easy installation and dismantling capabilities, making it lightweight and portable. Environmentally friendly and recyclable materials have been employed. It has a seismic-resistant construction system and can be used as a temporary shelter. Rubble from demolished buildings was used for the foundation, covered with traditional mud flooring. For the roof, split bamboo was utilized for the ribbed vaults, while whole bamboo was used for the ridge beams, with a plastic tarp sandwiched between two woven bamboo mats

4. Examination and Recommendations

The strategic headings created under the environmental, social, and economic dimensions of sustainability criteria have been consolidated into a table for the analysis of shelter units used after disasters. The resulting evaluation table allows for the examination of a defined sample group in accordance with sustainability criteria, identifying the status of each sub-criterion. The evaluation and scoring system are as follows: 5 grades are defined for the evaluation, namely excellent, good, moderate, bad, and very bad. Each of these is dis- played an assigned color. In this respect, green is for excellent, yellow for good, orange for mediocre, red for bad, and crimson for very bad.

In Table 4, each criterion and its sub-strategies are evaluated separately and suggestions are made for developing applicable designs or improving existing designs. From the perspective of environmental sustainability, it is of great importance to create self-sufficient housing units that will reduce environmental impacts, be environmentally friendly, minimize resource consumption and waste production.

Table 4: Evaluation of environmental sustainability criteria in structures and recommendations

CRITERIA / UNITS	Environmental						RECOMMENDATIONS
	1	2	3	4	5	6	
Rapido	🟩	🟩	🟩	🟩	🟩	🟩	To ensure environmental sustainability. Design should be created by considering the place-context relationship Self-sufficient and self-powered units should be created, Integration of renewable energy systems such as solar panels and wind turbines should be considered, Consider how much resources it will consume during the construction phase and consider alternative energy sources, Energy efficient appliances or equipment should be used, It should offer energy efficient architectural solutions such as natural ventilation, Consider the use of recyclable materials, The installation of gray water recycling systems should be considered, Harvest and store rainwater, Integration of wastewater treatment systems should be ensured, The duration of use and the areas of use should be determined correctly, and designs should be created by taking into account the damage to the area after the structures are removed, Use of prefabricated, modular, and demountable building systems, Consideration should be given to the production and use of temporary shelter units and the waste that may be generated after their use, and plans should be made to reduce this waste, They should be considered and designed to be reusable or recyclable after their lifetime, Local and natural materials (wood, earth, bamboo, etc.) should be preferred.
Timber Frame	🟥	🟫	🟧	🟨	🟧	🟧	
Paper Log House	🟩	🟫	🟩	🟩	🟨	🟨	
Container T. Shelter	🟥	🟥	🟨	🟨	🟩	🟩	
Transitional Shelter	🟫	🟫	🟧	🟧	🟧	🟧	
Cebu	🟫	🟫	🟩	🟩	🟩	🟧	
One Room Shelter	🟫	🟫	🟩	🟩	🟩	🟩	
Containers	🟫	🟫	🟨	🟫	🟧	🟧	
Timber Frame II	🟫	🟫	🟩	🟩	🟩	🟩	
Paper Log House II	🟫	🟫	🟩	🟩	🟩	🟧	

🟩 Excellent 🟨 Good 🟧 Moderate 🟥 Bad 🟫 Very-bad

In Table 4, an analysis of the selected examples based on social criteria has been conducted, and recommendations have been provided. The examined examples, including Container T. Shelter, Transitional Shelter, Cebu, One Room Shelter, Container, Timber Frame II, and Paper Log House II, indicate that renewable energy sources (solar, wind, etc.), water management, and recycling are not adequately implemented. To ensure environmental sustainability in temporary shelter units, solar panels can be integrated into the units. Wind turbines can be positioned in the shelter areas. Hybrid energy systems (solar + wind) can be utilized, and energy management systems can be established. High-efficiency LED lighting should be used, along with energy-efficient heating, cooling, and ventilation systems. Designs can be made to maximize the use of daylight, and passive solar design techniques (such as solar shading and thermal storage) can be applied. Natural ventilation and lighting systems can be utilized, and energy-efficient devices and equipment should be selected. Additionally, the establishment of greywater recycling systems, rainwater harvesting and storage, and wastewater treatment and reuse systems is important. This way, water management and recycling strategies can be effectively implemented. The recommendations for water management and recycling are also applicable to the Timber Frame and Paper Log House structures. Low-water consumption fixtures and devices can be used, and rainwater irrigation systems can be developed. Modular systems can be designed for water reuse, and rainwater storage ponds can be created. Sedimentation and filtration systems can be utilized for water recovery. In all structures, the use of local materials that do not adversely affect human health has been observed, along with designs that consider ecological balance and support biodiversity. The examined examples show the use of natural materials such as local wood, earth, bamboo, and reeds, benefiting from traditional construction techniques and local craftsmanship. Evaluating materials obtained from local vegetation, using local waste materials (such as agricultural and industrial waste), selecting non-harmful materials, and considering the recyclability and reusability of materials will minimize the environmental impacts of temporary shelter solutions after disasters.

