EVALUATION OF TEMPORARY HOUSING UNITS WITH MULTI-CRITERIA DECISION MAKING METHODS

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ABSTRACT

EVALUATION OF TEMPORARY HOUSING UNITS WITH MULTI-CRITERIA DECISION MAKING METHODS

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Disasters caused by natural hazards or socio-political crises pose widespread damage or mass migration on built environment resulted with loss of housing. To meet accommodation needs of disaster victims, post disaster temporary accommodation units, including temporary sheltering and temporary housing units, are common solutions not only to bridge the gap until permanent housing are ready to use but also to provide physical and psychological rehabilitation. As post-disaster accommodation units are absolutely diversified from the housing production in usual conditions with respect to necessity of prompt readiness and instant as well as extensive response, the management of provision, design and construction of them require rapid and organizational evaluation.

Even a permanent housing needs a challenging decision-making process for designers, decision-making process of post-disaster temporary housing units is one of the most contradictive and uncommon architectural design problems due to its crucial role on the recovery period of community. As the design guidelines of temporary housing units have not been well-emphasized in a systematic approach; in current practice, to overcome sheltering problem of victims, ready-made or instantly developed temporary housing units are applied by top-down decisions. Nevertheless, temporary accommodation projects that are evaluated with ad hoc decision-making approaches

generally yield various social, environmental and economic problems. Although several studies have been carried out contributing on qualifications of temporary units, there isn't any contribution on the issue of the decision-making process of temporary housing units.

This dissertation presents a generalized road map with several aspects based on multi-criteria decision-making methods for evaluation of temporary accommodation units with respect to conducted research on literature varying from diverse cases. For the decision-making process of temporary accommodation units, this method has been proposed from an architectural point of view and several real-case studies have been applied to present the practicality of the model. The presented approach aims not only to reach the most rational alternative for each case and its diverse specifications but also direct designers to carry out a design process with contextual approach.

Keywords: Post-disaster units, Temporary housing units, Multi-criteria decision making

ÖZ

GEÇİCİ KONUT ÜNİTELERİNİN ÇOK KRİTERLİ KARAR VERME YÖNTEMLERİ İLE DEĞERLENDİRİLMESİ

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Doğal afetler ya da sosyo-politik krizler sonucunda ortaya çıkan felaketler, başlıca konut kaybı olmak üzere yapılı çevrede birçok hasara yol açmaktadır. Afet mağdurlarının barınma ihtiyacına cevap verebilmek amacıyla yaygın bir çözüm olarak başvurulan afet sonrası geçici konaklama birimleri, kalıcı konutların kullanımı hazır olana kadar afet mağdurlarına fiziksel ve psikolojik rehabilitasyon sağlamaktadır. Afet sonrası geçici konaklama ünitelerinin, hızlı hazır olma, anlık ve kapsamlı müdahale gerekliliği göz önünde bulundurulduğunda, günlük konut üretiminden tamamen farklı olduğu ve tedarik, tasarım ve inşaat yönetimi açısından hızlı ve teşkilatlı bir değerlendirme gerektirdiği gözlenmektedir.

Sıkça uygulanan kalıcı bir konutun bile tasarımcılar için zorlu bir karar verme sürecine neden olduğu düşünüldüğünde, 'iyileşme' sürecinde toplum üzerindeki önemli rolü nedeniyle, afet sonrası geçici konaklama üniteleri, en çelişkili ve nadir görülen mimari tasarım sorunlarından biri olmaktadır. Geçici konaklama birimlerinin tasarım ilkeleri sistematik bir yaklaşımla oluşturulmadığı için, mevcut uygulamada, mağdurların barınma sorunlarının üstesinden gelmek için hazır veya anında geliştirilmiş geçici konut birimleri tepeden aşağı kararlar ile uygulanmaktadır. Buna rağmen, doğaçlama karar verme yaklaşımlarıyla değerlendirilen geçici konut projeleri genellikle çeşitli sosyal, çevresel ve ekonomik problemlere neden olmaktadır. Geçici konut birimlerinin nitelikleri konusunda çeşitli çalışmalar yapılmış olsa da, karar verme süreçleri üzerine

herhangi bir çalışma bulunmamaktadır. Bu tez, literatürde yer alan değişken afet sonrası durumları göz önünde bulundurarak geçici konut birimlerinin değerlendirilmesinde çok kriterli karar verme yöntemlerini esas alan genel bir yol haritası sunmaktadır. Geçici konut birimlerinin karar verme süreci için mimari bir perspektiften önerilmiş bu yöntemin uygulanabilirliği, birkaç gerçek olay üzerinde uygulanarak sunulmuştur. Önerilen yaklaşım, her bir durum ve onun çeşitli özelliklerinin incelenerek en rasyonel alternatife ulaşmanın yanı sıra, tasarımcıları bağlamsal yaklaşımla oluşturulmuş bir tasarım sürecine yönlendirmeyi hedeflemektedir.

Anahtar Kelimeler: Afet sonrası üniteler, Geçici konut üniteleri, Çok kriterli karar verme

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AFAD	T.C. Disaster and Emergency Management Presidency
AHP	Analytical Hierarchical Process
ALNAP	The Active Learning Network for Accountability and Performance in Humanitarian Action
CBA	Cost-Benefit Analysis
CHRP	Community-Based Housing Response Pool
DQI	Design Quality Indicator
DSS	Decision Support Systems
ELECTRE	ELimination Et Choix Traduisant la REalité
ES	Emergency Shelter
FEMA	Federal Emergency Management Agency
IDP	Internationally Displaced Person
HERR	Humanitarian Emergency Response Review
HQI	Housing Quality Indicators
IEMS	The Integrated Emergency Management System
IFRC/RCS	The International Federation of Red Cross and Red Crescent Societies
IOM	The International Organization for Migration
LTD	Long-Term Dwelling
MADM	Multi Attribute Decision Making

MCDM	Multi-Criteria Decision Making
NGO	Non-Governmental Organizations
NYC	New York City
UN	United Nations
UN / OCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNDRO	United Nations Disaster Relief Organization
UNHCR	United Nations High Commissioner for Refugees
UNISDR	United Nations International Strategy for Disaster Reduction
PKEMRA	Post-Katrina Emergency Management Reform Act

CHAPTER 1

INTRODUCTION

1.1 Background Information

Damage on built environment, mass migration, homelessness, and destruction of social life are some of the issues that communities confront with following a detrimental disaster. However, loss of housing is one of the menacing problems due to the difficulty of maintenance of lives of disaster victims caused not only by destruction of buildings but also by lack of housing following disaster.

As the main aim of disaster management is to prevent or to diminish risk to life of human beings' and to any livelihood systems affecting human beings, authorities and role-takers apply several precautions. Accordingly, post-disaster temporary units are applied as a common solution until permanent housing is ready to be used since loss of lives have been confronted in past post-disaster experiences due to the lack or rareness of provision of accommodation units. Three sheltering types, emergency shelters, temporary shelters and temporary housing units, are respectively applied by authorities to prevent suffering of affected communities starting from the emergence of disaster to the permanent reconstruction.

As temporary accommodation units should be achieved as a result of a design process, they involve a decision-making process since the responsibility of architects and designers is to convert the design problem into a well-structured quest for the given input variables such as location, climate and culture within a certain time. Besides constituting a physical space, temporary accommodation units satisfy the sheltering need of human beings which is defined as one of the deficiency needs of human beings.

Considering the critical role of temporary housing units for post-disaster environment, their decision-making process is required to be investigated in 'preparedness' period not to confront with detrimental problems in case of a disaster.

1.2 Problem Statement

The experiences in previous disasters show that premeditation in post-disaster decisions are either insufficient or totally absent that decisions are promptly made due to chaos following disaster (as cited in Johnson et al., 2006). Considering this, decision making following a disaster is more complex than decision-making in ordinary conditions due to being torn between contradictory issues (Boano, Rottlaender, Sanchez-Bayo, & Viliani, 2003).

Among the multi-institutional and branched structure of disaster management, decision making and taking action are squeezed between two main contradictory approaches: short-term necessities and long-term requirements. Although the aim and the principles of disaster management is relatively well-defined, the situation of chaos constrains decision makers to improvise post-disaster activities in a rush due to the absence of up-front planning. This usually directs decision makers to apply "fast and frugal heuristics" for deciding urgently in post-disaster phase. Moreover, the restricted time may result in focusing on only one and perhaps subjectively selected criterion of the problem so that remained criteria such as social, environmental and economic criteria could be overlooked.

Due to necessity of prompt readiness and instant as well as extensive response for post-disaster accommodation units, they are diversified from the housing production in daily conditions so that rapid and organizational evaluation become necessary in the management of provision, design and construction. However, in current practice, to overcome sheltering problem of victims in limited time of post-disaster environment, top-down decisions direct authorities to apply ready-made or instantly developed temporary housing units. Nonetheless, decision-making processes resulted with top-

down approaches pose diverse social, environmental and economic problems. Rather than examining only economy or another specific feature, the temporary housing is an issue needed to come up with an extensive perspective.

As a result of this problematic position of decision making in the evaluation of temporary housing units, temporary housing units are failed to meet the instant and/or future needs of the habitants or have negative effects. Therefore, the motivation of this thesis is the temporary housing units which are incompatible with the disaster affected community and their short-term and long-term results which are difficult to overcome.

1.3 Literature Review

Temporary accommodation, enacted in 1947 in Japan, is defined by The Disaster Relief Act as rapidly generated housing for disaster victims to host them in safe conditions before transferring them to permanent houses (Ueda & Shaw, 2016). While different contributions are made on the stipulated usage period of temporary housing units in literature, Song, Mithraratne, & Zhang (2016) indicate the usage period between 6 months to 3 years, whereas Ueda and Shaw (2016) limit the usage period to 2 years. However, the expected or defined period of time can usually be inadequate to provide permanent housing to affected society. For instance, with respect to the data published by UNHCR (2017), approximately 5 million Syrian people, which is approximately the 25% of the total population of Syria, have registered as refugee and migrated neighborhood countries, notably to Turkey, after the incident in Syria since 2011. Though it has been more than six years, approximately 10% of the victims are still accommodating in refugee camps whereas the remained 4.700.000 people are settled down urban, peri-urban and rural areas.

Elaborating on properties of temporary housing, it carries similar properties with permanent housing as being bigger and more resistant compared to temporary shelters (Félix, Monteiro, Branco, Bologna, & Feio, 2015). In addition, temporary housing owes necessary infrastructures as water supply, drainage, electricity (Félix et al.,

2015). However, design of temporary housing units should not be ordinary. Indeed, social areas can be achieved with several combinations of unit types and their relation to environment (Eren, 2012).

Félix, Branco, & Feio, (2013) group temporary housing approaches: prefabricated, mass-produced and standardized units into two major categories which are ready-made units and kit supplies. While ready-made units are totally constructed in workspaces, kit supply solutions are constituted with small, light and easy to handle components and combinable elements, appropriate to implement on site. Thus, kit supplies let individuals participate assembly or construction of units on site, while ready-made units seek heavy-transport systems to be established requiring few simple assembly works. However, both might fail to satisfy sustainability in terms of environmental, economic and social issues since making projects actualized and adapting them to local conditions are mostly not considered and the prompt generation of units pushes needs of the users into the background (Perrucci, Vazquez, & Aktas, 2016).

On the other hand, considering the temporary housing as highly applied element of reconstruction phase, Rafieian & Asgary (2013) examine temporary housing units, regarding to their location, into two types which are on site and on campsites. Since the affected families do not want to leave their damaged buildings, on-site temporary housing is figured out. On the contrary, governmental or non-governmental associations commonly apply temporary housing units in planned or unplanned campsites.

Elaborating on the decision-making process of temporary housing units, despite the rich history of MCDM, its use is a relatively new research subject on the decision-making strategy for various aspects of temporary housing units, such as site selection and sustainability. For instance, Kilci, Kara, & Bozkaya (2015) have emphasized the importance of locating the temporary housing areas after an earthquake and implemented the MCDM on a case in Turkey. Additionally, Trivedi & Singh (2017) pave a MCDM way for the site selection problem of emergency shelters while

Hosseini et al. (2016b) applied MCDM for reaching the sustainable site location of post-disaster temporary housing in urban areas.

Apart from the studies on the site selection, Hosseini, De La Fuente, & Pons (2016a) defines the problem as the sustainability of temporary housing units' technologies and covers it via MCDM. Their study employed a hybrid model to reach the most sustainable temporary housing technology alternative. They have used Analytical Hierarchy Process (AHP) to determine the weights of indexes and the Integrated Value Model for Sustainable Assessment (MIVES), which is a local assessment tool, to select the optimal alternative.

Taking into consideration of the vital role of temporary housing units for post-disaster environment and the problems of existing applications in current practice, their design occupies a critical place for the maintenance of human beings' life. To achieve an ideal disaster management process, necessity of a new evaluation framework, which is transparent and reviewable, for decision-making process of temporary housing units is monitored via MCDM.

1.4 Objective and Scope

The aim of this study is to investigate the potentials of MCDM methods in the evaluation process of temporary housing units by proposing a generalized road map including temporary housing design criteria. Moreover, the practicability of the proposed method, a hybrid approach formed by AHP and ELECTRE, is examined in the evaluation of temporary housing units on specific post-disaster real-life cases. The objectives of this dissertation are:

- to inform decision-makers about problems and guidelines of post-disaster temporary housing units,
- to generate an extensive and holistic decision criteria matrix for temporary housing units to guide architects and decision-makers,

- to present a systematic road map based on multi-criteria decision making methods for the evaluation of temporary housing units,
- to examine the practicability of the designated road map for several various post-disaster situations,
- to minimize problems of post-disaster temporary housing units caused by limited time of 'reconstruction' and 'recovery' phase of disaster management,
- to direct decision-makers and architects to be well-prepared in 'preparedness' phase of disaster management.

This dissertation is composed of five chapters. First chapter displays a general overview of the dissertation including a literature survey on temporary housing units and their decision-making process in a post-disaster environment.

Chapter 2 gives extensive information about the accommodation response in disaster management approaching the problem from disaster management perspective.

An overview of temporary housing units is described in Chapter 3 including their problems, guidelines and design criteria. In this chapter alternatives of temporary accommodation units are also displayed with their properties.

Chapter 4 is devoted to evaluation of temporary housing units in terms decision making and MCDM, including AHP and ELECTRE I methods. Proposed method for the evaluation of temporary housing units is presented with the decision criteria matrix.

After the representation of selected alternatives and selected, scenario-based application of the proposed methodology is described, in Chapter 5, through three real-life case studies to test the applicability of the proposed methodology.

Finally, Chapter 6 is dedicated to summary and conclusion of the evaluation of temporary housing units with respect to multi-criteria decision-making methods. In addition, limitations and future work are also included in this chapter.

CHAPTER 2

ACCOMMODATION RESPONSE IN DISASTER MANAGEMENT

2.1 Disaster Management

Disasters are mainly explained with displaying impacts on human society. It is possible to state impacts of disasters on human society as unavoidable loss of life, dramatic economic losses, interruption of developmental issues, devastation of the natural and built environment, inclining vulnerability, setback in local institutions and livelihoods and languishing of local community (Haigh & Amaratunga, 2010). Losses following a disaster is categorized into two as direct and indirect losses. While direct losses can generally be illustrated with damage to buildings, indirect losses can be sampled with loss of employment and deprivation of sales (Alexander, 2002). On the other hand, according to the statements of Smith (2013), the estimation of impacts of a disaster is mainly concerned with regarding to the loss human life.

Considering losses, disasters caused by natural hazards are claimed as one of the most harmful threats to humanity. Further, disasters caused by social, political and economic environments also threaten the world's population by causing to shorten or lose their lives. Nevertheless Wisner, Blaikie, Cannon, & Davis (2003) claims that the main issue is not emphasizing on natural hazards nor directly disasters themselves, the main issue is trying to plan or mitigate disasters. Taking into consideration of planning or mitigating the disasters, 'disaster management' comes into prominence in the context.

Disaster management, a continuous ongoing process, is identified as the organization and the management of sources and roles emphasizing on humanitarian aspects of emergency situations (IFRC, n.d.).

Despite differences in birth reasons of disasters, it is possible to accomplish disaster management paths in an analogous manner. Another issue is that disaster management paths can be carried out according to speed of arrival of disasters as creeping disasters, which develops progressively or cumulatively over a long period of time such as months or years, and sudden disasters such as tornadoes and earthquakes. Following the mitigation of disasters as a context in disaster management, the planning and management of disasters are vitally critical since it is possible to confront impacts of a disaster for years resulted in newly existed indirect losses (Alexander, 2002).

According to Oxfam, an organization providing shelter in emergency situations, the process of response to any disaster starts with the comprehension of the term emergency: "Any situation where there is an exceptional and widespread threat to life, health or basic subsistence, which is beyond the coping capacity of individuals and the community" (Oxfam GB, 2003).

In this context, the term 'disaster management' can be interchangeably commemorated with the term 'emergency management', although disaster management actually includes the emergency management in its context. On the other hand, 'crisis', avoiding people to handle with the daily activities and creating stress due to abrupt change, is one of the possible situations following the disaster itself. 'Crisis' and 'emergencies' are probable events following disasters. While emergency management responds to urgent and vital needs with the occurrence of the disaster, disaster management embraces the problem in a comprehensive and organized way with its organizational context (Moe & Pathranarakul, 2006).

Even though neutralizing all unfortunate consequences of disasters is impossible, reducing the impacts of disaster can be achieved with an effective disaster management (United Nations, 2004). The disaster management mainly aims to avoid or to reduce risk to human beings' life and to any livelihood systems affecting human beings. Indeed, the disaster management have the responsibility to emphasize not only on the actual disasters but also on the potential ones, venturing the life of human beings (Alexander, 2002). This means that disaster management mainly aims to reduce

impacts of disasters before they have happened and to take an action throughout and promptly after a disaster.

The following sections present the phases and role takers of disaster management and the link between architecture and disaster management.

2.1.1 Phases of Disaster Management

Commonly, in today's world, it is possible to describe phases of disaster management in a branched and organized way. Despite different approaches on the organization of disaster management regarding to its phases and responses, the main aim of phasing is to diminish conflicts between the role takers (Rueppel & Wagenknecht, 2007) . As a broad approach, de Guzman (2002) classifies the phases of disaster management into two: pre-disaster risk reduction and post disaster recovery. In fact, since the gathered information from one of two phases is reverberated to the other, the two phases consistently contributes to each other and progress.

On the other hand, IFRC (n.d.) displays the phases of disaster management into three major titles: preparedness, response and recovery as shown in Figure 2-1. As presented in this figure, in preparedness period, the goal of the institution is to prepare for disaster and to reduce risk of disaster before disaster happens. After the moment of disaster, response period starts synchronously with the continuation of reduction of risks of disasters and followed by recovering from disasters to reduce the impacts on society.

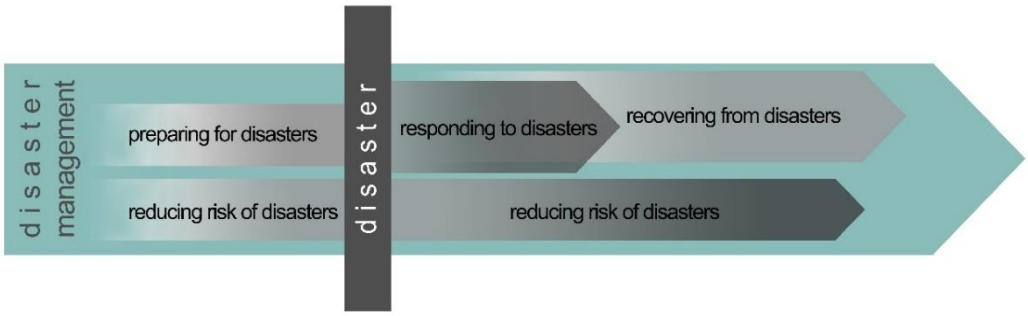

Figure 2-1 Phases of Disaster Management (Adapted from IFRC (n.d.))

Alternatively, United Nations (2004) embraces disaster management under five phases which are prediction, warning, emergency relief, rehabilitation and reconstruction. On the other hand, Jayaraman et al., (1997) emphasize on the point that even though the categorization of phases are totally different form each other, it is necessary to include certain activities: mitigation and preparedness, response and recovery. In other words, despite the variety in phases of disaster management, as represented in Table 2.1., the included activities are interpreted as similar.

Table 2-1 Phases of Disaster Management

Reference(s)	IFRC (n.d.)	de Guzman (2002)	United Nations (2004)	Jayaraman et al., (1997)
Phases of Disaster Management	• Preparedness • Response • Recovery	• Pre-disaster risk reduction • Post-disaster recovery	• Prediction • Warning • Emergency relief • Rehabilitation • Reconstruction	• Mitigation and preparedness • Response and recovery

Although the mentioned phasing approaches for disaster management are universal, country-based or local classifications are also existing. Gülkan and Başbuğ (2009) represent the stages of disaster management in their book, named as 'Perspectives in Disaster Management', with respect to different countries. As an institute of USA, The Integrated Emergency Management System (IEMS), introduces phases of disaster management into four headings: mitigation, preparedness, response and rehabilitation. The National Civil Protection Service, a unified institutional framework for civilian protection at national scale in Italy, embraces its activities into four phases: forecasting, prevention, relief operations and rapid rehabilitation (Gülkan & Başbuğ, 2009). Ergünay (2011) categorizes the phases of disasters into five regardless of birth and growth rate of disaster. And he states, these phases; mitigation, preparation, response, recovery and reconstruction, proceed on a cycle as a continuous process and includes pre-disaster period, time of incident and post-disaster duration (Ergünay, 2011). Consequently, although disaster management have been phased differently for

each country, as shown Table 2.2, disasters are still evaluated as a universal problem beyond borders.

Table 2-2 Phases of Disaster Management for different countries

Institution / Institution Member	The Integrated Emergency Management System (IEMS)	The National Civil Protection Service	Oktay Ergünay, General Directorate of Natural Disasters
Country	USA	Italy	Turkey
Phases of Disaster Management	• Mitigation • Preparedness • Response • Rehabilitation	• Forecasting, • Prevention, • Relief operations • Rapid rehabilitation	• Mitigation, • Preparation, • Response • Recovery • Reconstruction

2.1.2 Role Takers in Disaster Management

As mentioned in previous section, phasing is defined as a necessity in disaster management not to cause conflicts between role takers since the system is established on many different key actors and institutions which have to cooperate with each other to take precautions in the exact location with the appropriate equipment in short period of time (Rueppel & Wagenknecht, 2007).

Despite phasing, FEMA (Federal Emergency Management Agency), the first centralized agency in USA managing the nation's emergency planning and disaster response, has declares its scope as "all hazards, all phases" consisting both post-disaster response and recovery activities; and disaster mitigation and preparation for all diverse disasters (Miller, 2009).

Until 1940s and 1950s, disaster management can be interpreted as a structure with lack of collaboration. Following the reform in structure, the centralized model has broken its shell and the working model has started to become multi-organizational, intergovernmental and inter-sectoral (Waugh Jr. & Streib, 2006).

Considering this extensive structure of disaster management, four significant role takers step forward in this complex model. It is possible to define these four as governmental, non-governmental, public and private bodies. These four main bodies of the structure have responsibilities not only in humanitarian issues but also in developmental issues (Wisner et al., 2006). On the other hand, Shaw (2012) introduces four local role players of disaster management as local disaster managers, trainers, community organizers and local academic institutions.

Regardless to institution, International Federation of Red Cross and Red Crescent Societies states that there should be role takers from various disciplines to assess the situation of the disaster. The assessment teams come under a team coordinator/laison and manage five groups of specialists: logistics, public health - epidemiologist, food and nutrition, shelter and environmental health/water supply (IFRC, 2000).

2.1.3 Architecture and Disaster Management

The human society have main needs to be satisfied which do not differ with respect to culture, nationality or behavior. Maslow (1943) describes the needs of human beings in a hierarchical order and into two groups: being needs and deficiency needs. The deficiency needs as physiological need, safety and security need, social needs and esteem needs are instinctoid needs to be satisfied where the lack of them creates tension on human beings. Starting from the physiological need, which is defined as the lowest level of needs, human beings are driven to satisfy the needs in a hierarchy and are urged to reach higher needs. The last need to be satisfied in Maslow's Hierarchy of Needs is the self-actualization need which is categorized as a being need, as presented in Figure 2-2.

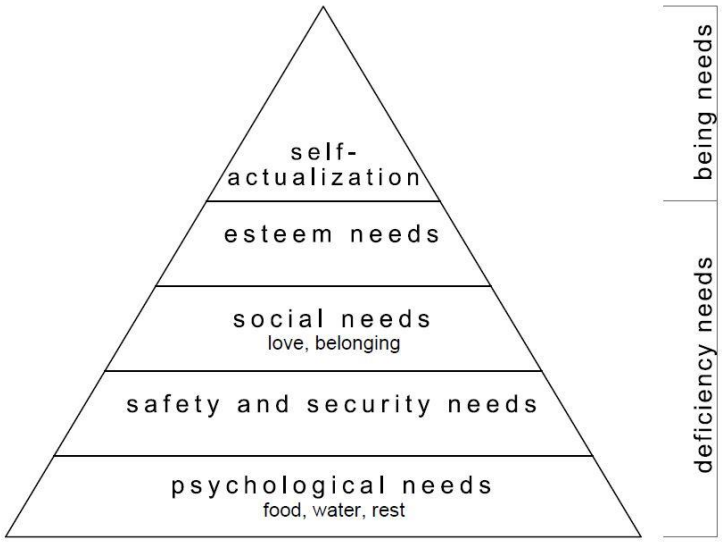

Figure 2-2 Maslow's Hierarchy of Needs (Adapted from Goble (1970))

The safety and security needs of human beings, classified as one of the four deficiency needs in Maslow's Hierarchy of Needs, is originated from the need of maintenance of lives of human beings. In this respect, human beings modify their surroundings to provide environmental control for their maintenance. In order to achieve environmental control, two methods are applied which are physical barriers and energy. Although the first and the easiest way of applying a physical barrier is clothing which is firstly started with turning into the advantage of nature by using the natural barriers such as leaves, bushes etc., afterwards sheltering is mostly preferred due to its durability. Consequently, to satisfy the safety and security needs of human beings for the continuation of their lives, 'shelters' are formed under the guidance of architecture discipline which defines its origin as 'the man' and the relationship between 'the man and his environment' (UNHCR).

Achieving the maintenance of lives, human beings have started to live together in groups. However, after getting started to live in semi-permanent clusters, disasters have appeared (Quarantelli, 2006). United Nations, as an arbiter institution, defines disaster as, "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and

impacts, which exceeds the ability of the affected community or society to cope with its own resources" (UNISDR, 2009). From a different point of view, Smith (2013) defines disasters as events causing extensive losses and influencing the working wheels of the community in a negative way.

In literature, 'catastrophe' and 'calamity' words are used as synonyms of 'disaster' although several authors utilize the word 'catastrophe' to define an exceptionally large disaster despite the lack of quantitative measures or operational thresholds to distinguish them (Alexander, 2002).

Considering different approaches and several synonyms, disaster, as a context, is a critical issue that man confronts and deals with it in certain parts of his life either as a victim or as an observer. Examining types of disasters, Ergünay (2011) categorizes disasters with respect to two major factors as its speed of arrival and its birth reasons. Elaborating on disasters regarding to its speed of arrival, there are two emergence types as suddenly happened and slowly happened. On the other hand, the birth reasons of disasters are gathered under four main headings as geophysics, meteorological, technologic and human reasoned disasters by Ergünay (2011), while Wisner et al. (2006) categorize them into three as natural, technological and complex emergencies.

According to the statements of Quarantelli (2006), natural hazards have always been the primarily and the only hazard posing a disaster in history, however they are not interpreted as pure natural since the relation between the natural environment and built environment may come to exist its outcomes. In other words, when pestilential conditions in built environment meets up with natural hazards, it results in a disaster. Thus, built environment is a crucial determinant on disasters, since outcomes of disasters are directly linked with the relation between them (Lizarralde, Johnson, & Davidson, 2010).

Considering all, as outcomes of several disasters is directly associated with the configuration of built environment, architecture discipline and disasters start to have a bound between each other. Besides, this close association gets stronger in the continuous process of disaster management aiming the maintenance of human beings,

since architecture discipline has a say in mitigating effects of disasters by creating a preserved area for disaster victims. This preserved area, in literature, is termed as post-disaster units which is one of the most contentious issues, located in the center of the structure of disaster management.

2.2 Accommodation of Victims in Disasters

Emphasizing on one of the five disciplines of disaster management, mentioned by IFRC (2000), it is possible to evaluate 'sheltering' as one of the most contradictory issues of disaster management.

In preparedness phase, aiming to avoid loss and damage to living creatures and livelihood systems, various pre-disaster applications are implemented such as precautions for designing and constructing items resisting disasters. Besides, researchers investigate potential 'sheltering' and 'housing' strategies in post disaster conditions (Moor, 2001) because sheltering or housing is usually an inevitable action following a disaster (Mileti, 1999).

Using 'post-disaster accommodations', including sheltering and housing units, is a highly applied method if loss of housing is confronted, considering the criticality of safety and security needs of human beings which is emphasized in detail in previous sections. UNDRO (1982) defines the post-disaster accommodation as fulfilling of sheltering needs of the disaster victims with the emergency, temporary and permanent sheltering with respect to housing policies and applications after a disaster. This section presents the policies in post-disaster accommodation and the differences between 'sheltering' and 'housing'.

2.2.1 Policies of Accommodation in Post-Disaster Response

In post-disaster response, either of the reconstruction of damaged buildings or construction of new permanent buildings needs time and is possible to last long. Since

constructing new accommodation units is a path to be preferred for the time gap, some circumstances direct governments and non-governmental organizations to accommodate disaster victims in various existing buildings such as public buildings, schools, hotels, sport halls, governmental buildings etc. called as 'collective centers' (Camp Coordination and Camp Management Cluster, 2010).

Arguing the necessity of constructing new post-disaster unit, McCarthy (2009), who is an analysist in Emergency Management Policy, asserts the policy of FEMA. According to the policy of FEMA, direct assistance, providing trailers and mobile homes, is applied as the last housing choice while the other housing options such as repair of homes or directing affected people to rental units are not appropriate. Accordingly, FEMA applied this strategy following the Hurricane Katrina. Although the post-disaster response strategy after hurricane is represented as depending on motel rooms and travel trailers, the greater part of affected community is funded to repair their homes and rent accommodations (McCarthy, 2009).

On the other hand, Bektaş (2007) declares that constructing post-disaster accommodation is a key of puzzle in housing recovery so that disaster affected communities usually apply this strategy in their reconstruction program. However, communities who discuss the necessity of it approach the issue from different perspectives so that it is a controversial problem. According to statements of Bektaş (2007), the two main reasons sparking this debate are difficulty in control of time span and undesired conditions of exceeded life of units. Accordingly, while UNDRO (1982) does not term post-disaster shelters as a necessity for each disaster due to the possibility of decelerating permanent reconstruction, Johnson et al. (2006) defines them as a vital and obvious response to provide quick recovery and a safe environment for rebuilding. Thus, as Bektaş (2007) asserts, time dependency and undesired conditions are reasons directing institutions and opining people into this discussion.

As a crucial part of this discussion, psychology of disaster impacted community is explicitly mentioned as one of the most significant reasons. Indeed, the physical construction of post-disaster accommodation is introduced with improving

psychological rehabilitation of users which can be implied as essential in exceptional emergencies (Arslan & Unlu, 2006). In other words, the decision of constructing new post-disaster accommodation provides not only physical reconstruction but also psychological reconstruction. Johnson et al. (2006) define the construction of temporary sheltering and temporary housing units as the evident of 'rehabilitation period'. Considering all, it is also interpreted that the role of architecture, which is providing physical spaces, have a non-negligible effect in the continuous cycle of disaster management comprising pre- and post-disaster period.

Discussing the necessity of post-disaster sheltering through real-life experiences, for instance, following Georgia's declaration of independence from the borders of Soviet Union in 1991, conflicts have posed 300,000 people to expose to be internally displaced person. In April 2008, 212,000 registered IDPs had been still suffering from poor conditions, indeed, almost half of the IDPs had been accommodating for almost 17 years in collective centers, which has been designed as hospitals, factories, schools, hotels and kindergartens. Thus, although the collective centers have intended to be used for a period of time, these places have become to be used for permanent uses by internally displaced people (UNHCR, 2009).

As another real-life experience, in 1992 and early 1993, the war, in Yugoslavia, has caused accommodation problem with respect to the unorganized and deficient management for refugees and internally displaced people. As a result, according to the data provided by UNHCR, approximately 20% of the exposed society has temporarily accommodated in 'collective centers' such as public buildings, schools, hotels, sport halls etc. while others accommodate in self-constituted shelters in Tuzla, Bosnia (as cited in Skotte, 2004) .

Seeking for differences in organizational and technical approaches of post-disaster response, Johnson et al. (2006) displays the comparison of two case studies: the 1999 earthquake in western Turkey and 1999 earthquakes in Armenia, Colombia. In the case of Turkey, all three mentioned phases of post-disaster shelter response are applied. To handle with the emergency needs, 80000 tents have been provided by Turkish military,

the Red Crescent and others. The phase between the emergency phase and permanent housing phase, one-year rent of 107000 vulnerable families and 41988 prefabricated temporary housing units have been afforded by governmental and private organizations. Finally, permanent housing project has been realized by the World Bank, European Development Bank, foreign governments and NGOs. On the other hand, in the case of 1999 earthquakes in Armenia, Colombia, instead of constructing temporary housing, permanent reconstruction has been decided to be constructed just after a few weeks following earthquakes. Although temporary housing units have not been supplied by decision makers, they have confronted with self-induced shelters resulted with ill-adapted sites. In addition to shot up epidemic illnesses, the extemporaneous reproduction of shelters and housing units have resulted with the invasion of illegal spaces in the city. Hence, one year after the incident happened, the management principles have been reconsidered and a new path has been charted out including the instantly derived problem: illegally constructed hovels. Constructing new temporary housing units have been decided due to aftermath of lack of them. Thus, the comparison of two different cases from different regions briefly represents that although decision makers initially intend not to build temporary housing units, earthquake victims have applied to any scratchy ceiling to maintain their lives and satisfy their basic needs. Johnson et al. (2006) states that this comparison has been examined whether and how to adopt a policy of post-disaster accommodation response with respect to diversity in organizational and technical approaches.

Before applying an accommodation unit, agencies should define and frame their domain and strategies. In today's world, sheltering response in disaster management is led by several agencies with respect to the birth reasons of disasters. Gray & Bayley (2015) presents four main agencies, responding to sheltering problem following disasters, as UNHCR, IFRC, UN HABITAT, IOM and their domains for diverse disaster types (Table 2-3).

Table 2-3 Agencies responding sheltering problem in disaster management and their domains for diverse disaster types (Adopted from Gray & Bayley (2015))

Agencies	Domains of Agencies
UNHCR	Involved in refugee crisis if only no cluster is required, leading multi-sectoral operations, commonly draws a pathway for internally displaced people (IDPs) who are affected by conflicts.
IFRC	A dual-mandate agency which seeks and implements best-practice models by gathering clusters and its national society members pursing the goal of cluster response.
UN HABITAT	Ordering long-term urban settlement policy including the Shelter Cluster at country level if only the rehabilitation and reconstruction phases must be experienced following the immediate disaster response.
The International Organization for Migration (IOM)	Responsible for the management within the cluster system in a camp coordination or camp management after natural hazards, organizing economic conflict and general migration.

In addition to these four agencies, Oxfam, another agency providing sheltering in emergency situations, seeks answers to its key determinants as (Oxfam GB, 2003);

- Comprehension of magnitude of losses and scope of needs – quality assessments,
- Managing effectiveness of the local response – local community and public authorities,
- Framing the role of institution.

On the other hand, Shelter after Disaster, which is a book including guidelines for assistance published by IFRC & UN/OCHA (2015), exhibits critical questions about sheltering and housing after disasters. The addressed questions are listed as follows (IFRC & UN/OCHA, 2015);

- Which method should be applied in the distribution of sheltering assistance? Free, subsidized or marketed?

- How can external support be balanced with local help?
- Which type of housing or shelter should be assisted?
- How can community participation be activated in post-disaster phase?
- Which policy should government follow to have control over the reconstruction period?

Lastly, according to the statements of Ashdown (2011) in Humanitarian Emergency Response Review (HERR), the six recommended matters in disaster management are listed as:

- Constituting a prospective pathway including preparation process and conflicts,
- Considering both long-term development and emergency response,
- Enhancing humanitarian system with strategic, political and operational leadership,
- Making innovations to be more efficient and effective,
- Providing a transparent and reviewable path for grantors and affected communities,
- Making agreements with new partners and strengthening the existing ones.

Although different agencies examine different matters, usually they do not respond disasters before defining their framework in post-disaster environments.

2.2.2 The Difference Between 'Sheltering' and 'Housing'

Shelter Project, which is a group making investigations on vulnerabilities in relief organization delivery of shelter and settlement, claimed that the critical issue of sheltering and housing sector is the "lack of clear definition of the sector, along with agreements on terminology" (as cited in Oxfam GB, 2003). Although these terms are frequently used interchangeably, there are considerable differences between these concepts.

Understanding and examining architectural design, expressive and figurative paradigms are minded out (Leila & Naima, 2016). In this manner, a form revives a sense and an interiorized meaning (Simon, 1996). Indeed, according to the statements of Hillier (2001), a place is a space hosting "a contest of identities, images and values" so that "shelter must be considered as a process, not as an object." as Davis (1978) states. Thus, an architectural space carries more than a form thereby architecture and architectural design are more than meets the eye. Accordingly, 'sheltering' and 'housing' is examined in a detailed way regarding to the values of architectural design. In this respect, beyond being a physical object, housing, as a space, have the meaning of morality. It represents not only physical values but also moral values. Besides representing a personal and even a public symbol, design of housing also reveals the established relation of the space with its individuals and enables to reflect their personality (Henrotay et al., 2009). Indeed, the sign of sheltering and housing for individuals who are exposed to a disaster is more meaningful compared to an individual within the daily life due to the provided features of post-disaster accommodation units such as confidence, security etc. (IFRC/RCS, 2013). Considering all, lack of housing, as a phenomenon, symbolizes the greatest material deprivation. Without making any discrimination among types of disasters, individuals suffering from the situation exigently requires a shelter and relief. Hence, disasters can be directly linked with the term of vulnerability (Wisner et al., 2003).

Examining sheltering and housing in post-disaster response, Quarantelli (1995) states that the meaning of two terms are easily confusable without referencing the time dependency in a life cycle of disaster considering returning back to normal daily life activities of community. To display the difference, Johnson (2002) reveals a distinction between sheltering and housing that while sheltering enables an immediate ceiling for a period after an incident and does not provide an environment to sustain the daily activities, housing refers to retrieve daily routine. Another contribution on understanding the difference is that the distinction depends on two matters: scale and timing (Oxfam GB, 2003).

In addition to comprehension of differences between sheltering and housing, each should fulfill major needs of affected groups. According to studies of Gray and Bayley (2015), sheltering must satisfy the following items as:

- Paying regard to virtue as individual dignity, privacy and security,
- Serving a 'home' which are available for adaptation and recovery of affected community,
- Providing physical conditions resisting to hazards.

On the other hand, in the book named 'Humanitarian Charter and Minimum Standards in Humanitarian Response', The Sphere Project (2011) represents several principles and minimum standards for humanitarian response which are universally applicable. Accordingly, 'an adequate housing' must respond to the following items (The Sphere Project, 2011):

- Providing enough space and serving an environment which is enduring to climatic hazards or possible threats related with health,
- Serving appropriate space for services, facilities, materials and infrastructure,
- Serving an affordable, habitable, accessible place regarding to region and culture,
- Availability of natural and common resources such as potable water, energy for cooking, heating and illumination, sanitation and washing activities, etc.,
- Accessibility to service buildings such as healthcare, educational and social facilities,
- Signifying cultural personality and personalization of housing considering housing policy and construction.

Comparing concepts of sheltering and 'an adequate housing' from different authors, while Gray and Bayley (2015) embrace the sheltering problem through major needs, The Sphere Project (2011) broadens the frame and deals the housing concept with an extensive manner. Thus, 'an adequate housing' must satisfy almost all the needs of human beings including psychological, physical and social issues.

2.3 Phasing and Types of Accommodation in Post-Disaster Response

Following disasters, manmade or natural, serving post-disaster accommodation is stated as 'crucial objects', providing sense of confidence, protection against climate, security and repression from diseases and health problems (IFRC/RCS, 2013). However, post-disaster accommodation is not a simple context since different phasing approaches and accommodation types have to be executed to achieve a sequential planning as a part of disaster management.

Barakat (1994) identifies and reveals three stages on the reconstruction after incidents as immediate relief, rehabilitation and long-term reconstruction. The phasing of Barakat refers to each kinds of disasters, but especially wars. Considering this, it is interpreted that categorizations show an alteration between each other regarding to type of disaster. On the other hand, emergency, restoration, replacement & reconstruction and reconstruction of commemorative are specified as four phases mainly for reconstruction following earthquakes (Kates & Pijawka, 1977). In addition, according to studies of Kates & Pijawka (1977), each following phase lasts approximately ten times longer than the previous phase.

Ian Davis (1978) contributes literature with a phasing on post-disaster reconstruction based upon strategies and interventions focusing on time. Similar to Kates & Pijawka (1977), the phasing suggested by Davis (1978) includes four main periods as emergency, rehabilitation, reconstruction and development.

Besides various contributions on phasing in post-disaster reconstruction, basically, post-disaster reconstruction is divided into three main phases, as emergency phase, transitional phase and reconstruction phase (UNOCHA, 2006). Considering all, different approaches are existing in phasing in post-disaster reconstruction, as presented in Table 2-4, resulted in different disaster management practices.

Table 2-4 Phasing in Post-Disaster Reconstruction from Different Approaches

Reference(s)	Barakat (1994)	Kates & Pijawka (1977)	Davis (1978)	UNOCHA (2006)
Phases of Post-Disaster Reconstruction	• Immediate Relief • Rehabilitation • Long-term Reconstruction	• Emergency • Restoration • Replacement & Reconstruction • Reconstruction of Commemorative	• Emergency • Rehabilitation • Reconstruction • Development	• Emergency • Transitional • Reconstruction
Type of disaster	especially for wars	especially for earthquakes	each type	each type

As different approaches are present in phasing, it is also possible to confront with differences in accommodation types in post-disaster reconstruction. Quarantelli (1995) presents accommodation types in post-disaster response as 'emergency sheltering', 'temporary sheltering', 'temporary housing' and 'permanent housing'. On the other hand, Forouzandeh et al. (2008) define post-disaster accommodation types in three main headings which are; emergency shelters, temporary shelters and permanent shelters/housing.

According to the categorization of Quarantelli (1995), which is a widely accepted categorization in literature, definitions of four main accommodation types in post-disaster response is listed as follows;

1) Emergency Shelter: a place hosting affected-community for a short period of time, that can also be a house of a friend or a public shelter etc.
2) Temporary Shelter: a place accommodating people for an anticipated short stay, approximately at most a few weeks after the disaster, that can be a tent, a public mass shelter etc.
3) Temporary Housing: a place enabling accommodation for temporary intends, approximately expected to be used for 6 months to 3 years enabling to turn back their daily activities, that can be a prefabricated house, a rented house etc.

4) Permanent Housing: a place hosting disaster victims under a ceiling, that can be a rebuilt house or a new re-settled house.

Finding the existing terminologies insufficient and avoiding the conflicts in post-disaster response appellation, IFRC/RCS (2013) introduces three new terminologies which are 'transitional shelters', 'progressive shelters' and 'core shelters/one-room shelters' to the literature. However the institution does not identify them as a phase of post-disaster accommodation, they introduce these three terminologies as an approach (IFRC/RCS, 2013). Figure 2-3 illustrates the overlaps between terminologies in sheltering duration.