From the perspective of social sustainability, it is important to address the social and psychological needs of disaster survivors living in the units, support community formation and social interaction, ensure accessibility for disabled and disadvantaged groups, and allow for the preservation of local cultural elements (Table 5).

Table 5: Evaluation of social sustainability criteria in buildings and recommendations

CRITERIA UNITS	Social				RECOMMENDATIONS
	1	2	3	4	
Rapido	🟫	🟫	🟫	🟫	To ensure social sustainability. Psychological counseling and therapy rooms can be designed, Playgrounds and educational spaces can be created for children, Social and vocational skills development spaces for young people can be provided, Recreation and socialization areas for the elderly can be organized, Rehabilitation and physical therapy centers can be established, Activity areas that support the social and emotional well-being of disaster victims can be created, Designs can be made to meet privacy and security needs, Shared spaces such as communal kitchens, laundry and recreation areas can be designed, Areas can be allocated for outdoor activities, concerts, festivals, Communal spaces can be created to strengthen neighborhood relations, Accessible designs can be made for wheelchair, visually and hearing impaired people, Accessibility elements such as ramps, elevators, disabled toilets, handrails can be integrated, Can apply universal design principles in guidance and information systems, Furniture and equipment can be selected according to the needs of disabled and elderly users, Inclusive and accessible spaces can be created by adopting universal design principles, Traditional designs can be made using local architectural textures, materials, and techniques, Symbols, motifs, and decorations reflecting the cultural identity of the disaster victims can be added, Incentives and support can be provided for the preservation of cultural and traditional elements, Communal areas reflecting the cultural identities of disaster victims can be designed.
Timber Frame	🟫	🟫	🟫	🟫	
Paper Log House	🟫	🟫	🟫	🟫	
Container T. Shelter	🟫	🟫	🟫	🟫	
Transitional Shelter	🟫	🟫	🟫	🟫	
Cebu	🟫	🟫	🟫	🟫	
One Room Shelter	🟫	🟫	🟫	🟫	
Containers	🟫	🟫	🟫	🟫	
Timber Frame II	🟫	🟫	🟫	🟫	
Paper Log House II	🟫	🟫	🟫	🟫	

🟩 Excellent 🟨 Good 🟧 Moderate 🟥 Bad 🟫 Very-bad

In Table 5, an analysis of the selected examples based on social criteria has been conducted, and recommendations have been provided. It has been observed that the objectives of the sub-strategies are not being met in the examined examples. In these structures, including temporary shelter units, if social sustainability criteria are not met, the temporary shelter solutions following a disaster will be unable to address the social and cultural needs of the survivors, community formation and solidarity will remain weak, and accessibility for disabled and disadvantaged groups will not be ensured. This situation will negatively impact the recovery and reintegration processes of the survivors, complicating social cohesion and integration. Furthermore, the preservation and transmission of cultural heritage will also become more challenging.

From the perspective of economic sustainability, it is important to achieve more cost-effective, locally supportive, and long-term resilient units in temporary shelter solutions following a disaster (Table 6).

Table 6: Evaluation of economic sustainability criteria in buildings and recommendations

CRITERIA / **UNITS**	**Economic**				**RECOMMENDATIONS**
	1	**2**	**3**	**4**	
Rapido	🟩	🟩	🟩	🟩	To ensure economic sustainability. Materials that do not require maintenance and repair can be selected, Techniques that save labor and time in the maintenance process can be applied, Self-repairing materials and systems that do not require maintenance and repair can be used, Material and energy-saving technologies can be used during construction and operation, Local labor force in the disaster area can be integrated into the construction processes, Local material producers, suppliers and artisans can be supported, Local employment can be ensured in the maintenance and operation of temporary shelter units, Local commercial and economic activities can be established in temporary shelter areas, Policies and incentives can be created to ensure the sustainability of local economic activities, Durable, long-lasting and maintenance-free materials may be preferred, Design solutions that increase the flexibility and adaptability of buildings can be created, Designs that allow for the reuse, transformation or recycling of structures can be created, Integration of technologies and systems that reduce the need for maintenance and repair of buildings can be achieved, Design solutions that reduce the risks of collapse, damage and deformation of structures can be created, Preventive maintenance and repair programs can be implemented to extend the life of buildings.
Timber Frame	🟩	🟩	🟩	🟫	
Paper Log House	🟩	🟩	🟩	🟧	
Container T. Shelter	🟩	🟩	🟩	🟩	
Transitional Shelter	🟩	🟩	🟩	🟩	
Cebu	🟩	🟩	🟩	🟩	
One Room Shelter	🟩	🟩	🟩	🟩	
Containers	🟩	🟩	🟩	🟩	
Timber Frame II	🟩	🟩	🟩	🟩	
Paper Log House II	🟩	🟩	🟩	🟫	