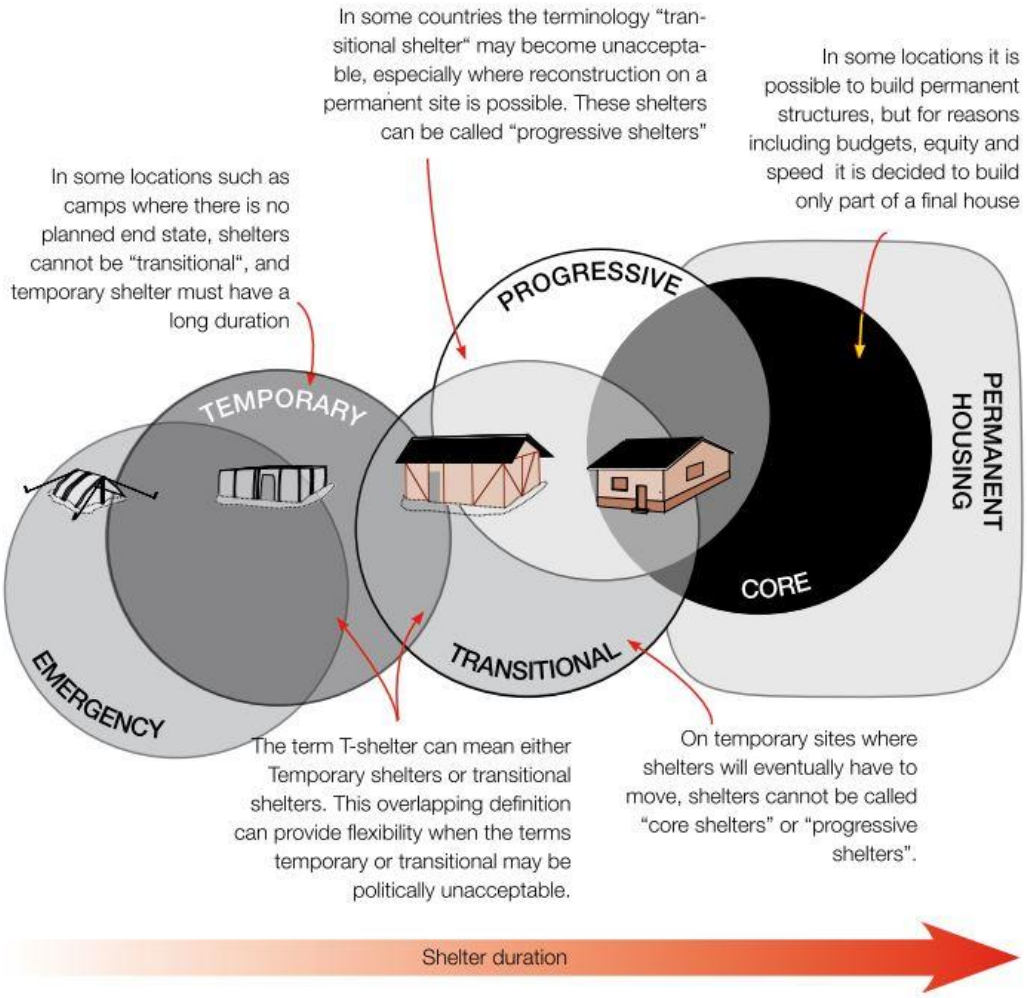

Figure 2-3 Sheltering Duration (IFRC/RCS, 2013)

Definitions of these three novel types on post-disaster reconstruction is examined as follows (IFRC/RCS, 2013);

1) Transitional Shelters: a promptly structured shelter, considering the upgradability or re-usability of materials in more permanent structures or repositioning to permanent locations from temporary ones to enable a more durable shelter for impacted communities.
2) Progressive Shelters: a rapidly structured space which is designed with the possibility of integration to future transformation and alteration in structural elements of the unit to be more permanent.
3) Core shelters / One room shelters: a place having one or two rooms, which is designed with the possibility of being a part of future permanent housing as an extension with its own means and resources. Instead of completing a full permanent house, the core/one room shelter presents a safe post-disaster unit reaching permanent housing standards.

On the other hand, Post-Katrina Emergency Management Reform Act (PKEMRA), which is an organization founded after the Hurricane Catrina in August 2005, defined as one of the most devastating natural disasters of US by FEMA, adds 'semi-permanent' type of housing to the literature. As the main aim of the institution is to provide safe and secure housing where disaster victims need them, this type of housing also enables the temporary housing alternative to be 'remote'. At the same time, features of cost-effectiveness and prompt readiness is achieved. (As cited in McCarthy, 2009).

In following sections, four main types of post-disaster accommodation response, emergency shelters, temporary shelter and temporary housing and permanent housing are explained in detail.

2.3.1 Emergency Shelters

To understand the use of emergency shelters, comprehending the emergency phase can be defined as an obligatory step. In emergency response, local authorities mainly elaborate on maintaining or rescuing lives under any circumstances without making any discrimination between types of disasters, although the period of intervention and required tools differ. After cancelling out the risk on lives of victims, relief resistance becomes the main topic including food, water and emergency shelter (IFRC, 2000). Emergency phase, in disaster management, is defined as the time being, starting with the moment of the incident, to provide shelter, food and a safe haven for the victims (As cited in Amstislavski, 2002).

IFRC (2000) frames the prominent emergency needs following a disaster in three main titles which are: (1) supplying basic life support needs: potable water and sanitation, sufficient nutrition, medical assistance, shelter (through housing and clothing) and fuel (for cooking and heating), (2) avoiding physical violence and aggression exposed by victims, especially refugees and internally displaced person and (3) providing psychological and social support to victims to overcome psychological and social stress posed by disaster. Thus, parallel to mentioned actions, the aim of the emergency phase is to provide "assistance in reconstructing their lives and communities" (Weiss & Collins, 2000).

Regardless to the institution, the immediately provided accommodation assistance meeting with the sudden sheltering needs of disaster victims is broadly referred to 'emergency shelter' (As cited in McCarthy, 2009). In fact, the Stafford Act's Section 403 defines the first sheltering intervention as 'essential assistance' (As cited in McCarthy, 2009). As explained in Section 2.2.2., the reason of not mentioning the first unit as 'emergency housing' is the lack of capability of the unit to respond the changing needs of sufferers confronted in time-being (Skotte, 2004). Moreover, according to the discourse of Quarantelli (1995), 'sheltering', not housing, serves the area for a certain time being, commonly a couple of weeks, when all the daily routine activities are propped up temporarily.

Emergency shelter is configurated on the purpose of accommodating displaced populations up to 6 weeks. As it supplies immediate needs, to maintain use of it for longer periods is relatively expensive (Miller, 2009) due to the required additional elements with respect to the climate change. Although the occupancy period of emergency shelters varies from one to another in literature, Hany Abulnour (2014) claims that they serve accommodation for days or weeks until the configuration of higher quality accommodation solutions. Consequently, it can be interpreted that the usage period of emergency shelters can be more than stipulated with respect to the configuration of accommodation serving better quality.

As generating new and basic emergency sheltering units is a possible path to follow (Skotte, 2004), it is possible to supply sheltering assistance with large emergency shelters, emergency group sites, rental assistance etc. (McCarthy, 2009). For instance, after the successive earthquakes on 17 August 1999 and on 12 September 1999 in Turkey, roughly 300,000 housing units become unusable resulted with the housing need for 600,000 people (As cited in Arslan, 2007). Accordingly, sheltering needs of victims have been fulfilled with three alternative methods: (1) accommodating in shelters of friends and relatives, (2) moving to a second undamaged house or a rented house, or accommodating in empty public buildings and (3) generating camps or tent shelters near to the damaged buildings (Price,2000).

On the other hand, since accommodating people in newly generated units is a highly applied method following disasters, UNDRO (1982) indicates the newly generated possible emergency sheltering solutions with three alternatives: tents, imported designs and units and standard designs incorporating indigenous materials. Considering these three alternatives, it can easily be interpreted that emergency sheltering alternative should be configured basically to act as prompt as possible. Indeed, Pottier (1996) defines the emergency phase as the period that there is no time to pause for thinking. Therefore, the need of swift action results in several consequences in the design of emergency shelters or the design is directly shaped with the timing criterion.

Besides tents and other sudden solutions, a German chemical company applied a unique method after the earthquake in 1970 in Akçaalan, Turkey. According to the article of Özkan (2000), the German company, among several international and local organizations, started to produce spun polyurethane domes just in two days after the earthquake and provide victims 405 dome shelters in a month. As company supplies materials from Germany, transportation of crew, chemicals and machinery is implied as a challenging step. However, the company achieved to fit all into one cargo plane (Özkan, 2000).

To configure a newly generated accommodation in daily conditions, hundreds of noteworthy work items should be considered, one of which is the infrastructure. However, in emergency phase of post-disaster response, instead of configuring a new infrastructure, each design choice should be generated with respect to the existing infrastructure either by physically linking up to it or by forming extensions to it (Skotte, 2004). In this manner, one of the items of work, infrastructure which takes plenty of time, can be skipped, hence prompt intervention can be achieved.

While taking action as swift as possible in the configuration of emergency shelters is an achievement, it avoids society to participate in the process (Pottier, 1996). In other words, community participation is glossed over or kept in a certain level, resulted in top-down approaches in crisis management. According to the statements of Arslan and Unlu (2006), the community participation after the Düzce earthquake can be evaluated in the lowest level due to the psychologic situation of the earthquake victims, hence their physical health. However, it is also possible for disaster victims to use this intervention period for the evaluation of effects of the disaster and for defining the planning of housing actions in temporary and permanent phases regarding to current conditions (Arslan & Unlu, 2006). Considering the temporary and permanent housing, as a further step, instead of configuring new units for each phase separately, Skotte (2004) suggests that emergency shelters should be appropriate to improve and extend into permanent housing to avoid ‘double-construction’, hence unnecessary cost.

2.3.2 Temporary Shelters and Temporary Housing

A time gap is existing after emphasizing on maintenance or rescue of lives until the permanent housing is provided for disaster victims to get back daily lives. Johnson, Lizarralde and Davidson (2006) state this time gap as required to be bridged over and suggest 'temporary housing' as the best accommodation solution for the affected society. In other words, authors define the period between the time-being that disaster has just happened and the all ordinary daily life gets back on the rails as 'rehabilitation period', bridging the gap. However, implication difference between sheltering and housing is also existing in post-disaster temporary units.

It is possible to define 'temporary shelters' and 'temporary housing' under the title of 'temporary accommodation' (Johnson, 2002). Basically, temporary accommodation is introduced as units accommodating disaster exposed society within an urban context including services such as education, health etc. (Schittich, 2010). Since the continuation of daily lives of disaster impacted society in former residences is impossible, providing temporary accommodation is an urgent intervention until the accomplishment of permanent housing (Hany Abulnour, 2014). Indeed, parallel to statements of Johnson, Lizarralde and Davidson (2006), Félix, Monteiro, Branco, Bologna, & Feio (2015) also declare that the purveyance of temporary accommodation as an essential priority during post-disaster reconstruction. However, in addition to the critical situation of providing provisional housing to disaster survivors, the main challenging situation of temporary accommodation is to provide safe and secure housing promptly as well as cost-effective, hence communities are willing to live in it (As cited in McCarthy, 2009).

In addition to temporary shelters and temporary housing, temporary accommodation can be in the form of self-built shelters, mobile homes, homes of family or friends' homes or apartments. Yet, whatever the type is, they all aim to serve an temporary environment where the exposed society can carry on their household responsibilities and activities (Johnson, 2002).

Although each temporary housing alternative enables disaster exposed society to return to their normal daily life activities until the generation of permanent houses (Bolin, 1990; Johnson, 2007a), it is necessary to project the type of unit according to the strategy on permanent housing. The realistic predictions on construction of permanent housing, led by governments, NGOs and aid organizations, direct the strategy of temporary accommodation (Johnson, 2002). Since each type has its own distinctive properties such as physical character, function and effects to exposed society, the strategy for temporary accommodation in a post-disaster situation should be configured accordingly. Thus, differences must be considered as a significant determinant since each type serves a slightly different function, so that inconstant results (Johnson, 2002). For instance, if the construction period for permanent housing is predicted between one year to two years following a disaster; winterized tents, self-built shelters and inexpensive temporary houses – paper houses, mobile units and homes of families and friends can bridge the gap (Johnson, 2002). On the other hand, if the predicted time takes more than two years, more enduring temporary accommodation housing are applied such as prefabricated or wooden temporary housing units (Johnson, 2002). Another example is that, as an actual event, five temporary accommodation types, which are prefabricated temporary houses, wooden temporary houses, paper temporary houses, winterized tents, and self-built shelters, have been applied in disaster-exposed area in Turkey instead of applying only one type of temporary accommodation alternative (Johnson, 2002). Accordingly, the reason of this diversity can be interpreted as that each different functional accommodation type has distinctive reflection to the society that's why role-takers apply different temporary accommodation types for different post-disaster environments.

Understanding differences between temporary shelters and temporary housing, Hany Abulnour (2014) explains the distinction by applying the suggested list of Johnson et al. (2006), as shown in Table 2-5. According to Johnson et al. (2006), five significant issues direct decision makers or role takers in temporary accommodation response as (1) the type of temporary accommodation, (2) the procurement and the cost, (3) the location to be placed, (4) duration time and (5) future utilization of units.

In addition to questions put by Johnson et al. (2006), Hany Abulnour (2014) clarifies differences of temporary shelters and temporary housing regarding to activities of people. People, accommodating in temporary shelters, tend to stay at their shelters except going out for their duties in work or schools and errands. On the other hand, temporary housing units enable affected community to resume their standard daily activity as going work or school, cooking, shopping etc. In addition, other available daily activities of temporary housing, such as housekeeping and socializing, are also considered with necessary conditions and spaces (Johnson, 2007a). Therefore, though temporary shelters enable people to have their own spaces, people are not able to maintain their daily routine typically in them due to ineligibility of space (Félix et al., 2015), as displayed in comparative study in Table 2-5. Considering all, temporary housing, as a temporary accommodation type, is crucial and necessary for the program of reconstruction, since it detract people from chaotic and uncertain situation of disaster (Johnson, 2007a).

Table 2-5 Differences between Temporary Shelter and Temporary Housing (Adopted from Hany Abulnour (2014))

Issues about temporary accommodation by Johnson et al. (2006)	**Temporary Sheltering**	**Temporary Housing**
The type of temporary accommodation	a public shelter	a rented apartment
	a friend's house	
	a shelter under a plastic tent	a prefabricated home
	any other prefabricated enclosure	
Duration time	incubating people immediately after a disaster	incubating people for longer periods of time (even years) in comparison to temporary shelters
Future utilization	usage is ended when the people are provided with temporary houses of higher quality or new permanent homes.	usage can be ended when permanent housing is provided. Possible to evolve temporary houses into the permanent solutions if a high-quality standard of living is provided.
Activities of people	People staying in shelters are more likely to stay all day, but the conditions are not fully appropriate	Allowing to return normal daily activities, i.e. work, school, cooking at home, shopping, etc.

2.3.3 Permanent Housing

Permanent housing is the housing intervention in permanent phase, referring to two options which are getting back to former residences after repair or enabling to move to newly constructed housing units. Elaborating on newly generated permanent units, it is possible to locate them in or near disaster-impacted area or to a different permanent relocation area (Ganapati, 2013).

Although permanent housing seems as the last housing step of post-disaster reconstruction, it should be the first phase to be necessarily planned since emergency and temporary accommodation strategies are projected accordingly (Johnson, 2002). In other words, the planning strategy of permanent housing can be interpreted as the core of the post-disaster response, to pave the way for other phases.

Permanent post-disaster housing approaches are mentioned as the most challenging part of the recovery process due to lack of perfect solution fitting to each disaster and each person, although they are defined as affected community of same disaster. In this manner, location, stability, security and quality are significant items but the interaction of social, political, cultural and economic factors should also be elaborated on to reach a sustainable legacy. Considering all, post-disaster permanent housing is interpreted as place more than a physical structure due to its process (Gray & Bayley, 2015).

Since disaster management policies differ in international context as mentioned in previous sections, permanent housing approaches are managed according to these policies. Comparing countries according to their permanent housing policies, United States does not give the major responsibility to government in the reconstruction or rebuilding of residences (Comerio, 1998; Zhang & Peacock, 2009). However, Turkish government took the initiative of the large-scale construction of permanent housing units following the detrimental earthquake on August 17, 1999 (Ganapati & Ganapati, 2009). Similarly, governments of India, Indonesia, and Sri Lanka also took the responsibility of constructing the large-scale permanent housing projects after the Indian Ocean Tsunami in 2004 (Ruwanpura, 2009).

CHAPTER 3

AN OVERVIEW OF TEMPORARY HOUSING UNITS

3.1 Problems of Temporary Housing Units

The action of designing a house contains much complexity due to being a reflection and result of several interactions such as social, cultural, religious, political, environmental, technical and etc. (UNDRO, 1982). However, design of post-disaster housing units are distinctive compared to housing units in usual time (Baradan, 2008). Consequently, problems and unexpected outcomes of post-disaster housing units also vary from the housing units constructed in usual conditions.

In this manner, according to the assertions of ALNAP, The Active Learning Network for Accountability and Performance in Humanitarian Action, the configuration of housing is declared as the "least successful form of aid when compared to other humanitarian intervention sectors" (as cited in Oxfam GB, 2003).

Considering feed-backs of the Sphere Project, Saunders (2004) declares critical problems of accommodations following disasters from managerial perspective which is underlined by UNDRO for more than 20 years. These problems are sorted as; inadequate configuration of sector (1), the lack of universal terminology (2), inadequate guidelines (3), poor comprehension of properties of local conditions and how to struggle with them (4), unnecessary collaboration of governments and beneficiaries (5), communication problem between technical advisors and practitioners (6), dispute on the issue of durable and temporary solutions (7), poor cooperation of extensive developmental issues such as livelihoods (8) (Saunders, 2004).

As a different perspective, Fred Cuny (1978), who examines post disaster housing, represents difficulties of housing by relating them with two arguments:

- the lack of comprehension of complexities of housing in developing countries,
- the failure of association of post-disaster housing with the buildings constructed in usual conditions.

Examining problems of post-disaster temporary housing units in depth, Félix et al. (2013) categorize problems into two major titles as sustainability problems and cultural inadequacy problems, as shown in Figure 3-1. Furthermore, sustainability problems, defined as one the major problems, are also branched into two as (1) unsustainability regarding to cost and (2) unsustainability regarding to environmental issues.

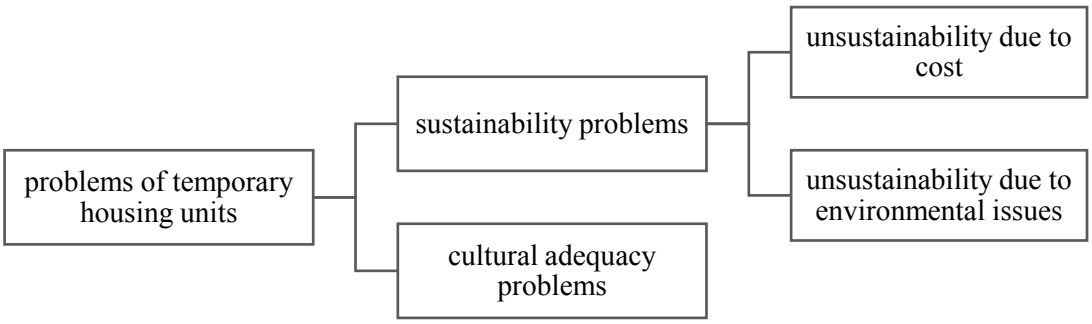

Figure 3-1 Problems of temporary housing units according to Félix et al. (2013)

Taking into consideration the unsustainability due to cost, Johnson (2007b) mentions that cost of temporary units is generally high comparing with their life span. While UNDRO (1982) asserts that cost of a temporary housing unit is as same as cost of a permanent one, Hadafi & Fallahi (2010) introduce that they are three times more expensive than permanent ones. As a result, as excessive cost is mentioned as a problem for temporary accommodation units, it is also possible to confront with problems of too low cost. IFRC/RCS (2013) represents problems of temporary accommodation units regarding to both excessive and too low cost as represented in Table 3.1.

Table 3-1 Potential risks of temporary accommodation units regarding to cost (Adapted from IFRC/RCS (2013))

Potential risks of temporary accommodation units	
Excessive cost	**Too low cost**
- Being too slow and lateness in delivery - Inadequate number of units or inadequate size - High standards for households resulted in divisions in society and dependency in future disasters	- Collapse results in injuries - Refusal of inhabitants - Low quality materials which is unavailable to use/reuse for permanent accommodation - Short lifespan

In addition to the mentioned approaches on cost, Johnson (2007b) declares that excessive cost of temporary accommodation units directly affects the reconstruction of permanent housing as resources are overspent for temporary units. As a consequence, it poses problems which affects entire disaster management schedule.

With respect to the categorization of Félix et al. (2013), unsustainability due to environmental issues is another sub-heading of problems of temporary housing units. In this direction, Sener & Altun (2009) state that in situ slab foundations of temporary housing units cause to 'fields of concrete' after demolition of units. Short-term usage of temporary units also strengthens this problem since permanent touches are implemented on environment for contemporary situations.

Accordingly, the lack of systematic approach is resulted in bringing immediate needs into forefront; as a result, decisions are incomprehensive and dissatisfactory in long term. Indeed, despite the necessity of accommodating in temporary units for long periods, generally more than planned, long term necessities are glossed over (Johnson et al., 2006). In this manner, materials or units can have much longer lifespan considering their intended period of use, but there isn't any contribution to manage their future use after disassembly of short-term used units. Consequently, this is a devastating waste of resources (Arslan & Cosgun, 2008), including infrastructure, resulted in environmental problems besides the social problems (Félix et al., 2015).

Taking into consideration the cultural adequacy problems according to the categorization of Félix et al. (2013), there is a risk of serving inappropriate and culturally unacceptable designs for disaster victims (Gulahane & Gokhale, 2010). These designs can be defined as culturally 'alien' to their environment (Félix et al., 2013). On the other hand, standardized and technology-based temporary housing units for local communities are resulted with unsuitability (Lizarralde & Davidson, 2006). El-anwar, Asce, & Chen (2016) assert that decisions based on quantitative measures on temporary housing units cause significant problems due to the lack of consideration of the specific socioeconomic needs and unique preferences of each disaster impacted family. In addition, the lack of appropriate housing approaches appreciating the needs and preferences of users also pose cultural adequacy problems (El-anwar et al., 2016).

According to the investigation conducted by El-anwar et al. (2016), there are three main reasons of that temporary housing units do not meet the expectations of displaced communities. El-anwar et al. (2016) list these reasons as:

- late delivery,
- inability to fulfill the social, psychological, and economic needs of displaced families,
- poor accessibility of temporary housing locations to essential services and public transportation.

Elaborating on 'late delivery' as a problem, 'timing' is termed as one of the most faced problems of temporary accommodation units following disasters. Associated with the selection of heavy materials for temporary structures, erection of structures is not only difficult to assemble but also time-consuming. Accordingly, transportation and future storage of structures are also mentioned as problematic by Asefi & Sirus (2012), affecting timing factor directly. This can be interpreted such that making units ready for disaster impacted community is directly related with the production time, delivery time and assembly-demolition time.

On the other hand, building physics, including but not limited to thermal resistance, noise reduction and waterproofing is also declared as one of the main problems of

temporary housing units (Sener & Altun, 2009). Durability of implemented materials is mentioned as a vital problem of temporary housing units including in building physics. For instance, after 1999 Düzce earthquake in Turkey, timber structured temporary housing units, located in Fidanlık site, has decayed (Arslan & Cosgun, 2008) and consequently, the lifespan of units has shortened.

As an extensive study on problems of housing in rehabilitation period, Limoncu & Bayülgen (2005) evaluate housing problem with its entire components by examining several post-earthquake conditions in Turkey. Table 3-2 lists the problems of temporary housing in rehabilitation period under seven major subjects which are problems related with management, location choice and settlement, design of units, substructure, socio-psychology, economy and sustainability & reusability. As Table 3-2 displays, design problems of temporary housing units are one of the main constituents, which can be directly linked with the responsibility of architects and designers. That means, it is possible to overcome design problems of temporary housing units by applying collaboration with them.

Table 3-2 Related Problems with Housing in Rehabilitation Period (Adapted from Limoncu & Bayülgen (2005))

Managerial Problems	The lack of preparedness
	The lack of organization
	Difficulties in transportation of materials
Location Choice and Settlement Problems	Difficulties on finding construction area
	Nonexecution of location choice regarding to essential criteria
	Ignorance of locality in settlement plans
	No additivity of settlements to urban life
Design Problems of Temporary Housing Units	Incompatibility with the life-style of community
	Incompatibility with climatic conditions
	Issues of Wet Areas such as Inadequacy of Volume and/or Area
	Application problems due to interpretation of international solutions caused by economic reasons
Substructure Problems	Inadequacy of basic substructure
Socio-Psychological Problems	Planning without considering social-cultural-commercial life
	Generating settlement without contribution of the victims
Economic Problems	Applying international solutions
	Transportation costs
	Not designing regarding to sustainability and reusability
Sustainability & Reusability Problems	Creation of insufficient physical place
	Not paying attention to connection details during construction
	Exceeding estimated usage-time resulting with damages and unable to use for following post-disaster situations
	Reusability of sites accommodating temporary units

According to studies of Félix et al. (2015), as an extensive approach, firstly the role of temporary housing should be displayed in reconstruction phase. Then, common problems of temporary housing should be found out to suggest guidelines not to confront encountered problems once again. Subsequent to successive actions stated by Félix et al. (2015), problems confronted in literature are minded out to contribute to design guidelines of temporary housing units and Figure 3-2 is generated to display managerial and technical problems of temporary housing units.

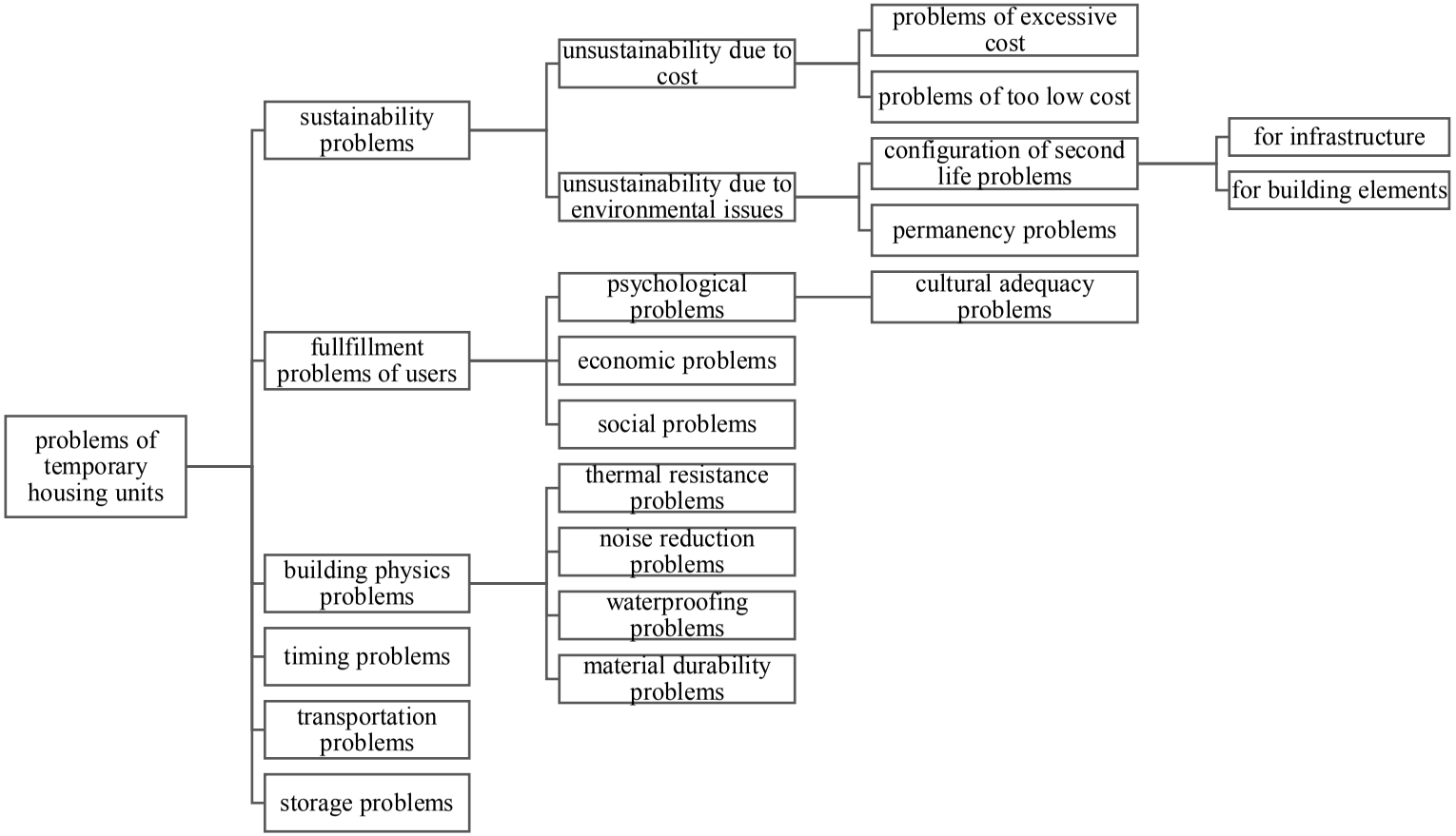

Figure 3-2 Problems of temporary housing units

3.2 Guidelines for Temporary Housing Units

Although there is not any guidelines and managerial documents for temporary housing unit designs in literature, governmental and non-governmental organizations (NGOs) as well as academicians have several contributions in order to minimize or overcome problems of post-disaster temporary units.

Considering problems of temporary housing units, a new post-disaster accommodation framework is required regarding to the suggested models and the decision support systems in literature. The required framework can achieve the ultimate use and the implementation of models by agencies which are responsible for emergency management. Indeed, this framework ought to direct decision-makers to enable (El-anwar et al., 2016);

- serving customized housing approaches satisfying the unique and specific needs of different user groups,
- having information about available housing stock, including plans of temporary housing units, in and around the disaster impacted areas.

Hany Abulnour (2014) suggests several basic guidelines to lead the 'management' of temporary housing units including their provision, design and construction in recovery and reconstruction phases. To achieve a successful management scheme for temporary housing, presented extensive and applicable basic guidelines are listed as (Hany Abulnour, 2014);

- The uniqueness of each disaster situation – contextualization,
- Engaging and supporting communities,
- Prompt engagement in the reconstruction process,
- Prioritization,
- Efficient coordination.

In addition, to improve outcomes of temporary housing units, Félix et al. (2015) propose three major principles as;

- Pre-planning,
    - Preparing an area with infrastructures beforehand,
    - Forecasting,
    - Making a wide and accurate characterization of the local context,
    - Establishing the ways of action.
- Using local resources and local-oriented designs instead of imported and standard solutions,
- Supplying more than just temporary accommodation units by focusing on more sensitive and people-oriented strategies.

On the contrary, several researchers approach temporary housing units focusing on sustainability principle. Accordingly, Johnson (2007) carried out a research on how to achieve 'second life' for temporary housing units by examining sustainability principle on them. As a result, Johnson (2007) has reached three major principles;

- Economic principle,
    - providing a longer life span associated with the upfront investment,
- Environmental principle,
    - recycling the entire unit or parts of it as much as possible,
    - not locating units in periphery, choosing locations close to city,
- Social Principle,
    - Serving more unit with low cost.

El-anwar et al. (2016) assert that an improvement will be achieved for temporary housing units if the listed four items are applied;

- the consideration of specific needs and priorities of each disaster impacted family,
- the evaluation of the performance of each candidate temporary housing unit configuration to meet with the needs of disaster impacted family,
- the consideration and management of life cycle costs of temporary housing projects,

- the minimization of the requirements based on computation in a situation of large-scale optimization problems.

3.3 Design Criteria of Temporary Housing Units

Starting from the contribution of Vitruvius on history of architecture, the definition of criteria and sub-criteria have always been contradictive terms differentiating with respect to era, technology, culture and the society (as cited in Harputlugil, Prins, Gültekin, & Topçu, 2014).

According to the work of Vitruvius (1999), 'de Architectura', architecture must exhibit three qualities, firmitas, utilitas and venustas as stability, utility and aesthetics. Without these three qualities, an architectural object is lacking, in other words these three are declared as criteria bringing a structure into completion. In this manner, Gann, Salter, & Whyte (2003) present a framework for design assessment named as Design Quality Indicator (DQI). This framework, which is called as 'a modern-day interpretation of the Vitruvian work', evaluates the design quality under three main titles which are 'Function', 'Build Quality' and 'Impact' (Gann et al., 2003). In fact, according to the examination of Harputlugil et al. (2014), the quality of a building can only be achieved when these three key points work together.

In a design process, architects decide on several design problems including cost, aesthetics, functionality and compliance with building codes and administrative regulations. In common perspective, architects, with an extensive design team, deal with design problem among design objectives, thus the most appropriate design solution is reached. The key design objectives of buildings is presented by Park, Meacham, Dembsey, & Goulthorpe (2014) as shown in Figure 3-3.

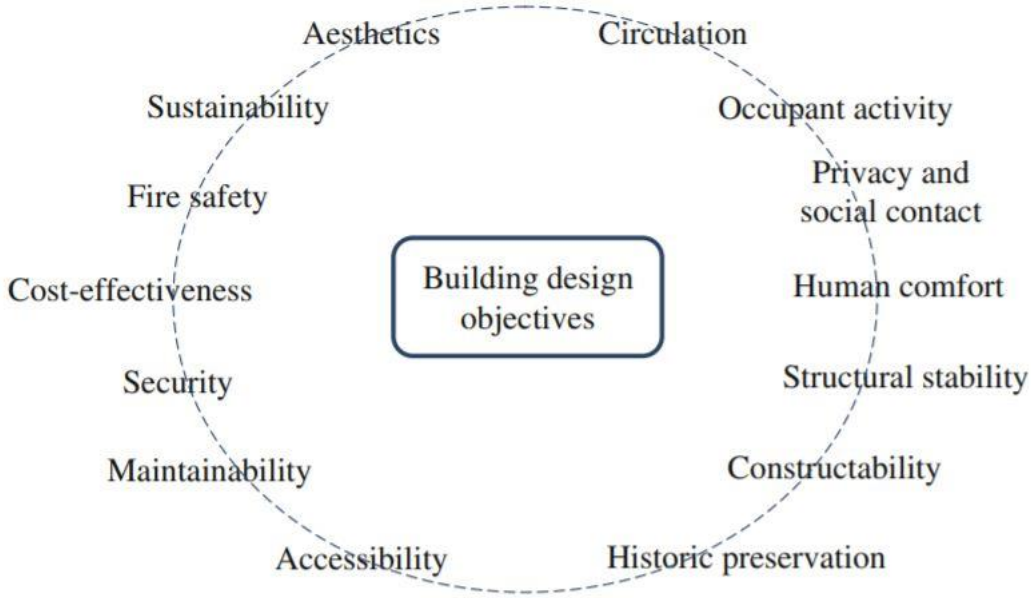

Figure 3-3 Design Objectives of Architects (Park et al., 2014)

Elaborating on housing function, The National Affordable Homes Agency (2008) represents ten indicators in order to measure quality of housing named as Housing Quality Indicators (HQI) which is a design quality assessment tool. Rather than evaluating the unit solely, the method assesses unit's design in detail through indicators 5-9 and its context and surroundings through indicators 1-4 & 10 which have been listed in Table 3-3 (The National Affordable Homes Agency, 2008).

Table 3-3 Ten Indicators of Housing Quality Assessment (Adapted from The National Affordable Homes Agency (2008))

Number of Indicators		**Main Criteria**	**Sub Criteria**
1	Location	Location	Location
2	Design	Site	Visual impact, layout and landscaping
3			Open space
4			Routes and movement
5		Unit	Size
6			Layout
7			Noise, light, services & adaptability
8			Accessibility within the unit
9			Sustainability
10	Performance	External Environment	Building for Life

As another perspective on housing function, UN HABITAT (2014) alleges that "Adequate housing must provide more than four wall and a roof." and lists the following criteria that should be met:

- Security of tenure,
- Availability of services, materials, facilities and infrastructure,
- Affordability,
- Habitability,
- Accessibility,
- Location,
- Cultural adequacy.

However, the generation process of post-disaster temporary housing units is different from houses constructed in usual conditions due to specific policies of recovery and reconstruction phases of crisis management (Eren, 2012). Indeed, design objectives of post-disaster housing units is also interpreted as different compared to housing units built in ordinary conditions. Considering the provision, design and construction of post-disaster temporary housing in reconstruction and recovery process, there isn't any

common applied criterion accepted by decision-makers as guidelines, though many contributions have reached in literature.

In order to reach an innovative temporary unit design, Asefi & Sirus (2012) propose a unit system achieved four main goals which are;

- foldability, ease of and rapid assembly and ease of transportation,
- expansion and flexibility,
- compactibility and ease of assembly and durability of structural and covering elements,
- good visual appearance.

On the other hand, according to the statements of Songür (2000), there are five main objectives to consider in generation of temporary housing units. These five objectives are listed as (Songür, 2000);

- Mounting time,
- Stability of the structural system,
- Reusability of the unit,
- Meeting the needs of the user,
- Safety of the unit.

As a far-reaching approach for housing following disasters, Bashawri, Garrity, & Moodley (2014) presents factors affecting units as follows:

- Environmental factors
    - Climate variations
    - Recycling, upgrading and disposal
    - Hygienic (water &air)
- Economic factors
    - Type of shelters - cost
    - Lifetime
    - Livelihood

- Technical Factors
    - Easy to erect and dismantle
    - Materials and insulations
    - Classification of hazards and performance
    - Physical and psychological effects
- Socio-cultural factors
    - Cultural difference
    - Dignity and security
    - Communication

'What If New York City…' design competition for post-disaster provisional housing, organized by NYC Office of Emergency Management in 2008,displays a set of criteria for post-disaster provisional housing (as cited in Torus & Şener, 2015). Criteria of the competition, displayed in Table 3-4, seeks dwelling solutions for recovery period of a catastrophic coastal storm for New York City.

Considering criteria displayed in Table 3-4, Torus & Şener (2015) reach nine main criteria representing generic ideas and representative studies of 39 submitted projects to the competition. According to their research, these nine criteria are listed as;

- Lightness,
- Flexibility,
- Reusability of material,
- Reusability of unit,
- Easy transportation,
- Rapid implementation,
- Economy,
- Security,
- Environmental compatibility.

Table 3-4 Criteria of “What if NYC?” competition (Adapted from Torus & Şener (2015))

Criteria	**Goals**
Density	Maximize number of housing units per land area
Rapid Development	Provide units ready to be occupied as soon as possible
Site Flexibility	Maximize the ability to be accommodate as many different sites as possible
Unit Flexibility	Maximize the ability to accommodate as many variable household types and sizes as possible
Reusability	Maximize the potential for reuse of the structures either for future disasters or other purposes
Livability	Maximize the strength, utility, convenience, and comfort of the dwellings
Accessibility	Allow access for people who have limited mobility
Security	Make public space defensible and help people feel safe
Sustainability	Reduce energy costs and the carbon foot- print of the dwellings
Identity	Maximize the ability of New Yorkers to feel a sense of identity and even pride in where they live
Cost Efficiency	Maximize the best value for investment

To understand important features of temporary housing units for different climate conditions, the request of UNHCR (2013) is also a beneficial source which evaluates temporary housing units with respect to architectural and design standards with expectations of the institution as represented in Table 3-5.

To summarize, there are several contributions on features of temporary housing units from various sources. However, as mentioned contributions present, they either approach units from a specific point of view such as sustainability, economy etc., or over-generalize necessary criteria without embracing the problem in depth, hence they do not shed a light on decision-making process of temporary housing units.

Table 3-5 Architectural and Design Standards of UNHCR (2013) in the evaluation of temporary housing units (Adapted from UNHCR (2013))

Item	Design	Description	For all weather	For cold climate	For hot climate
1	Setting-up	• Quick transport • Easy to assemble with minimum tools	Easy	Easy	Easy
1.1	Time per unit	• Few hours or days	Less than 6 hours	Less than 48 hours	Less than 24 hours
1.2	Manpower	• Maximum 2-3 persons • To reduce assembly time, the number can be increased	2-3 persons	2-3 persons	2-3 persons
1.3	Skill	• Assembly on site with basic tools (Non-powered portable hand tools)	Unskilled labors	Unskilled labors with some technical support	Unskilled labors with some technical support
2	Shape	• Any acceptable shapes			
3	Size	• Maximum 5 persons • 3.5 m^2 per person for hot and all climate conditions and 4.5m^2 per person for cold climate conditions (based on Sphere Project)	$17.5\ m^2 < A < 20\ m^2$	$20\ m^2 < A < 24\ m^2$	$17.5\ m^2 < A < 20\ m^2$
4	Height	• Minimum height from floor to the ceiling • Lower height in cold climates is preferable • Greater height in hot climates is preferable	$2.0\ m < H < 2.5\ m$	$2.0\ m < H < 2.5\ m$	$2.1\ m < H < 2.7\ m$
5	Life Span	• Possible to accommodate a few years	1 years – 2 years	1 years - 5 years	1 years - 5 years
6	Ventilation	• Direct Sunlight	≥ 2 openings	≥ 2 openings (excluding window opening)	≥ 2 openings (excluding window opening)
7	Vectors Control	• Prevent or resisting to vectors.	Mesh/Net fixed in ventilation openings/window		
8	Maintenance	• Easy to maintain by family	Easy		

Table 3-5 (continued)

9	Thermal	• Possible to upgrade with suitable insulation for	UV ≥ 3,500 hours	UV ≥ 6,500 hours	UV ≥ 7,500 hours
10	Fire	• Minimum fire-resistance rating	F.R. ≥ 30 minutes	F.R. ≥ 60 minutes	F.R. ≥ 60 minutes
11	Water Proof	• Waterproof materials for the heavy rains and high humidity			
12	Dead and Live Loads	• Be able to carry minimum 100 kg/m^2 live load on the roof • If stories are existing, live load is taken as 160kg/m^2.	L.L. ≥ 100 kg/m^2		
13	Wind Load	• Minimize horizontal and vertical wind loads • Able to resist minimum combined wind load pressure	≥ 70 km/h ≥ 60 kg/m^2	≥ 80 km/h ≥ 70 kg/m^2	≥ 110 km/h ≥ 90 kg/m^2
14	Snow Load	• Able to resist snow load for roof	≥ 100 kg/m^2 (Mono slope or gable roof (15 degree)	≥ 120 kg/m^2	
15	Earthquake	• Able to withstand earthquake			
16	Flood				
17	Rain/Storm		≥ 70 mm/hr (15 min. period)		
18	Weight of Unit (w)	• Light and compactly packed for cost-effective transport • Storable prolonged periods of time • Able to disassemble in an environmentally friendly way	80 kg ≤ w ≤ 160 kg	160 kg ≤ w ≤ 250 kg	120 kg ≤ w ≤ 200 kg
19	Packed Volume	• Designed with easy transportation principle • Possible to deploy in flat packed units • Possible to assemble no more than two people without tools or equipment	0.15 m^3 ≤ V ≤ 0.25 m^3	0.25 m^3 ≤ V ≤ 0.35 m^3	0.18 m^3 ≤ V ≤ 0.30 m^3

3.4 Alternatives of Temporary Housing Units

Within the scope of this study, several temporary housing unit alternatives which are previously introduced as applicable in post-disaster situations are examined. In order to create an extensive candidate set of alternatives, temporary housing units which are designed with diverse approaches as academic and/or institutional aims, have been investigated. The selected alternatives of temporary housing units among numerous of alternatives are shown in Table 3-6. The design and technical details of the selected alternatives are given in following lines.

Table 3-6 Alternatives of Temporary Accommodation Units

Image of Selected Alternatives of Temporary Housing Units	**Information About Selected Alternatives of Temporary Housing Units**	
	Name	Ablenook
	Designer:	Sean Verdecia and Jason Ross
	Type	Post-Disaster Housing Unit Designed with Academic Purposes
	Name	AFAD Winner | A First Prize Awarded Design in a National Competition of AFAD* in Turkey
	Designer:	Ali Serdar Bayram, Can Yengül and Murat Yavuz
	Type	Awarded Post-Disaster Housing Unit
	Name	Better Shelter
	Designer:	UNHCR & IKEA
	Type	Corporately Designed Post-Disaster Housing Unit
	Name	DAKO | A Second Prize Awarded Design in a National Competition of AFAD* in Turkey
	Designer:	B. Senkardeşler & O. Yıldırım
	Type	Awarded Post-Disaster Housing Unit

Table 3-6 (continued)

	Name	Humanitarian House International (HHI) | LTD
	Designer:	Stuart Ohlson
	Type	International and Donatable Post-Disaster Housing Unit
	Name	MobARCH
	Designer:	Sinan M. Şener and M. Cem Altun
	Type	Post-Disaster Housing Unit Designed with Academic Purposes
	Name	Paper Log Houses | Kobe, Japan
	Designer:	Shigeru Ban
	Type	Sustainable Post-Disaster Accommodation Unit
	Name	Über Shelter
	Designer:	Rafael Smith
	Type	Post-Disaster Accommodation Unit

(*) T.C. Disaster and Emergency Management Presidency

<u>Ablenook | with 2 bays</u>

Ablenook is a 'rapidly deployable modular dwelling' designed as a product of a research project for disaster relief at the University of South Florida by two young architects, Jason Ross and Sean Verdecia (Melendez, 2012). While the main goal of these two architects is defined as to generate a cheap, flexible and mobile unit, the product also supports disaster victims with dignity and privacy (Borgobello, 2013).

The Ablenook, a post-disaster accommodation unit designed with academic purposes, is based on a 6 m^2 single unit. In the need of larger spaces, multiple use of modules is put together in horizontal and vertical directions, as shown in Figure 3-4 (Borgobello, 2013). Moreover, the design offers protected terrace besides closed spaces as shown

in Figure 3-4. Taking into consideration of the goals of designers, properties of Ablenook are as presented in Table 3-7.