🟩 Excellent 🟨 Good 🟧 Moderate 🟥 Bad 🟫 Very-bad

In Table 6, the selected examples are analyzed economically in line with the criteria and recommendations are made. It is seen that the sub-strategies meet their objectives in the analyzed examples. If the economic sustainability criteria are met, post-disaster temporary shelter solutions will be more cost-effective, supportive of the local economy and durable in the long term. In this way, economic recovery and development processes in the disaster area will be accelerated, local employment and income opportunities will increase, efficient use of resources will be ensured and shelter needs of disaster victims will be met more economically.

5. Conclusion

Disasters not only result in loss of life but also cause many people to become homeless, highlighting the urgent need for shelter for disaster victims. Therefore, ensuring that disaster victims have access to temporary shelter units as quickly as possible is of critical importance. However, the design of temporary shelter structures should not only focus on meeting immediate needs but also adhere to sustainability principles. In this regard, the use of environmentally friendly materials, energy and water management, waste management, flexibility, and reuse should be considered. Designing temporary shelter units in accordance with sustainability criteria will not only meet the basic needs of disaster victims but also support long-term recovery and reintegration into society. In this context, analyzing the practical outcomes of temporary shelter units used after disasters will provide guidance for future designs and academic studies. This analysis offers recommendations for understanding the sustainability performance of temporary shelter solutions, transferring the findings to future research, and developing evaluation tools. In this way, more sustainable, inclusive, and cost-effective temporary shelter solutions can be designed and implemented. From an environmental perspective, positive outcomes such as improved energy efficiency, enhanced water and waste management practices, increased use of renewable energy, and widespread recycling activities have been achieved in temporary shelter units. As a result, the environmental impacts of post-disaster recovery and reconstruction processes have been minimized, long-term sustainability has been ensured, and natural resources have been preserved. However, neglecting environmental criteria may lead to environmental degradation, social inequalities, and economic constraints.

From a social perspective, temporary shelter units contribute significantly by addressing the psychosocial needs of disaster victims, fostering community formation, ensuring accessibility for disabled and disadvantaged groups, and preserving local cultural and traditional elements. These factors strengthen social cohesion and solidarity, facilitating the recovery and reintegration processes of disaster victims. However, in the analyzed examples, these criteria were overlooked, which may hinder social integration and cohesion in the future, making it more challenging to preserve cultural heritage. From an economic perspective, temporary shelter units provide significant benefits by reducing construction, operation, and maintenance costs, boosting local economies and employment opportunities, and promoting the development of long-lasting and durable building systems. As a result, post-disaster economic recovery and development will be accelerated. Otherwise, construction, operation, and maintenance costs will rise, local economies and employment opportunities will be limited, durable building systems will not be established, and post-disaster economic recovery and development will slow down. Additionally, resources will be wasted, and the sheltering needs of disaster victims will be met at a higher cost. In conclusion, the implementation of environmental, social, and economic sustainability criteria in temporary shelter units will ensure that post-disaster recovery and reconstruction processes are more sustainable, inclusive, and cost-effective. Otherwise, issues such as environmental damage, social inequalities, and economic constraints may arise. This study provides insights that will guide future design and academic research, offering clues for developing criteria and approaches to evaluate the sustainability performance of temporary shelter units. Consequently, more sustainable solutions can be developed for post-disaster recovery and reconstruction processes. Ultimately, the presence of sustainability features in temporary shelter units is crucial for both supporting the well-being of disaster victims and reducing environmental impacts. To ensure that temporary shelter solutions are durable, environmentally friendly, and responsive to the needs of disaster victims, key criteria such as eco-friendly materials, energy efficiency, water management, waste management, flexibility, and reuse should be considered. Taking these factors into account will enable the development of more resilient and sustainable temporary shelter solutions in post-disaster processes.

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