Figure 3-4 Multiple Use of Ablenook Design (Borgobello, 2013)

Table 3-7 Properties of Ablenook

Properties of Ablenook		Reference(s)
Number of Accommodated Person	5 people for 2 bays | each unit is for 2.5 people	("Ablenook: The Innovative Disaster Relief Housing Solution", 2017)
Floor Area	12 m^2	Borgobello (2013)
Minimum Ceiling Height	3.05 m	Guttman (2017)
Mounting/Demounting Time	4 hours | assembly time for each unit is about 2 hours	Borgobello (2013)
Packed Dimension of Unit / Ease of Transportation & Storage		
Weight of Unit		
Lifespan of Unit	More than 50 years	("Ablenook: The Innovative Disaster Relief Housing Solution", 2017)
Footing on Site	Telescoping stilts	
Touched Area to Soil	1.44 m^2 (area of each leg is estimated as 0.3 m x 0.6 m regarding to drawings)	from drawings
Production Cost	$ 16000	Borgobello (2013)
Required Untrained Person for Implementation	2 people	Borgobello (2013)
Required Educated Person for Implementation	No specific requirement	
Required Common Materials for Implementation	No specific requirement	
Required Special Materials for Implementation	No specific requirement	
Shelf Life		
Transportability /Ways of Transportation	6 units in a truck	from renders
Modularity	yes	from renders
Adaptability	yes	from renders
Climate Convenience / Temperature Range		
Wind Resistance		

AFAD Winner | A First Awarded Design in a National Competition of AFAD* in Turkey

AFAD Winner is a temporary housing unit aiming to satisfy eleven main criteria decided by its' designers who are Ali Serdar Bayram, Can Yengül and Murat Yavuz These eleven criteria are defined as; 1) material, 2) structural performance, 3) the ease and speed/race of production, 4) storage, 5) cost, 6) climatic interior comfort, 7) heat values, 8) noise values, 9) aesthetics values, 10) anti-bacterial environment and 11) fire-resistance (Bayram, Yengül & Yavuz, 2014).

The main unit of the temporary housing design comes to exist by assembling of three main modules which are M1-intermediary module, M2-completion module and M3-floor module. To achieve an easy and rapid assembly, modules are designed as joinable without any materials. For WC and bath facilities, a separate module is designed which is possible to adapt to the main unit. Modules are designed as packable and storable, in fact modules are packed in an order since minimum packed dimension is taken as an aim. Besides, interior elements are also designed with the minimum packed dimension (Bayram, Yengül & Yavuz, 2014). Table 3-8 represents properties of AFAD Winner.

Table 3-8 Properties of AFAD Winner

Properties of AFAD Winner		Reference(s)
Number of Accommodated Person	4	Bayram, Yengül & Yavuz (2014)
Floor Area	16.86 m^2 | 16 m^2 – 0.86 m^2 WC	
Minimum Ceiling Height	1.85 m	
Mounting/Demounting Time	0.5 hours	
Packed Dimension of Unit / Ease of Transportation & Storage	Main Unit | 1.21m x 3.15 m x 2.00 m WC | 1.2m x 1.2 m x 2.48 m	
Weight of Unit	700 kg – total weight - 500 kg | foldable modules and fixtures - 200 kg | WC & Shower Module	
Lifespan of Unit		
Footing on Site	Telescoping stilts	
Touched Area to Soil	1.44 m^2 (area of each leg is estimated as 0.2 m x 0.2 m regarding to drawings)	

Table 3-8 (continued)

Production Cost		Bayram, Yengül & Yavuz (2014)
Required Untrained Person for Implementation	2	
Required Educated Person for Implementation	No specific requirement	
Required Common Materials for Implementation	No specific requirement	
Required Special Materials for Implementation	No specific requirement	
Shelf Life		
Transportability /Ways of Transportation	- 35 shelters in A400 cargo plane - 20 shelters in CHINOOK CH-47 transport helicopter - 10000 shelters in cargo ship - 20 shelters in 1 articulated lorry	
Modularity	yes	
Adaptability	yes	
Climate Convenience / Temperature Range	Appropriate for between -30° – 50°C	
Wind Resistance		

Better Shelter

The Better Shelter is a sustainable temporary accommodation solution which is developed by the collaboration of UN Refugee Agency UNHCR and the IKEA Foundation for persons displaced by armed conflict and/or natural disasters. The product aims to achieve several criteria which are 1) safe and dignified, 2) sustainable, 3) cost-efficient, 4) modular and adaptable, 5) easy to assemble and disassemble (UNHCR & IKEA Foundation, n.d.).

The shelter is constructed in three stages which are steel foundation, roof with ventilation and solar panel and walls with windows and door. Properties of Better Shelter are presented in Table 3-9.

Table 3-9 Properties of Better Shelter

Properties of Better Shelter		Reference(s)
Number of Accommodated Person	5	UNHCR & IKEA Foundation (n.d.)
Floor Area	17.5 m^2	
Minimum Ceiling Height	1.8 m	
Mounting/Demounting Time	5-6 hours	
Packed Dimension of Unit / Ease of Transportation & Storage	1.99 m x 1.09 m x 0.52 m	
Weight of Unit	161 kg – total weight	
Lifespan of Unit	3 years with basic maintenance	
Footing on Site		
Touched Area to Soil	- If on soil - 17.5 m^2	
Production Cost	1150 €	
Required Untrained Person for Implementation	No specific requirement	
Required Educated Person for Implementation	4	
Required Common Materials for Implementation	Hammer, drive steel for ground anchors, drive steel for ground pipe puncher (all included in pack)	
Required Special Materials for Implementation	Included in pack	
Shelf Life	Minimum 5 years under dry, clean and ventilated conditions.	
Transportability /Ways of Transportation	- 17 shelters in Container 20 feet - 48 shelters in Container 40 feet HC - 36 shelters in Container 40 feet DC	
Modularity	yes	
Adaptability	yes	
Climate Convenience / Temperature Range	Appropriate for between 5° – 40° C	
Wind Resistance	Appropriate for ≤ 64.8 km/h or 18 m/s. Increases with additional measures.	

DAKO | A Second Prize Awarded Design in a National Competition of AFAD* in Turkey

DAKO is a second-prize awarded temporary housing unit design in a national competition of T.C. Disaster and Emergency Management Presidency (AFAD) named as "Post-disaster Temporary Housing Unit Idea Competition" in Turkey.

Designers of unit offer three major features that a temporary housing unit must have, which are easy construction without any montage, multiple-unit transportation in one time and an easy storage (Senkardeşler & Yıldırım, 2014). Table 3-10 lists the properties of DAKO.

Table 3-10 Properties of DAKO

Properties of DAKO		Reference(s)
Number of Accommodated Person	4	Senkardeşler & Yıldırım (2014)
Floor Area	18.2 m^2	
Minimum Ceiling Height	2.54 m	
Mounting/Demounting Time	0.33 hour	
Packed Dimension of Unit / Ease of Transportation & Storage	7.00 m x 2.60 m x 0.30 m	
Weight of Unit		
Lifespan of Unit		
Footing on Site		
Touched Area to Soil	18.2 m^2	
Production Cost	3950 TL	
Required Untrained Person for Implementation	No specific requirement	
Required Educated Person for Implementation	1	
Required Common Materials for Implementation	No specific requirement	
Required Special Materials for Implementation	1 crane and 1 forklift	
Shelf Life		
Transportability /Ways of Transportation	- 10 shelters in 1 lorry	
Modularity	No	
Adaptability	No	
Climate Convenience / Temperature Range		
Wind Resistance		

Humanitarian House International (HHI) | Long-Term Dwelling (LTD)

Humanitarian House International, whose designer is Stuart Ohlson, introduces two different models for divergent post-disaster periods as the Emergency Shelter (ES) for emergency period and Long-Term Dwelling (LTD) as a temporary accommodation unit. Both design have the same dimension, framing and flooring of units, however materials are adaptable. While Emergency Shelter (ES) is clothed with plastic membrane, Long-Term Dwelling (LTD) is clothed with a more durable material. Accordingly, it is possible to convert a ES unit to a LTD unit in 8 hours enabling to extend lifespan of unit (Ohlson & Melich, 2014). Table 3-11 presents properties of LTD.

Table 3-11 Properties of Humanitarian House International (HHI) | LTD

Properties of Humanitarian House International (HHI) | LTD		Reference(s)
Number of Accommodated Person	11	Ohlson & Melich (2014)
Floor Area	16.54 m^2	
Minimum Ceiling Height	3.04 m	
Mounting/Demounting Time	Less than 24 hours	
Packed Dimension of Unit / Ease of Transportation & Storage	1 standardized shipping container	
Weight of Unit	544.31 kg	
Lifespan of Unit		
Footing on Site	Telescoping stilts designed to be levelled on grades up to 10%.	
Touched Area to Soil	1.56 m2 (area of each leg is estimated as 0.25 m x 0.25 m regarding to photographs)	
Production Cost	2500 $	
Required Untrained Person for Implementation		
Required Educated Person for Implementation		
Required Common Materials for Implementation	Saws, hammers or wrenches	
Required Special Materials for Implementation	No specific requirement	

Table 3-11 (continued)

Shelf Life		Ohlson & Melich (2014)
Transportability /Ways of Transportation	- 1 shelter in 1 shipping container	
Modularity	no	
Adaptability	yes	
Climate Convenience / Temperature Range	Appropriate for equatorial and sub-tropical regions. Materials will not breakdown in 90%+ humidity or temperatures of 100 degrees Fahrenheit (37.7 Celsius)	
Wind Resistance	The house will withstand winds of 80 miles per hour (mph).	

MobARCH

MobARCH can be defined as a modular temporary accommodation to be used following a possible earthquake in İstanbul. In the design process of the unit, four main processes are applied which are in order of setting design objectives, developing design and evaluation criteria, evaluation of existing systems and 'melting' of 'fragmental' alternatives and 'best' existing systems into the final design. As a part of the methodology, design objectives are reached which are: 1) technology, construction and materials, 2) ecological objectives, 3) cost, 4) building physics, 5) spatial organization, 6) sociological objectives and 7) aesthetics (Sener & Altun, 2009). Table 3-12 shows properties of the final design of MobARCH reached by the mentioned methodology.

Table 3-12 Properties of MobARCH

Properties of MobARCH		Reference(s)
Number of Accommodated Person	4	Sener & Altun (2009)
Floor Area	54 m^2	
Minimum Ceiling Height	2.10 m	
Mounting/Demounting Time		
Packed Dimension of Unit / Ease of Transportation & Storage		
Weight of Unit		
Lifespan of Unit		
Footing on Site		
Touched Area to Soil	4 m^2 (area of each leg is estimated as 0.5 m x 0.5 m regarding to photographs)	
Production Cost		
Required Untrained Person for Implementation		
Required Educated Person for Implementation		
Required Common Materials for Implementation		
Required Special Materials for Implementation		
Shelf Life		
Transportability /Ways of Transportation		
Modularity	yes	
Adaptability	no	
Climate Convenience / Temperature Range		
Wind Resistance		

Paper Log Houses | Kobe, Japan

Shigeru Ban, who is the designer of Paper Log Houses, firstly, offered the sustainable post-disaster temporary accommodation units following the 1995 earthquake in Kobe, Japan. Then, Shigeru Ban Architects (SBA) has transformed Paper Log Houses for the 1999 earthquake in Turkey. And subsequently, sustainable units have applied to mitigate effects of loss of housing following the 2001 earthquake in India. Therefore, Paper Log Houses can be accepted as an internationally applied design in response period of disaster management (Shigeru Ban Architects, 2005).

Criteria leading Paper Log Houses are defined by designer as inexpensive materials, simple construction methods, satisfactory insulation and aesthetics. Taking into consideration of agreed criteria, walls of accommodation unit is built with 106mm diameter, 4mm thick paper tubes and a tenting material is applied for the roof (Shigeru Ban Architects, 1995). Properties of Paper Log Houses constructed following 1995 earthquake in Kobe, is presented in Table 3-13.

Table 3-13 Properties of Paper Log Houses | Kobe

Properties of Paper Log Houses		Reference(s)
Number of Accommodated Person		
Floor Area	52 m^2	(Shigeru Ban Architects, 2005)
Minimum Ceiling Height		
Mounting/Demounting Time	Less than 1 hour	(Mortal, et al., 2018)
Packed Dimension of Unit / Ease of Transportation & Storage		
Weight of Unit		
Lifespan of Unit		
Footing on Site	No specific requirement	
Touched Area to Soil	0 m^2 – no permanent montage	from renders
Production Cost	Under $ 2000	(Shigeru Ban Architects, 2005)
Required Untrained Person for Implementation	10 people	(Mortal, et al., 2018)
Required Educated Person for Implementation	No specific requirement	
Required Common Materials for Implementation		

Table 3-13 (continued)

Required Special Materials for Implementation		
Shelf Life		
Transportability /Ways of Transportation		
Modularity	yes	
Adaptability	yes	
Climate Convenience / Temperature Range		
Wind Resistance		

Über Shelter

Über Shelter is a temporary accommodation unit designed for displaced people, by Rafael Smith as an undergraduate thesis project in Purdue University (Aviv, 2008). Smith defines 5 points that a shelter must satisfy which are 1) ease of transportation and demounting, and flat shipping, 2) designed with recyclable materials and reusability in future, 3) ease of assembly with few or no tools, 4) compatible with current infrastructure and 5) able to be stacked.

Über Shelter, designed as a double-story unit, is a basic modular unit which is easy to assemble and dismantle with few people and common materials. As the designer of Über Shelter states, the unit is differentiated from other shelters due to its design with recyclable materials in order to achieve the reusability of accommodation unit (as cited in Smith). Table 3-14 presents properties of Über Shelter.

Table 3-14 Properties of Über Shelter

Properties of Über Shelter		Reference(s)
Number of Accommodated Person	3	Rafael Smith, Uber Shelter Project (2010)
Floor Area	23 m^2	
Minimum Ceiling Height	2.13 m	
Mounting/Demounting Time		
Packed Dimension of Unit / Ease of Transportation & Storage	1.22 m x 2.44 m x 0.61 m	
Weight of Unit	544 kg	
Lifespan of Unit		
Footing on Site	Telescoping stilts	
Touched Area to Soil	0.32 m^2 (area of a leg is estimated as 0.2 m x 0.2 m regarding to drawings)	
Production Cost	1000 $ - 3000 $ labor included	
Required Untrained Person for Implementation	4	
Required Educated Person for Implementation	No specific requirement	
Required Common Materials for Implementation	A wrench, a ratchet and a screwdriver	
Required Special Materials for Implementation	No specific requirement	
Shelf Life		
Transportability /Ways of Transportation	Through air, sea or land regarding to flat shipping	
Modularity	Yes	
Adaptability	Yes	
Climate Convenience / Temperature Range		
Wind Resistance		

CHAPTER 4

EVALUATION OF TEMPORARY HOUSING UNITS

4.1 Decision Making

Decision-making, as a daily activity process, is represented as the action of identifying and choosing among alternatives with respect to the constraints and preferences of decision maker. Thus, the existence of alternative choices directs people to handle the situation with decision-making processes that an individual or a group choose the one which satisfies goals, objectives, desires etc. (Fülöp, 2001). While Kleindorfer, Kunreuther, & Schoemaker (1993) define decision-making as the intentional and reflective choices depending on perceived needs, another claim is that decision-making is to solve a problem by choosing, ranking or classifying over the current alternatives characterized by multiple criteria (as cited in Topçu & Kabak).

Action of decision making starts with the identification of the decision maker(s) and stakeholder(s), subsequently the problem is defined and requirements, goals and criteria are figured out (Baker et al., 2001). Although Baker et al. (2001) state that the only participant of decision-making process is decision maker(s), Damghani, Taghavifard, & Moghaddam (2009) classify participants into two main actors: decision maker and the model builder, named as the analyst.

Considering a common decision-problem, Fülöp (2001) lists five major steps of decision-making process as shown in Figure 4-1.

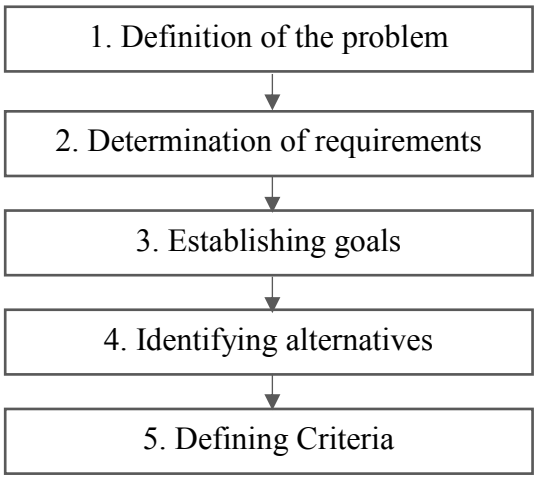

Figure 4-1 Steps of decision making process (Adopted from Fülöp (2001))

From a different perspective, Vitoriano et al. (2015) state that a standard decision aid problem is approached through four main phases in an order as: 1) design of observation to acquire data, 2) comprehension of data and its structure, 3) understanding the problem and 4) decision making. Elaborating on the third phase, understanding the problem, it is possible to face with several difficulties as absence of data, uncertainty, imprecision, diversified criteria, contradictory, inconsistent and/or unexpected information. As a consequence, decision maker(s) should apply a structured model for prediction, test and discussion. Following the action of understanding the problem, the action of selection is emphasized via a strategic positioning or a strategic policy in the last phase of the process.

Among steps of decision-making, one of the most significant matter to make right decision is to cope with the imprecise information since majority of decision-making processes includes uncertainties (Ribeiro, 1996). Accordingly, the existence of uncertainty poses the existence of probability. In other words, since uncertainty is a fact, probability, stemming from the verb 'probe' means to 'find out', is a guide to cope with the decision problem.

Elaborating on the individual in decision-making, Simon (1982) states the term of 'bounded rationality' which is a term to display cognitive limitations of decision-maker while reaching a rational choice. In addition, as Gigerenzer and Todd (1999)

state, ‘fast and frugal heuristics’ are generally applied by individuals seeking for the prompt way of decision making, particularly when there is limited time as in emergencies or disasters. In other words, people usually apply their own habits and traditions to achieve decision-making instead of following a systematic process.

As there are diverse circumstances to be coped with, people, who are suffering from insufficient information or skills, may not reach rational decisions, in deed, people owing time and information usually do a malfunction considering probabilities of decision. Even people who are aware of statistics, are inclined to make decisions with respect to their own experience rather than the available information (Damghani et al., 2009). Consequently, people need a systematic approach to lead them while they confront with a decision-making problem, especially in emergency situations where lots of diverse circumstances combined with lack of time and order.

4.1.1 Decision Making in Disaster Management

Decision-making in emergency situations can be categorized as one of the most challenging situations with respect to uncertainty. Indeed, as emergency is defined as an exceptional incident compelling the capacity of available resources for organizations who is responsible for handling with, emergency situations need a decision-making action.

As phases of disaster management is well-explained in Chapter 2, each phase owes its specific aims and complexity level depending on timing, organizational structure and collaboration (as cited in O’Sullivan, Kuziemsky, Toal-Sullivan, & Corneil, 2013). Indeed, heterotaxic and instant circumstances cause a challenging environment for decision making process regarding to the lack of time and resources so that any wrong approaches have the possibility to result with severe consequences (Hardy & Comfort, 2015). In other words, decision-making should be achieved as prompt as possible with the limited information due to the suddenly occurred situation.

Elaborating on the complexity of decision-making in usual conditions, decisions and taking actions following a disaster are squeezed between the contradictory issues of the situation: relief and development; temporary needs and permanent response; participation and co-optation; vulnerabilities and capacities etc. in disaster management (Boano et al., 2003). In other words, there are several criteria to take into consideration in decision-making in disaster management. Furthermore, despite the fact that disasters are generally managed by local authorities, their complexity level is quite high due to the contribution of local and international institutions (McConnell & Drennan, 2006). In this manner, although response phase, following a disaster, is managed by local authorities, actions of several national and international authorities should be managed pickily. Thus, considering the outnumber of contributed groups regarding to level of emergency, how to respond to disasters, as crises, starts to become an emerging and large-scale problem that socio-technical system of individuals, groups, organizations and jurisdictions need to coordinate their own steps in a compatible environment (Hardy & Comfort, 2015).

4.1.2 Decision Making Process of Post Disaster Temporary Housing Units

Although the contributors of disaster management display multi-branched structure of disaster management, decision making process of post-disaster temporary housing units are performed by the assessment teams of one of the five disciplines of disaster management institutions: 'sheltering'. In other words, assessment team of 'sheltering' is responsible for the evaluation of post-disaster temporary housing units.

The characteristics of "dichotomy" in disaster management is mostly faced in the decision-making process of shelter provision and settlements planning, generated with both humanitarian needs and development resources (as cited in Boano et al., 2003). Although the two approaches focus on different frames, deficiencies and conflicts can be handled with enhancing approaches. "Better development" can reduce the need for emergency relief; better "relief" can contribute to development" (Duffield, 1998).As a similar approach, decision-making process of temporary housing units is also

approached with two main bodies: relief-oriented and development-oriented objectives. While relief-oriented body aims to reduce or prevent loss of lives with short-term humanitarian assistance, development-oriented body defines its frames as long-term assistance with respect to economic, social and physical structures (as cited in Boano et al., 2003). In this segmented structure of disaster management, decision making and taking action are squeezed between two main contradictory approaches: short-term necessities and long-term requirements.

According to Gray & Bayley (2015), it is possible to explain this contradictory issue following disasters through five items as humanitarian discipline, structural financing, lack of human resources, the politics of properties and conditions, and institutional coordination of stakeholders.

Taking into consideration of this dichotomy, despite the variability on needs and strategies of temporary accommodation units throughout time, IFRC/RCS (2013) defines 'a successful shelter design' which balances the contradictory factors as shown in Table 4-1.

Table 4-1 Contradictory factors of successful shelter design (Adapted from IFRC/RCS (2013))

Contradictory factors of temporary housing units	
Safety	Cost
Lifespan	Timeliness
Size	Number to be built
Comfort	Materials availability
Privacy	Maintenance and upgrade
Liability of implementing	Equity with host population
	Capacity to implement
	Cultural appropriateness

To handle with the complexity of the problem, one of the most implemented management method for temporary accommodation is 'top-down' decision-making approach following impactful disasters (Hany Abulnour, 2014). 'Top-down' approach is commonly performed by governmental authorities with the lack of participation of the users of accommodation units (as cited in Johnson, 2007a). Furthermore, top-down approach, which can be defined as a conventional method, enables to apply and observe formal norms of building standards and land use management (Drakakis-Smith, 1981). However, top-down approaches in decision-making process of temporary housing units cause several problems such as generation of standardized components and units which ignore unique local needs of different occupants (Hany Abulnour, 2014). Indeed, Zhang, Setunge, & van Elmpt (2014) accept that top-down reconstruction approach is inherent so that implementing appropriate containers for post-disaster temporary accommodation is shown as an appropriate method.

By associating statements of Hadafi & Fallahi (2010) and Quarantelli (1995), Hosseini, De La Fuente, & Pons (2016) declare that decision makers apply prefabricated temporary housing units for displaced people, in a situation of a mass migration, due to five main reasons. These five reasons are listed as instancy, high demand, pressure on government, lack of alternatives and preventing the exodus of displaced people. In addition, Félix, Branco, & Feio (2013) declare that the reason to apply prefabricated, mass-produced and standardized temporary accommodation units is interpreted as the necessity of rapid and extensive response.

In contrast to top-down approach, it is possible to let communities and users take responsibility in decision-making and management of temporary housing units so that communities have chance to contribute to decision-making and politics, termed as bottom-up approach. Applying community-based approaches in evaluation of temporary housing units, commonly organized by Non-Governmental Organizations (NGOs), are mentioned as a successful strategy due to bringing appropriate solutions out for cultural, economic and ecologic circumstances. Further, contribution of communities enables to integrate reconstruction work with development opportunities resulting with the maximization of investments (Tipple, 2000).

El-anwar et al. (2016) introduce Community-Based Housing Response Pool (CHRP) which is a pathway for decision-makers in housing response. The response is referred as practical for emergency planners as it satisfies the listed principles as;

- enabling automated and real-time information of temporary housing alternatives,
- enabling a flexible path appropriate to be followed by both centralized and decentralized assistance applications,
- Serving a number of available temporary housing plans for decision makers to display the precedencies.

Elaborating on cooperative, bottom-up and community led approach, for instance, following Typhoon Haiyan in 2013, disaster-affected community contributed to the 'resilient recovery'. Flexible finance, provided by the Dutch Government, Cordaid and Nassa (Caritas Philippines), let role-takers implement bottom-up approach. To achieve an effective community designed recovery plan, disaster cycle is broken to let community experience it. Thus, the disaster affected community become one of the leaders of recovery phase instead of being recipients. Consequently, UK Shelter Forum, which is organized in November 2014, was mentioned the applied method in Typhoon Haiyan as a significant example for shelter provision application, influencing the humanitarian agencies with directing them to seek new forms of collaboration and funding (Gray & Bayley, 2015).

Considering the problematic aforementioned consequences, Johnson et al. (2006) introduce a systematic approach for the decision making process of temporary housing units in disaster management, mainly applicable for natural disasters. In other words, considering phases of disaster management, authors display an action plan for temporary housing units in 'preparedness' phase. As shown in Figure 4-2, the mechanism proves that strategic planning should have started before the actualization of catastrophe, in other words disaster. Thus, instead of an ad hoc planning, the systematic perspective contains eight preliminary works as designation of type of temporary housing (1), degree of vulnerability (2), political-social-cultural, economic

environment (3), climate - weather (4), long term effects of temporary housing (5), time lag of procurement, planning, construction (6), strategy for permanent construction (7) and available sites for temporary housing (8).

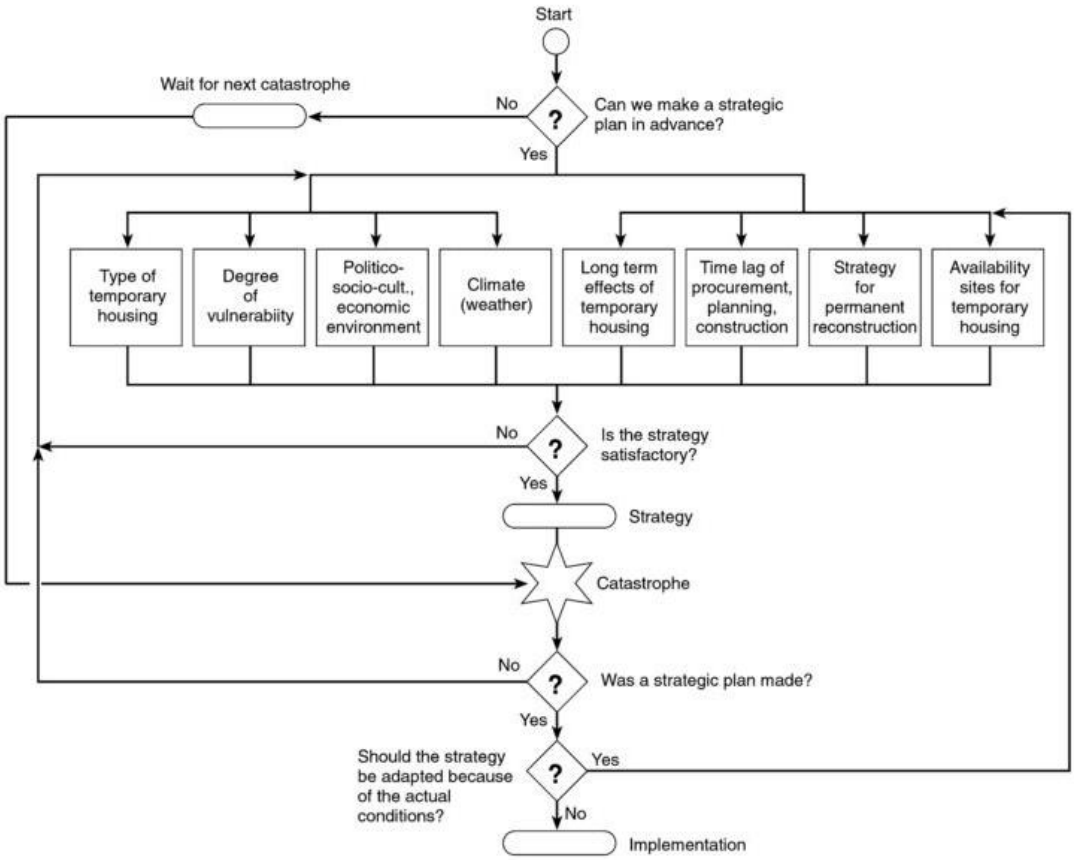

Figure 4-2 Strategic planning prior to natural disasters – or not (Johnson et al., 2006)

Ad hoc decision-making processes instead of pre-disaster strategic planning, by governments and non-governmental organizations (NGO), following a disaster results in detrimental problems on accommodation unit designs (Johnson, 2007b). Besides, high pressure and the lack of resources, in a post-disaster situation, result in the generation of inadequate temporary housing units (Johnson, 2002). Considering all, although Johnson et al. (2006) proposes a strategic planning to avoid prompt response, understanding problems with its dimensions is crucial to propose feasible planning methodologies.

4.1.3 Types of Decision Making Techniques

It is essential for each manager to achieve efficient and optimal use of human resources, equipment and other organizational resources so that the maximum productivity level for equipment and resources is a prespecified aim. It is possible to confront with decision problems, owing complex conditions of diverse convergent criteria/attributes and uncertainty, however the aim of managers does not deviate since they are obliged to reach the best decision regarding to their goals (Rao, 2013).

To cope with the mentioned compelling situations of the decision-making, it is possible to regard decision analysis as a path to follow due to possibility of resulting with better decisions with the rigorous applications (Clemen & Reilly, 2013). Coping with the decision-making problem in disaster management, there are frequently used techniques such as decision trees, cost & benefit analysis and multi-criteria decision making among others.

Arguing decision sketching tools, Gregory et al. (2012) introduces 'decision-trees' in disaster management for its relevance and usefulness to the conditions. Decision trees are introduced with the following statements as:

- a tool to display and structure decisions and probabilistic situations in an organized way considering the probabilistic results,
- with respect to the possible multi-attributed results, analysis is computed considering the single or multi-attribute utilities displaying in decision tree,
- practicality in discrete events or decisions between the initial decision and eventual results.

On the other hand, The Cost-Benefit Analysis (CBA), in other words 'cost effectiveness', aims to determine "the best possible economic use of the resources" (Paruccini, 1994). Nonetheless, according to the statements of Paruccini (1994), the CBA method is generally criticized due to causing ethic problems since it is not possible to evaluate everything considering its price.

One of the most applied ways is the multiple attribute decision making (MADM), generally called as multi-criteria decision making (MCDM), which is categorized under the Operations Research models handling with the decision problems including a number of decision attributes (Rao, 2013). The aim of MADM or MCDM is to choose an appropriate alternative among a group of possible alternatives with respect to each attribute of all alternatives (Rao, 2013).

Considering the need for a structured decision-making technique in post-disaster response, this study presents a generalized road map with several aspects based on MCDM for evaluation of temporary accommodation units as an attempt of utilizing the potential of MCDM in disaster conditions.

4.2 Proposed Method for Evaluating Temporary Housing Units

Decision-making is one of the inevitable tasks of architectural design process since responsibility of architects is to convert a design problem into a well-structured quest for the given input variables such as location, climate and culture within a certain time. Indeed, responding to housing problems of victims in catastrophes makes the decision-making even more complicated not only for architects but also for authorities that the selection of temporary housing units in post-disaster situations are commonly resulted with top-down decision-making approaches due to the necessity of prompt response. As a result, disorganized methods for the decision-making process of post-disaster temporary housing units are insufficient or result with detrimental problems not only to society but also to environment and economy.

Moor (2001) states that designing and constructing temporary housing units for being used in case of disasters has always been difficult due to their unpredictability. In this manner, the emphasis is now on “the more predictable and manageable disasters like earthquakes, fires, hurricanes, landslides and floods, and increasingly, to … threats from pollution, crime and poverty”, however there should also be a path-way even for unpredictable disasters to provide a livelihood environment for disaster victims.

Although critical decisions are usually well-prepared or made in 'preparedness' period of disaster management, reaching the most appropriate decision is almost impossible due to the uncertainty of input variables until the disaster has happened. On the other hand, recognizing the significance of decision making in disaster management, it is necessary to apply an evaluation system considering emergency situations of the post-disaster environment.

Considering all, MCDM is proposed in this study, as an applicable strategy to reach the most rational temporary housing unit design within short-period of time of the post-disaster environment. Further, this dissertation suggests a path-way by making use of MCDM for the evaluation of post-disaster temporary housing units applicable for disaster with various scales and types.

Regardless of the predictability of disaster, Figure 4-3 presents the proposed methodology which is projected on four-phased process as:

i. Comprehension of disaster and its critical features,
ii. Regulation of criteria of temporary accommodation units,
iii. Determination of weights of indicators,
iv. Application of appropriate decision-making model.

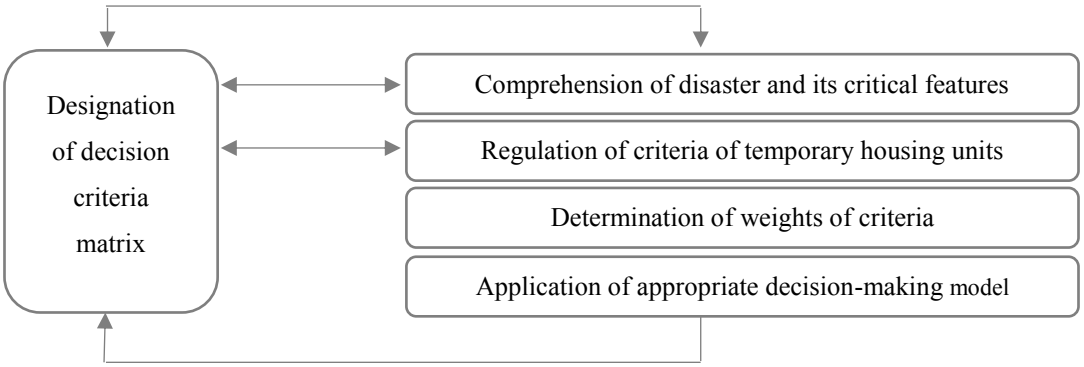

Figure 4-3 Proposed path-way for the evaluation of temporary housing units

As a part of the strategic disaster management methodology, there is a continuous activity as the designation of decision criteria matrix contributing four phases by

leading or directing designers and decision-makers as a guideline in case of a disaster-relief.

Apart from the continuous action of the designation of decision criteria matrix process, the decision-making process of temporary housing units starts just after the moment of disaster with comprehension of disaster and its critical features. This is followed by the regulation of criteria of temporary housing units that enables decision-makers to apply a contextual path rather than implementing same restraints and criteria to each disaster. Afterwards, weights of criteria are determined and finally the MCDM method which is appropriate to the situation is applied to reach the most appropriate temporary accommodation alternative.

In this study, to display the practicality of the proposed decision-making pathway for temporary accommodation units, the proposed decision-making method is applied on several real-case studies by following the four phases. Moreover, temporary housing unit indexes of alternatives which directs architects, designers and authorities on decision been presented.

4.3 Multi-Criteria Decision Making Methods

MCDM aims to evaluate alternatives with respect to diverse criteria by structuring a global preference relation for a set of candidates (as cited in Topçu & Kabak). However, there are various ways of reaching the optimum alternative through MCDM such as selecting, ranking, classifying, screening or prioritizing.

According to the statements of Triantaphyllou (2000), although each MCDM method aims to assist decision makers to choose among a discrete set of alternatives by presenting diverse numeric techniques, determining on the best method has always been a paradox. In this manner, besides numerous investigations on MCDM methods, there are also several studies on comparison of MCDM methods.

To clarify differences between MCDM Methods, Velasquez & Hester (2013) conduct an investigation by examining MCDM methods mentioned in scholarly literature; thus eleven MCDM methods have been reached. Table 4-2 represents eleven MCDM methods with their advantages, disadvantages and areas of applications.

Table 4-2 Comparison of MCDM Methods (Adapted from Velasquez & Hester (2013))

Method	Advantages	Disadvantages	Areas of Application
Multi-Attribute Utility Theory (MAUT)	Takes uncertainty into account; can incorporate preferences.	Needs a lot of input; preferences need to be precise.	Economics, finance, actuarial, water management, energy management, agriculture
Analytic Hierarchy Process (AHP)	Easy to use; scalable; hierarchy structure can easily adjust to fit many sized problems; not data intensive.	Problems due to interdependence between criteria and alternatives; can lead to inconsistencies between judgment and ranking criteria; rank reversal.	Performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning.
Case-Based Reasoning (CBR)	Not data intensive; requires little maintenance; can improve over time; can adapt to changes in environment.	Sensitive to inconsistent data; requires many cases.	Businesses, vehicle insurance, medicine, and engineering design.
Data Envelopment Analysis (DEA)	Capable of handling multiple inputs and outputs; efficiency can be analyzed and quantified.	Does not deal with imprecise data; assumes that all input and output are exactly known.	Economics, medicine, utilities, road safety, agriculture, retail, and business problems.
Fuzzy Set Theory	Allows for imprecise input; takes into account insufficient information.	Difficult to develop; can require numerous simulations before use.	Engineering, economics, environmental, social, medical, and management.
Simple Multi-Attribute Rating Technique (SMART)	Simple; allows for any type of weight assignment technique; less effort by decision makers.	Procedure may not be convenient considering the framework.	Environmental, construction, transportation and logistics, military, manufacturing and assembly problems.
Goal Programming (GP)	Capable of handling large-scale problems; can produce infinite alternatives.	It's ability to weight coefficients; typically needs to be used in combination with other MCDM methods to weight coefficients.	Production planning, scheduling, health care, portfolio selection, distribution systems, energy planning, water reservoir management, scheduling, wildlife management.

Table 4-2 (continued)

ELECTRE	Takes uncertainty and vagueness into account.	Its process and outcome can be difficult to explain in layman's terms; outranking causes the strengths and weaknesses of the alternatives to not be directly identified.	Energy, economics, environmental, water management, and transportation problems.
PROMETHEE	Easy to use; does not require assumption that criteria are proportionate.	Does not provide a clear method by which to assign weights.	Environmental, hydrology, water management, business and finance, chemistry, logistics and transportation, manufacturing and assembly, energy, agriculture.
Simple Additive Weighting (SAW)	Ability to compensate among criteria; intuitive to decision makers; calculation is simple does not require complex computer programs.	Estimates revealed do not always reflect the real situation; result obtained may not be logical.	Water management, business, and financial management.
Technique for Order Preferences by Similarity to Ideal Solutions (TOPSIS)	Has a simple process; easy to use and program; the number of steps remains the same regardless of the number of attributes.	Its use of Euclidean Distance does not consider the correlation of attributes; difficult to weight and keep consistency of judgment.	Supply chain management and logistics, engineering, manufacturing systems, business and marketing, environmental, human resources, and water resources management.

Considering the comparison of Velasquez & Hester (2013), AHP method (Saaty, 1980), scalable and easy to adjust in size, is emphasized due to its application in corporate strategy. In addition, it enables decision makers not only to reach weights, but also to compare alternatives with a relatively easy path (Velasquez & Hester, 2013).

As AHP, a choosing method, is selected to apply in the evaluation of temporary housing units, an outranking method is aimed to be applied as a second method in order to compare the applicability of different families in temporary housing unit evaluation. In this manner, two outranking methods; PROMETHEE (Brans, Vincke, & Mareschal, 1986) and ELECTRE (Roy, 1991) methods have been investigated. Applying Table 4-2, constituted by Velasquez & Hester (2013), ELECTRE has been

decided to be applied on the evaluation of temporary housing units due to its advantage on uncertainty and vagueness. Among several versions of ELECTRE (I-II-III-IV-Iv-IS-A-TRI) method, ELECTRE I is determined to be applied considering its simplicity compared with the other ELECTRE methods (Munier, 2011).

In application of MCDM methods, three steps must be applied including the numerical analysis of alternatives as follows:

1) Determination of the relevant criteria and alternatives,

2) Consideration of numerical calculations regarding to weights of criteria and values of alternatives on these criteria,

3) Evaluation of numerical calculations to reach a ranking of each alternative.

Although it is possible to reach the best alternative through the mentioned three steps, researchers have developed several multi-criteria software tools or decision support systems (DSS) to enable the applicability of the MCDM methods in a practical way (Mustajoki & Marttunen, 2017). Therefore, as DSS are applied to perform large number of computations in short period of time (Baizyldayeva, Vlasov, Kuandykov, & Akhmetov, 2013), it is possible to apply several DSS models in the evaluation of temporary housing units.

Considering all, decision methods require evaluation of the weights of indices by groups of experts, with multidisciplinary contributions or individuals. Alternatively, the relative weights of each criterion can be implicitly found by Analytical Hierarchical Process (AHP). By using the pair-wise comparison feature of AHP, the complexity of having multiple criteria can be tackled. In other words, AHP enables decision makers to handle multiple criteria in one matrix in a relatively basic process. Thus, this study recommends making use of AHP as the first step of the proposed hybrid MCDM method.

Succeeding in the determination of weight of indices via AHP, ELECTRE I (a relatively common MCDM method) is used as the second step of the proposed method,

as suggested by (Rao, 2013). The role of thresholds in decision-making is critical since several architectural properties have to be assigned as restraints depending on the genuine features of the disaster and the victims. Due to its feature of considering the concordance, discordance and threshold values, ELECTRE I is adopted the hybrid method proposed in this study.

At the third phase of the proposed method, the results of ELECTRE I, which do not necessarily yield a single best choice, but rather yield a kernel of outranking options (Rogers et al., 2000), is combined with the results of AHP that basically gives a ranked set of alternatives. Therefore, the integrated use of AHP and ELECTRE I let the analyst, namely the decision maker, evaluate alternative temporary housing units to reach the most rational option.

4.3.1 Analytic Hierarchy Process (AHP)

The Analytical Hierarchical Process (AHP), introduced by Thomas Saaty (1980), is a hierarchical multi-criteria decision-making aid representing an effective tool to handle prioritization problems (Saaty & Vargas, 2013). AHP is a well-known methodology coping with the measurement of qualitative or intangible criteria depending on the pairwise comparisons (Figueira, Greco, & Ehrgott, 2005). To be easily comprehended by decision-makers, it structures the decision problem into levels, objectives, criteria, sub-criteria and alternatives (Munda, 2008). Indeed, criteria, in the practice, are generally organized in a tree-structure, enabling AHP to perform a series of pairwise comparisons within smaller segments of tree and then between small segments at a higher level of tree-structure (Fülöp, 2001). Thus, the levelled structure enables decision makers to handle with smaller set of decisions (Munda, 2008). The four main axioms of AHP are listed as (Munda, 2008):

i. Existence of any two alternatives (or sub-criteria) – the configuration of pair-wise comparisons of alternatives for any criterion with respect to a reciprocal ratio scale,

ii. Finite comparison of each pairwise criteria,
iii. Formulation of the decision problem into a hierarchy,
iv. Representation of all criteria and alternatives in a hierarchy.

Following the identification of criteria, the methodology of AHP evaluates criteria and alternatives with the following steps (San Cristóbal Mateo, 2012):

Step 1. Designation of aim of the problem with criteria and alternatives.

Step 2. Generation of pairwise comparison matrix (A).

A pairwise comparison matrix (A) is in the size of n x n, while 'n' represents the number of criteria. Matrix (A) is generated to display how much more important criterion with index "i" is than criterion with index "j". Since the matrix (A) shown by Equation (1) is generated regarding to verbal judgements of decision-maker, verbal judgements are transformed into numerical quantities regarding to integer/importance values between 1 to 9 as represented in Table 4-3.

$$A = \begin{pmatrix} 1 & a_{12} & \mathrm{L} & a_{1n} \\ 1/a_{12} & 1 & \mathrm{L} & a_{2n} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{M} \\ 1/a_{1n} & 1/a_{2n} & \mathrm{L} & 1 \end{pmatrix} \qquad \text{(Equation 4-1)}$$

There are two rules of comparison matrix;

i. If $a_{ij} = \alpha$, then $a_{ji} = 1/\alpha$ and $a_{ij} > 0$
ii. If the criterion with index "*i*" is as important as the criterion with index "*j*", then $a_{ij} = a_{ji} = 1$, and $a_{ii} = 1$ for all *i*.

Table 4-3 Saaty's nine-point intensity scale (Saaty, 1980)

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two factors contribute equally to the objective.
3	Somewhat more important	Experience and judgment slightly favor one over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other.
9	Absolutely More important	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate Values	When compromise is needed.

<u>Step 3.</u> Recovering the weighting vector (W),

Weighting vector indicates the relative importance of each criterion. Equation (2) shows the weighting vector (W). The sum of the elements of matrix (W), which is in the size of "1 x n", must be equal to 1.

$$W = [w_1 \quad w_2 \quad \mathrm{L} \quad w_n] \qquad \text{(Equation 4-2)}$$

Elements of matrix (W) are found with respect to the following equations as:

i. Normalized pairwise comparison matrix ($\overline{A}$) is found by dividing each member of matrix (aij) by the sum of the members at the same column of that member as given in Equation (4-3).

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \qquad \text{(Equation 4-3)}$$

ii. Find the elements of the weighting vector by taking the average of the entries in row m of matrix (Anorm) as shown in Equation (4-4)

$$w_i = \frac{\sum_{j=1}^{n} \bar{a}_{ij}}{n} \qquad \text{(Equation 4-4)}$$

Step 4. Testing the consistency of pairwise comparison matrix.

i. Calculate A W^T,

ii. Compute maximum eigenvalue (λ_{max}) of matrix (A) with respect to Equation (5):

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{\left[A \cdot W^T\right]_i}{W^T_i} \qquad \text{(Equation 4-5)}$$

iii. Compute the Consistency Index (CI) by using Equation (4-6),

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad \text{(Equation 4-6)}$$

iv. Finding out the Random Index (RI) for a given value of "n" using Table 4-4s.

Table 4-4 Random Index (RI) regarding to values of n

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

v. Calculate Consistency Ratio (CR) with Equation (4-7):

$$CR = \frac{CI}{RI} \qquad \text{Equation (4-7)}$$

If CR < 0.10, the consistency value is satisfactory to proceed the decision problem with AHP. In the contrary case, if CR ≥ 0.10, there is an inconsistency, hence AHP method may not yield rational results.

Step 5. Create a pairwise comparison matrix and a weighting vector for each criterion.

i. As number of alternatives is represented as “m”, generate “n” number of “m x m” comparison matrices.

ii. For each “m x m” comparison matrix, repeat Step 3 and 4.

Step 6. Calculate the score vector (S) for each alternative.

Find the decision matrix (H) having the size of m x n by concatenating “n” number of weighting vectors, with size m x 1 found at Step 5 horizontally. Thereafter, find the score vector with “m” members as given in Equation (4-8). Each element of the score vector, (s_i), represents the objective weight of each alternative under consideration.

$$s_i = \sum_{j=1}^{n} h_{ij} \cdot w_j \qquad \text{Equation (4-8)}$$

Following the steps of AHP briefed above, a ranked order of alternatives is found where the alternative (candidate) with the highest score is the one that dominates the others according to the criteria used in the analysis.

4.3.2 ELECTRE I

ELimination Et Choix Traduisant la REalité (ELECTRE) method, proposed initially by Benayoun et al. (1966) and further studied by Bernard Roy (1991) as a philosophy of decision aid, is constituted to remedy the deficiencies of existing decision-making methods. ELECTRE has several versions as I, II, III, IV, IS and TRI. Although all these versions have structured on identical fundamental concepts, their operational path somewhat differs in process (Buchanan & Sheppard, 1998).

ELECTRE I, revealing the relations between alternatives with outranking method, aims to specify the strength of preference of one alternative to another. To reach the preferences, the method organizes a concordance matrix, if there is a strong superiority

of one alternative over another, further creates a discordance matrix, displaying the opposing of the superiority of one alternative to another. In ELECTRE, threshold approach is used to evaluate the superiority of one alternative over another (Munier, 2011).

Conceiving the characteristics of uncertainty and vagueness in decision problems makes ELECTRE a widely-used multiple attribute decision making method, since it is possible construct the method into predictions and estimations (Rao, 2013; Buchanan & Sheppard, 1998).

Following several steps such as defining the decision problem, identification of the decision criteria and corresponding weights, the methodology of ELECTRE I evaluates alternatives with respect to the following steps (Fülöp, 2001):

Step 1. The designation of decision matrix.

"n" number of criteria values are located on columns to the corresponding rows representing the "m" number of alternatives, hence "m x n" sized decision matrix (H) is reached.

Step 2. Calculation of standardized/normalized decision matrix ($\overline{H}$).

The elements of standard/normalized decision matrix are reached by using Equation (4-9),

$$\bar{h}_{ij} = \frac{h_{ij}}{\sqrt{\sum_{k=1}^{m} h_{kj}^2}} \qquad \text{Equation (4-9)}$$

Step 3. Generation of weighted standardized/normalized decision matrix (Y).

As shown in Equation (4-10), matrix (Y) is calculated by multiplying normalized decision matrix (H) with diagonal weighting matrix. In Equation (4-10), the weighting among criteria should be explicitly identified by the decision maker.

$$Y = \bar{H} \cdot diag(W) = \begin{bmatrix} \bar{h}_{11} & K & \bar{h}_{1n} \\ M & O & M \\ \bar{h}_{m1} & L & \bar{h}_{mn} \end{bmatrix} \begin{bmatrix} w_1 & L & 0 \\ M & O & M \\ 0 & K & w_n \end{bmatrix} = \begin{bmatrix} \bar{h}_{11} w_1 & K & \bar{h}_{1n} w_n \\ M & K & M \\ \bar{h}_{m1} w_1 & K & \bar{h}_{mn} w_n \end{bmatrix}$$

Equation (4-10)

Step 4. Calculation of the concordance (C) and discordance (D) matrices.

i. Each element of concordance matrix (cij) is found by using Equation (4-11),

$$c_{ij} = \sum_{k=1}^{n} w_k \quad \text{if } y_{ik} > y_{jk} \qquad i, j = 1, \ldots, m \text{ and } i \neq j$$

Equation (4-11)

ii. By using Equation (4-12) and (4-13), each element of discordance matrix (dij) is calculated as follows,

$$r_k = \max_{i=1,\ldots,m} y_{ik} - \min_{i=1,\ldots,m} y_{ik} \qquad k=1, \ldots, n$$

Equation (4-12)

$$d_{ij} = \max_{k=1,\ldots,n} \left(\frac{y_{ik} - y_{jk}}{r_k} \right) \qquad i, j=1, \ldots, n \text{ and } i \neq j$$

Equation (4-13)

Compared pair of alternatives can either be an element of concordance matrix or discordance matrix regarding to ELECTRE I method. The main diagonal (i=j) of concordance and discordance matrices are empty since they compare same alternatives.

Step 5. Calculation of the concordance threshold and discordance threshold values.

i. Concordance threshold value (c*) is computed with Equation (4-14),

$$c^* = \frac{1}{m(m-1)} \sum_{i=1}^{m} \sum_{j=1}^{m} c_{ij}$$

Equation (4-14)

ii. Discordance threshold value (d*) is found by using Equation (4-15),

$$d^* = \frac{1}{m(m-1)} \sum_{i=1}^{m} \sum_{j=1}^{m} d_{ij} \qquad \text{Equation (4-15)}$$

<u>Step 6.</u> Concordance dominance (E) and discordance dominance (F) matrices

Elements of concordance dominance matrix (ekl) and discordance dominance matrix (fkl) are computed by using Equations (4-16) and (4-17), respectively.

$$e_{ij} = \begin{cases} 1 \text{ if } c_{ij} \geq c^* \\ 0 \text{ if } c_{ij} < c^* \end{cases} \qquad \text{Equation (4-16)}$$

$$f_{ij} = \begin{cases} 1 \text{ if } d_{ij} < d^* \\ 0 \text{ if } d_{ij} \geq d^* \end{cases} \qquad \text{Equation (4-17)}$$

As mentioned in matrices (C) and (D), diagonals of concordance dominance (E) and discordance dominance (F) matrices are empty.

<u>Step 7.</u> Calculation of aggregate dominance matrix (G)

The elements of aggregate dominance matrix (g_{ij}) are computed by using Equation (4-18) where the diagonal of matrix (G) is empty.

$$g_{ij} = e_{ij} \cdot f_{ij} \qquad \text{Equation (4-18)}$$

Elements of aggregate dominance matrix (G) displays dominance between rows and the corresponding columns. “1” represents the dominance of row compared to the corresponding column. Accordingly, the elements of dominance set are identified with respect to (G) matrix, i.e. all elements of this set are dominant to those which are not in this set.

By identification of the dominance set, outranking is achieved. The elements (if the size of the dominance set is more than one) cannot be compared with each other. In such a case, the analyst can review the concordance and discordance threshold values

in order to reduce the number of elements of this set. However, it is still possible not to reach a set with an only element, hence a result cannot be reached.

4.4 Sensitivity Analysis

As decision-making process is achieved as a result of a series of operations, questioning the reliability of the evaluation in which the scores of the two best alternatives are close to each other is considerably usual (Elker, 2009). In this manner, sensitivity analysis is the answer to the 'What-if' questions by changing the values of a certain input (As cited in Østergård, Jensen, & Maagaard, 2016).

In modelling and analyzing decision models, sensitivity analysis has a significant role for decision makers since it enables them to have valuable insights. It is possible to achieve sensitivity analysis through thoughtful judgements, precise control of probabilities, and displaying graphs (Clemen & Reilly, 2013).

One of the simplest ways of sensitivity analysis is to change the weight of a single criterion. For more complicated decision problems, sensitivity graphical tools can be performed to display the analysis (Forman & Selly, 2003). As a more complicated pathway, Triantaphyllou & Sánchez (1997) proposes a new sensitivity analysis method through changing the score vectors of the alternative against the criteria.

Considering all, several sensitivity analysis methods are applied in literature to test the reliability of the evaluation. In this manner, although the application of MCDM methods presents the best alternative, sensitivity analysis can directly affect the result.

4.5 Decision Criteria Matrix for Temporary Housing Units

Although decision-makers are obliged to reach necessary criteria to evaluate post-disaster temporary housing units following a disaster, limited time directs them to make their decisions either with deficient criteria or with the lack of conscious of

multiple criteria which eventually results in chaos. Thus, the decision analysis pathway proposed in this study aims not only to prevent mentioned problems due to the need for prompt response but also to design a comprehensive criteria matrix to lead the decision-makers in case of a disaster. The decision criteria matrix for temporary housing units, which can also be implied as a decision tree, is generated considering contributions on criteria of temporary housing units from various sources. However, instead of displaying a design criteria matrix from a certain perspective, an extensive and holistic criteria matrix is prepared by utilizing criteria and sub-criteria in Table 4-5. As a result, Figure 4-4 is generated to display temporary housing indexes of alternatives.

The proposed criteria matrix, which is a step of strategic disaster management methodology, aims to be a basis matrix. Although such a comprehensive matrix includes each criterion, applying it for each disaster as it is may be a misapplication since each disaster has its own critical features with respect to the contextualism principle. Thus, although the generation of the basis criteria matrix of temporary housing units by making use of it as a guide for authorities in decision-making process, a detailed investigation of diverse disaster types can be carried out so that decision-makers can apply different criteria matrices for different disaster types.

Table 4-5 Criteria and Sub-Criteria for Temporary Accommodation Units

Criteria for Temporary Accommodation Units	**Sub-criteria for Temporary Accommodation Units**	**Reference(s)**
C_1. Production Cost	I_1. Cost of Structural Elements	Bashawri, Garrity, & Moodley (2014), Comerio (2004), Donohou (2012), Félix et al. (2013), Hany Abulnour (2014), IFRC/RCS (2013)
	I_2. Cost of Non-Structural Elements	
C_2. Implementation Cost	I_3. Cost of Human Power	Adopted by author
	I_4. Cost of Material/Device Power	Adopted by author
C_3. Transportation cost		Limoncu & Bayülgen (2005), Johnson (2007b)
C_4. Reusability Cost		Adopted by author
C_5. Maintenance Cost		Adopted by author
C_6. Social & Psychological Properties	I_5. Safety / Security	Donohou (2012), Bashawri et al. (2014), Félix, Monteiro, Branco, Bologna, & Feio (2015), Johnson (2007b)
	I_6. Appropriateness to Culture	(Bashawri et al., 2014) (Félix et al., 2015) (Hany Abulnour, 2014) (Johnson, 2007a)
	I_7. Availability of Participation	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (n.d.), Hany Abulnour (2014), UNDRO (1982)
C_7. Physical Properties	I_8. Adequate Area of Unit	Bektaş (2007), Félix et al. (2015)
	I_9. Packed Dimension of Unit / Ease of Transportation & Storage	Asefi & Sirus (2012), Ergünay (2011), Félix et al. (2015), Johnson (2007b)
	I_{10}. Weight of Unit	Asefi & Sirus (2012), Bashawri et al. (2014), Ergünay (2011), Félix et al. (2015)
	I_{11}. Flexibility of Units / Modularity	Asefi & Sirus (2012), Félix et al. (2015), International Organization for Migration (2012), Johnson (2007c), Zhang et al. (2014)
	I_{12}. Climate Convenience	Bashawri et al. (2014), Bektaş (2007), Donohou (2012), Johnson (2007b)
	I_{13}. Durability to Potential Disasters	Camp Coordination and Camp Management Cluster (2010), Forouzandeh, Hosseini, & Sadeghzadeh (2008), Hany Abulnour (2014)

Table 4-5 (continued)

C_8. Timing Properties	I_{14}. Mounting / Demounting Time	AGOTS (2007), Asefi & Sirus (2012), Bashawri et al. (2014), Hany Abulnour (2014)
	I_{15}. Lifespan of Unit	Bashawri et al. (2014), Donohou (2012), Johnson (2007b)
C_9. CO_2 Emission	I_{16}. CO_2 Emission of Production	Bashawri et al. (2014)
	I_{17}. CO_2 Emission of Implementation	Bashawri et al. (2014)
	I_{18}. CO_2 Emission of Transportation	Bashawri et al. (2014)
C_{10}. Standing Properties on Soil	I_{19}. Permanent Touched Area to Soil	Sener & Altun (2009)
	I_{20}. Temporary Touched Area to Soil	Sener & Altun (2009)
C_{11}. Reconfiguration of the Product / Future Use	I_{21}. Reusability	Arslan (2007), Donohou (2012), International Organization for Migration (2012), Johnson (2007c)
	I_{22}. Upgradability	Bashawri et al. (2014), Bektaş (2007), Hany Abulnour (2014), International Organization for Migration (2012)
	I_{23}. Recyclability	Arslan (2007), Bashawri et al. (2014), Donohou (2012), International Organization for Migration (2012)

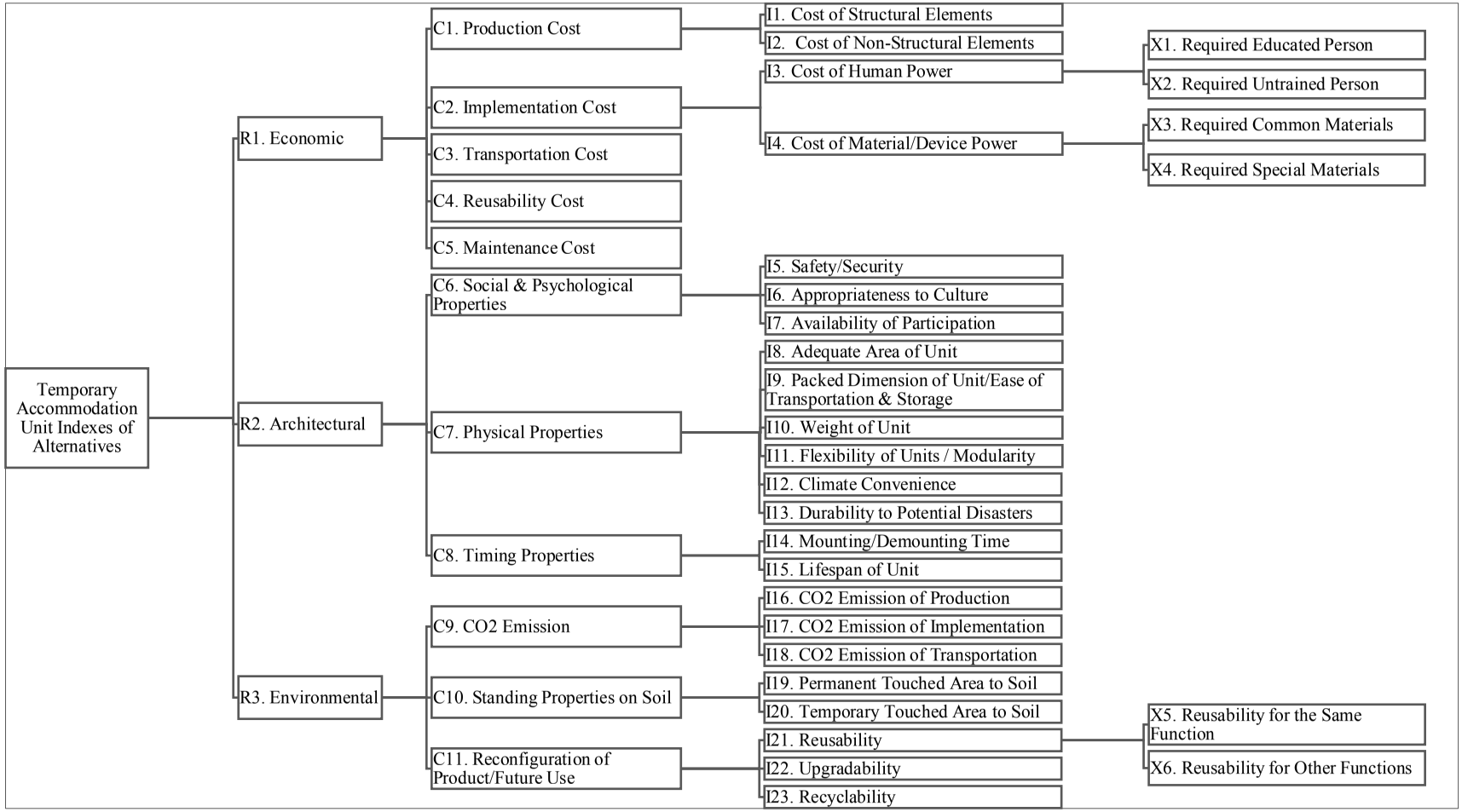

Figure 4-4 Decision Criteria Matrix of Temporary Housing Units

CHAPTER 5

SCENARIO BASED APPLICATION OF THE PROPOSED METHODOLOGY – CASE STUDIES

Three real-life case studies are selected to illustrate the applicability of proposed method for the evaluation of temporary housing units. The three selected real-life case studies, caused by different birth reasons of disasters, are listed as:

- Real Life Case Study 1 | 1999 Kocaeli Earthquake
- Real-Life Case Study 2 | Syrian Refugees in Turkey
- Real-Life Case Study 3 | Dam Failure in Banqiao China in 1975.

The following sections presents the selected evaluation criteria and alternatives to test the applicability of the proposed method on three real-life cases.

5.1 Selected Evaluation Criteria for Temporary Housing Units

Decision Criteria Matrix of Temporary Housing Units, represented in Figure 4-4, is an extensive matrix including entire possible criteria in evaluation of temporary housing units. Nevertheless, as the matrix displays, several design properties of temporary units are not declared by designers or the authorities that designers have collaborated.

Embracing criteria in decision-making, results of application of multi-criteria decision making methods are rational as if attributes/criteria are (Majumder, 2015);

- Compatible with the decision problem,
- Independent of each other,
- Displayed in same scale,
- Measurable,
- The lack of disengagement with alternatives.

Considering the available information in Figure 4-4 and principles of criteria in the application of MCDM, asserted by Majumder (2015), Figure 4-4 is adapted for the application of multi-criteria decision-making methods on several scenario-based cases. Further, certain criteria are combined to achieve independent criteria.

Consequently, taking into consideration of the extensive decision criteria matrix, 5 criteria are defined to evaluate temporary accommodation units which are (Table 5-1);

- Unit area produced with a unit cost,
- Number of units transported/stored in a unit volume,
- Living space per person,
- Normalized permanent touched area of a unit (Touched Area / Unit Floor Area),
- Number of units assembled in a unit time.

Table 5-1 Selected Criteria for Evaluation of Temporary Accommodation Units

	Selected Criteria to Evaluate Temporary Accommodation Units	**unit**
c1	Unit area produced with a unit cost	(m^2 / $)
c2	Number of units transported/stored in a unit volume	(no / m^3)
c3	Living space per person	(m^2)
c4	Normalized permanent touched area of a unit (Touched Area / Unit Floor Area)	(m^2 / m^2)
c5	Number of units assembled in a unit time	(no / h)

Although the selected five decision criteria among the temporary housing unit indexes of alternatives do not correspond to all consequences of a disaster, they contribute reasonably well to the pathway as being compatible with the decision problem.

5.2 Selected Temporary Housing Unit Alternatives

Several alternatives of temporary housing units and their properties are presented as a part of the study in Chapter 3. However, although mentioned alternatives are existing in literature, Majumder (2015) asserts that selected alternatives must perform several principles to be applied in application of multi-criteria decision making methods. According to Majumder (2015), selected alternatives must be available to be;

- Procurable,
- Comparable,
- Concrete not ideal,
- Practical.

Due to the available information that can be reached during literature survey and statements of Majumder (2015), 4 temporary housing alternatives have been selected to illustrate the proposed methodology of this dissertation. Table 5-2 summarizes the selected temporary housing units and corresponding features. As a result, Table 5-3 displays the selected criteria and alternatives in a hierarchy.

Table 5-2 Selected temporary housing alternatives with corresponding features

Properties	Better Shelter | version 1.2	DAKO	HHI | LTD	Über Shelter
Number of Occupants	5	4	11	3
Floor Area	17.5 m^2	18.2 m^2	16.54 m^2	23 m2
Minimum Ceiling Height	1.8 m	2.54 m	3.04 m	2.13 m
Mounting/Demounting Time	5-6 hours	0.33 hour	Less than 24 hours	
Packed Dimension of Unit	1.99 m x 1.09 m x 0.52 m	7.00 m x 2.60 m x 0.30 m	1 standardized shipping container	1.22 m x 2.44 m x 0.61 m
Weight of Unit	161 kg – total weight		544.31 kg	544 kg
Lifespan of Unit	3 years with basic maintenance			
Footing on Site			Telescoping stilts designed to be levelled on grades up to 10%.	Telescoping stilts
Touched Area to Soil	- If on soil - 17.5 m^2	18.2 m^2	1.56 m2 (area of each leg is estimated as 0.25 m x 0.25 m regarding to photographs)	0.32 m2 (area of a leg is estimated as 0.2 m x 0.2 m regarding to drawings)
Production Cost	1150 €	3950 TL	2500 $	1000 $ - 3000$ labor included
Required Untrained Person and Educated Person for Implementation	0 educated person 4 educated people	0 educated person 1 educated person		4 untrained people 0 educated person

Table 5-2 (continued)

Required Materials for Implementation	Hammer, drive steel for ground anchors, drive steel for ground pipe puncher (all included in pack)	1 crane and 1 forklift	Saws, hammers or wrenches	A wrench, a ratchet and a screwdriver
Shelf Life	Minimum 5 years under dry, clean and ventilated conditions.			
Transportability /Ways of Transportation	-17 shelters in Container 20 feet -48 shelters in Container 40 feet HC -36 shelters in Container 40 feet DC	- 10 shelters in 1 lorry	- 1 shelter in 1 shipping container	Through air, sea or land regarding to flat shipping
Modularity	Yes	No	No	Yes
Adaptability	Yes	No	Yes	Yes
Climate Convenience / Temperature Range	Appropriate for between 5° – 40° C		Appropriate for equatorial and sub-tropical regions. Materials will not breakdown in 90%+ humidity or temperatures of 100 degrees Fahrenheit (37.7 °	
Wind Resistance	Appropriate for ≤ 64.8 km/h or 18 m/s. Increases with additional		The house will withstand winds of 80 miles per hour	

Table 5-3 Selected Criteria and Alternatives for Scenario Based Applications

Evaluation Criteria	**Better Shelter | version 1.2**	**DAKO**	**HHI | LTD**	**Über Shelter**	**Choice of Direction**
Unit area produced with a unit cost 1150 € = 1437.5 $ and 3950 TL = 987.5 $	17.5 m^2 / 1437.5 $ * *	18.2 m^2 / 987.5 $ **	16.54 m^2 / 2500 $	23 m^2 / 3000 $	**Increasing**
Number of units transported/ stored in a unit volume	1 / 1.127932 m^3	1 / 5.46 m^3	1 / 38.44464 m^3	1 / 1.815848 m^3	**Increasing**
Living space per person	17.5 m^2 / 5	18.2 m^2 / 4	16.64 m^2 / 11	23 m^2 / 3	**Increasing**
Normalized permanent touched area of a unit **(Touched Area / Unit Floor Area)**	17.5 m^2 / 17.5 m^2	18.2 m^2 / 18.2 m^2	1.56 m^2 / 16.54 m^2	23 m^2 / 0.32 m^2	**Increasing**
Number of units assembled in a unit time	24 hours / 6 hours	24 hours / 0.33 hours	24 hours / 24 hours	24 hours / 2 hours ***	**Increasing**

(**) fixed exchange rate system is applied as 1 € = 5 TL, 1 $ = 4 TL and 1 $ = 0,8 €

(***) (c5) value of Über Shelter is assigned as 2 hours by the author

5.3 Real-Life Case Studies

5.3.1 Real-Life Case Study I | 1999 Kocaeli Earthquake

At midnight time on 17 August 1999, an earthquake with magnitude of M_w 7.4 struck Kocaeli and Gölcük, densely populated areas in Northwestern Turkey. More than 18.000 people died, about 23.000 buildings have been reported as heavily damaged or collapsed (Figure 5-1-left). Consequently, almost 120.000 families were confronted with the loss of housing problem due to the devastating earthquake (Erdik, Demircioglu, Sesetyan, Durukal, & Siyahi, 2004).

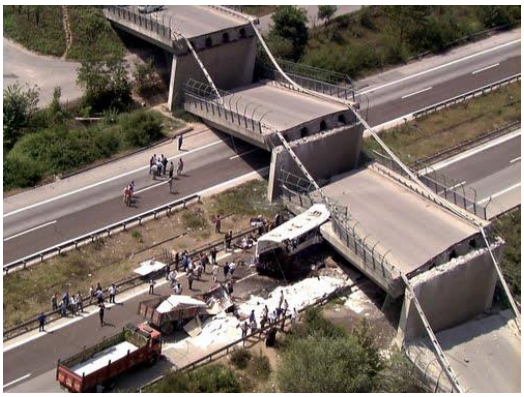

Figure 5-1 left) Demolished Apartment Houses (Yapı, 2012), right) Demolished Bridge in 1999 Kocaeli Earthquake (Aydan, Ulusay, Kumsar, & Tuncay, 2000)

As results of earthquake are considerably widespread and extensive, a disaster management plan has been applied. By taking into consideration of 120.000 families, who expeditiously need sheltering, providing temporary housing units for affected community is also included in disaster management.

The first case study is structured on the case of Kocaeli Earthquake in Turkey focusing on the urgent need for excessive number of temporary housing units and restricted access to sources due to the collapse of infrastructures such as highways etc. (i.e., overpass on Trans European Motorway which is the primary highway connecting Northeastern of country to the capital city, as shown in Figure 5-1-right). Accordingly,

the ease of transportation and assembly, recognized by the mounting time (c5) and packed dimension (c2) are taken as primary (governing) criteria on evaluation of units.

Taking into consideration of the worth-stressing criteria of temporary housing evaluation for 1999 Kocaeli Earthquake, it is possible to sort criteria as:

Sorting (1): c5 > c2 > c1 > c3 > c4

Taking into consideration of Sorting (1), Weighting Vector (W) of criteria are recovered with the application of equations (4-3) and (4-4) of AHP method, represented in Table 5-4.

Table 5-4 Weighting Vector of Selected Evaluation Criteria Reached with AHP for 1999 Kocaeli Earthquake

Selected Evaluation Criteria		**Weighting Vector**
c1	Unit area produced with a unit cost	0.10
c2	Number of units transported/stored in a unit volume	0.33
c3	Living space per person	0.07
c4	Normalized permanent touched area of a unit	0.04
c5	Number of units assembled in a unit time	0.46
	Sum of the elements of matrix (W)	**1.00**

In the application of ELECTRE I, Table 5-4. which is displaying the Weighting Vector (W) of criteria as a result of the application of AHP method, is taken as a base since ELECTRE I method are not constituted to reach Weighting Vector (W). Table 5-5 represents matrices of Concordance Dominance (E) and Discordance Dominance (F) which are designated with respect to equations of (4-15) and (4-16). Embracing the dominance, matrix of Aggregate Dominance (G) is computed with the equation (4-17), as shown in Table 5-6. As a result, matrix of Aggregate Dominance (G) displays the comparison equations: A1 > A3, A2 > A3, A4 > A3 and A4 > A1. As a result, although all of the elements are dominating an alternative A3, no alternative is superior to any of elements of this set of alternatives in the application of ELECTRE I for 1999 Kocaeli Earthquake.

Table 5-5 Concordance Dominance (E) and Discordance Dominance (F) Matrices Estimated with ELECTRE I for 1999 Kocaeli Earthquake

E	A1	A2	A3	A4
A1		0	1	0
A2	1		1	1
A3	0	0		0
A4	1	0	1	

F	A1	A2	A3	A4
A1		0	1	0
A2	0		1	0
A3	0	0		0
A4	1	0	1	

Table 5-6 Matrix of Aggregate Dominance (G) Estimated with ELECTRE I for 1999 Kocaeli Earthquake

G	A1	A2	A3	A4
A1		0	1	0
A2	0		1	0
A3	0	0		0
A4	1	0	1	

Carrying out the AHP, Score Vector (SV) of alternatives are estimated with equation (4-8), displayed in Table 5-7.

Table 5-7 Score Vector (SV) of Temporary Accommodation Alternatives Estimated with AHP for 1999 Kocaeli Earthquake

Selected Evaluation Criteria		**Score Vector (SV)**
A1	Better Shelter | version 1.2	0.28
A2	DAKO	0.35
A3	HHI | LTD	0.06
A4	Über Shelter	0.31

‘DAKO’, which is A3, has been selected as the best available option as a result of the application of the proposed method for 1999 Kocaeli Earthquake as a real-case study example.

5.3.2 Real-Life Case Study II | Syrian Refugees in Turkey

As mass migration is a complex phenomenon posing numerous problems such as economic, social, environmental and political, it is possible to define accommodation problem as the most important one among confronted problems due to number of affected people.

As a second case study, which is an example of mass migration, after the catastrophic conflict in Syria in October 2011, approximately 3 million refugees, 60% of the total refugees, have registered to Turkey as shown in Figure 5-2-left. As a result, Turkish government decided to welcome the refugees with an open-door policy providing "temporary protection" (UNHCR, 2017). Up to May 2014, 22 camps located near to the Syrian border have been hosting approximately 220.000 refugees whereas 515.000 Syrian citizens have been registered as urban refugees. Although Turkish government is occasionally criticized about supplying protection and humanitarian assistance to refugees in camps, the complicated situation of urban refugees is clearly monitored from the situations in various cities (Kirişci, 2014).

Changing the point of view, mass migration is not only a challenging situation for refugees but also for host country or countries with respect to the economic, social and environmental reasons (UNHCR, 2017). Taking into consideration of accommodation problem of vast number of refugees, 3 million people, mass migration occupies a prominent investment position for host countries due to configuration of temporary accommodation units and their maintenance.

Approaching the mass migration problem in Turkey, following Syrian conflict, from an economic perspective, substantial amount of money is needed to maintain the daily life of refugees, notably the ones in camps. However, only the 34% of the total funding requirements have been received by Turkish government, resulted with $589,666,616 gap in the budget, as represented in Table 5-8. Consequently, these results lay stress on money in such a mass migration case. In this manner, as Hany Abulnour (2014) states, the cost of the temporary housing units should be seriously considered to maintain their conditions as the cost and the overall quality of the unit is proportional.

Table 5-8 Funding Requirements of Syrian Refugees in Turkey (UNHCR, 2017)

	Funding Requirements of Syrian Refugees in Turkey
Total Appeal	$890.172.034
Received to Date	$300.505.418
Gap	$589.666.616
Coverage	34,00%
Last Updated	2017-09-08

On the other hand, besides crux social problems as an outcome of mass migration, environmental consequences due to the huge demand on temporary units are confronted, hence extensive infrastructure. As seen in Figure 5-2-right, a large area has been razed to constitute campsites for Syrian refugees inside a totally natural and unurbanized fertile lands resulting with the interruption of ecosystem. Due to the temporary use of areas, though roughly 7 years passed after the conflict, a remarkable amount of area cannot be used, indeed, the razed area will remain as unfunctional. Yet, to avoid the destruction, diverse design techniques would be applicable such as temporary housing units on footings, as a design criterion, resulted in minimum required permanent area on ground.

Figure 5-2 left) Syrian Refugees in Turkey border (As cited in Salmorbekova, Almustafa, Rizvi, Seibold, & Plotkin, 2016), right) Syrian Refugee Camps in Turkey ("One of the Refugees Camp in Turkey", 2016)

Thus, the second case study is constructed onto Syrian Refugees in Turkey, which is one of the biggest problems of recent years, embracing the problem with the mentioned economic and environmental constraints, which is multi-directional. Accordingly, cost (c1) and permanent touch to ground (c4) have been relatively prioritized as represented in Sorting (2). With this comprehensive approach, the evaluation of temporary housing units is achieved considering both short-term necessities and long-term requirements which is interpreted as a vital principle for decision-making in post-disaster environments.

Sorting (2): c1 > c4> c5 > c2 > c3

With respect to the Sorting (2), generated for Syrian refugees in Turkey, equations of (4-3) ad (4-4) of AHP method is implemented to reach Weighting Vector (W) of each criterion. Table 5-9 represents the Weighting Vector (W) of each criterion for the second case, Syrian Refugees in Turkey.

Table 5-9 Weighting Vector of Selected Evaluation Criteria Reached with AHP for Syrian Refugees in Turkey

Selected Evaluation Criteria		Weighting Vector
c1	Unit area produced with a unit cost	0.42
c2	Number of units transported/stored in a unit volume	0.10
c3	Living space per person	0.06
c4	Normalized permanent touched area of a unit	0.26
c5	Number of units assembled in a unit time	0.16
Sum of the elements of matrix (W)		**1.00**

As ELECTRE I does not embrace the estimation of Weighting Vector (W) of criteria, Table 5-9 is put into process in the application of evaluation of temporary housing units through ELECTRE I. As a result, matrices of Concordance Dominance (E) and Discordance Dominance (F) are generated as shown in Table 5-10. Finally, Aggregate Dominance (G) is acquired in Table 5-11 displays the result of the application of ELECTRE I for Syrian Refugees in Turkey. According to the elements of matrix of Aggregate Dominance (G), the following equations are achieved as: A1 > A3, A2 > A3 and A4 > A3. Consequently, it is estimated that none of the alternatives are superior to other alternatives regarding to the results of ELECTRE I for Syrian Refugees in Turkey.

Table 5-10 Concordance Dominance (E) and Discordance Dominance (F) Matrices Estimated with ELECTRE I for Syrian Refugees in Turkey

E	A1	A2	A3	A4
A1		0	1	1
A2	1		1	1
A3	0	0		0
A4	0	0	1	

F	A1	A2	A3	A4
A1		0	1	0
A2	0		1	0
A3	0	0		0
A4	1	0	1	

Table 5-11 Matrix of Aggregate Dominance (G) Estimated with ELECTRE I for Syrian Refugees in Turkey

G	A1	A2	A3	A4
A1		0	1	0
A2	0		1	0
A3	0	0		0
A4	0	0	1	

Following equations of AHP Method, Score Vector (SV) of alternatives, as represented in Table 5-12, are achieved regarding to the Weighting Vectors (W) and values of alternatives for each criterion. Table 5-12 demonstrates the result of AHP method for the evaluation of temporary housing units for Syrian Refugees in Turkey.

Table 5-12 Score Vector (SV) of Temporary Accommodation Alternatives Estimated with AHP for Syrian Refugees in Turkey

Selected Evaluation Criteria		**Score Vector (SV)**
A1	Better Shelter | version 1.2	0.22
A2	DAKO	0.34
A3	HHI | LTD	0.08
A4	Über Shelter	0.36

Following the proposed method, the dominance set and SVs of AHP yield 4th alternative, Über Shelter, as the best available option for the given evaluation criteria and post-disaster conditions.

5.3.3 Real-Life Case Study III | Dam Failure in Banqiao China in 1975

In early 1950s, the construction of the Banqiao Dam on Ru River, in China, was finalized to control of floods in Huai River basin (Xu & Zhang, 2009). Despite a few

seismic retrofitting actions, the dam, located in Henan Province, has been operating until an unpredicted typhoon had struck the Henan Province. In August 1975, one of the most catastrophic dam failures of world history has happened due to that typhoon in central China. Consequently, Chinese community has faced with a detrimental disaster due to the swell of the Banqiao Dam and dozens of smaller dams (Figure 5-3-left) (Si, 1998).

Following this occasional situation, 85,000 people have lost their lives (Si, 1998) and 10 million of people have lost their homes and livelihood activities (Hu and Luo 1992). Subsequently, a million hectares of farmland, including 29 counties and municipalities, have been exposed to the damage of flood (Figure 5-3-right). Indeed, the Jingguang Railway, which is the most commonly used way of transportation from Beijing, the capital city of China, to Guangzhou, was out of use for 18 days (Liu, Pang, & Xie, 2009). Besides, according to statements of U.S. Department of the Interior Bureau of Reclamation (2014), nine days after the occurrence of disaster, over a million people have still been waiting for help on watery rubbles so air transportation has been applied to deliver aid. Consequently, famine and disease have appeared due to flood and limited transportation, resulted with loss of lives of almost 100,000 people (Hu and Luo 1992).

Figure 5-3 left) Collapse of Banqiao Dam (Fish, 2013), right) Flood After Collapse of Banqiao Dam (Crouch, 2015)

Due to the destructiveness of the drastic flood, a huge area including accommodation units, cultivated areas and industrial places have become unusable, not only dams. Therefore, government has faced with economic problems besides excessive loss of lives and livelihood systems. In addition, as the necessity of serving temporary units for excessive number of disaster affected people, cost of temporary units has been come into prominence. On the other hand, as air transportation have been applied due to the limited transportation caused by flood, packed dimension of units has been aimed to minimize to serve temporary housing units more in number.

As a consequence, the last case study is raised on the case of Dam Failure in Banqiao China in 1975. Centering upon the economic restrictions and need for small packed dimension (c2) due to limited transportation and immediate need of excessive number of housing units, Sorting (3) is achieved for Dam Failure in Banqiao China in 1975 as:

Sorting (3): c1 > c2 > c4 > c5 > c3

Referring to the Sorting (3) for the Case Study 3, Weighting Vector (W) of criteria are estimated with the application of AHP method. Hence, Table 5-13 represents the Weighting Vector (W) of criteria.

Table 5-13 Weighting Vector of Selected Evaluation Criteria Reached with AHP for Dam Failure in Banqiao China in 1975

Selected Evaluation Criteria		**Weighting Vector**
c1	Unit area produced with a unit cost	0.40
c2	Number of units transported/stored in a unit volume	0.31
c3	Living space per person	0.08
c4	Normalized permanent touched area of a unit	0.14
c5	Number of units assembled in a unit time	0.07
	Sum of the elements of matrix (W)	**1.00**

Taking into consideration of results of Table 5-13, representing Weighting Vector (W) of criteria, ELECTRE I is implemented for Dam Failure in Banqiao China in 1975. As a result of the equations of (4-15) and (4-16) of ELECTRE I, Concordance Dominance

(E) and Discordance Dominance (F) are achieved (Table 5-14). Reaching the rational alternative among candidate alternatives, matrix of Aggregate Dominance (G) is estimated by applying equation (4-17). As a result, the dominance set given in Table 5-15, for Dam Failure in Banqiao China in 1975, has found none of the 4 alternatives as the most rational temporary housing unit, with respect to the acquired equations as; A1 > A3, A2 > A3 and A4 > A3.

Table 5-14 Concordance Dominance (E) and Discordance Dominance (F) Matrices Estimated with ELECTRE I for Dam Failure in Banqiao China in 1975

E	**A1**	**A2**	**A3**	**A4**
A1		0	1	1
A2	1		1	0
A3	0	0		0
A4	0	1	1	

F	**A1**	**A2**	**A3**	**A4**
A1		0	1	0
A2	0		1	0
A3	0	0		0
A4	1	0	1	

Table 5-15 Matrix of Aggregate Dominance (G) Estimated with ELECTRE I for Dam Failure in Banqiao China in 1975

G	**A1**	**A2**	**A3**	**A4**
A1		0	1	0
A2	0		1	0
A3	0	0		0
A4	0	0	1	

With respect to the Weighting Vector (W), equation (4-8) is applied to reach Score Vector (SV) of alternatives. The dominance set and the Score Vector (SV) shown in

Table 5-16 yield Better Shelter as the appropriate temporary housing unit for the last case study, reached with the proposed evaluation method.

Table 5-16 Score Vector (SV) of Temporary Accommodation Alternatives Estimated with AHP for Dam Failure in Banqiao China in 1975

Selected Evaluation Criteria		**Score Vector (SV)**
A1	Better Shelter | version 1.2	0.33
A2	DAKO	0.28
A3	HHI | LTD	0.08
A4	Über Shelter	0.31

5.4 Comparison of Scenario Based Applications of the Proposed Methodology

Considering the three diverse post-disaster situations considering associated features, weighting of criteria is varied from case to case. Table 5-17 monitors the comparison of the two applied MCDM methods, which are AHP and ELECTRE I.

Table 5-17 Comparison Table of Results of Proposed Methodology for 3 different Real-Life Case Study

Real-Life Case Study		**AHP**	**ELECTRE I**	**Final Result**
CS I	1999 Kocaeli Earthquake	DAKO	DAKO is in Dominance Set	DAKO
CS II	Syrian Refugees in Turkey	Über Shelter	Über Shelter is in Dominance Set	Über Shelter
CS III	Dam Failure in Banqiao China in 1975	Better Shelter	Better Shelter is in Dominance Set	Better Shelter

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 Summary

This dissertation has been structured on the evaluation of temporary housing units with MCDM methods. Consequently, the potential of MCDM has been investigated to cope with the uncertainty of input variables of post-disaster environment focusing on temporary housing evaluation.

Considering various experiences in history discussed in this study, disasters are one of the issues threatening the maintenance of lives of disaster affected victims and livelihood systems. Further, results of disasters can be sometimes even more hazardous hence 'preparedness period' in disaster management should be well-emphasized to minimize direct and indirect losses.

Among several detrimental results of disasters, it is possible to assert loss of housing as one of the compelling problems raised due to not only the destruction of built environment but also with one of its' results: urgent necessity need of housing for affected community. There are many studies in literature to display the critical role of temporary housing units, bridging the gap between the emergency and the reconstruction phase by providing physical and psychological motivation. Nevertheless, usually lack of structured decision-making process yield top-down decision-making approaches resulted in numerous problems.

Firstly, a decision criteria matrix, a generalized extensive matrix which is appropriate to be adapted regarding to critical features of diverse disasters, is generated due to the lack of information in literature on the design criteria of temporary housing units. In

addition, available temporary housing alternatives previously proposed by commercial and academic purposes have been assembled to provide an extensive temporary housing database.

Considering the difficulty of decision-making in emergency situations, decision-making process of temporary housing units is shown to have a great importance with respect to experienced problems. By embracing problems, guidelines and criteria conducted in literature, the necessity of a new pathway for the evaluation of temporary housing units is shown up. Consequently, a new methodology is proposed to minimize the consequences of uncertainties and limited time of post-disaster conditions.

As the determination of the best MCDM method among several alternatives is mentioned as a paradox in literature, comparison of MCDM methods are applied to determine on the most appropriate method for the evaluation of temporary housing units. As a result, AHP, a choosing method, has been determined due to its properties scalability and ease of adjustment in size. In addition, ELECTRE I, which is a outranking method, is selected considering its advantage on uncertainty and vagueness which is appropriate for post-disaster environment.

In order to investigate the applicability of the proposed methodology for the evaluation of temporary housing units, the structured pathway is conducted on three real-life case studies. Taking into consideration of critical features of disasters, weights of criteria are determined with the AHP method. Following the proposed phases of framework, through the application of the appropriate MCDM model, which are confirmed as AHP and ELECTRE I, the most rational alternative of temporary housing unit for each real-life case study has been reached.

6.2 Conclusions

The main objective of this dissertation is to evaluate the potential of MCDM methods for temporary housing selection by proposing a new MCDM-based method. The use of the proposed methodology on case-studies based on real-life experiences, by

carrying out a pathway through AHP and ELECTRE I methods, showed the practicality of this new framework. Considering the provided features as transparency and reliability of MCDM methods, the MCDM methods can be benefitted and used in the evaluation of temporary housing units in a feasible way. To conclude:

- Considering the birth reasons and the results of disasters, each disaster and its critical features affecting communities and authorities differ from each other. Accordingly, disaster management pathways should be designed considering the contextualism principle.

- Instead of applying top-down approaches resulted with standardized units in limited time of post-disaster environment, a predetermined decision-making process, MCDM, is proposed for the evaluation of temporary housing units in 'preparedness period' phase of disaster management.

- The lack of contribution on design criteria of temporary housing units pushes decision-makers to make their decisions with inadequate or biased information. Consequently, a generalized decision criteria matrix for temporary housing units is proposed to provide a basis for future applications of MCDM.

- This hybrid MCDM method in the evaluation of temporary housing units is proposed as a feasible and efficient method not only for the authorities and disaster management organizations but also for designers and architects leading their design by considering multi-criteria approaches.

- As each MCDM method follows a diverse path for decision-making process, their results can assign different alternatives as the appropriate one. The use of the proposed hybrid methodology also enables decision-makers to implicitly verify the final results.

- The use of MCDM methods in the evaluation of architectural objects can be considered as a rational approach in design process due to its applicability including both qualitative and quantitative data.

6.3 Limitations of the Study

This research has a number of limitations on the applicability of the proposed methodology. Firstly, although several alternatives of temporary housing units are mentioned as a part of the study, it is not possible to reach entire properties of temporary housing alternatives, that may be resulted with the exclusion of the best alternative. Secondly, the evaluation of the proposed framework includes newly generated unit alternatives, however the use of a previously-generated units has not been pursued in the evaluation as an alternative. Lastly, the applicability of the selected models, which are AHP and ELECTRE I, have been performed in the evaluation of temporary housing units, and other MCDM methods have not been applied.

Elaborating on the selected MCDM methods, as outranking methods can present a dominance set instead of a choice, it is possible to confront with alternatives being unable to defeat each other as a result of the application of ELECTRE I. In case of a such situation, embracing the decision problem by choosing, ranking or classifying methods are also recommended.

6.4 Recommendations for Further Research

The main outcome of this investigation is that MCDM can be assigned as a decision-making process for the evaluation of temporary housing units following disasters. Based on the scenario-based application of the proposed methodology on real-life case studies, alternative MCDM methods can be applied to compare and further verify the results. In a post-disaster situation needed to evaluate a large number of calculations, decision support systems can be an answer to deal with the complication of the decision problem.

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