International Journal of Architectural, Civil and Construction Sciences
ISSN: 2415-1734
Vol:10, No:10, 2016

Identifying Temporary Housing Main Vertexes through Assessing Post-Disaster Recovery Programs

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***Abstract*—**In the aftermath of a natural disaster, the major challenge most cities and societies face, regardless of their diverse level of prosperity, is to provide temporary housing (TH) for the displaced population (DP). However, the features of TH, which have been applied in previous recovery programs, greatly varied from case to case. This situation demonstrates that providing temporary accommodation for DP in a short period time and usually in great numbers is complicated in terms of satisfying all the beneficiaries' needs, regardless of the societies' welfare levels. Furthermore, when previously used strategies are applied to different areas, the chosen strategies are most likely destined to fail, unless the strategies are context and culturally based. Therefore, as the population of disaster-prone cities are increasing, decision-makers need a platform to help to determine all the factors, which caused the outcomes of the prior programs. To this end, this paper aims to assess the problems, requirements, limitations, potential responses, chosen strategies, and their outcomes, in order to determine the main elements that have influenced the TH process. In this regard, and in order to determine a customizable strategy, this study analyses the TH programs of five different cases as: Marmara earthquake, 1999; Bam earthquake, 2003; Aceh earthquake and tsunami, 2004; Hurricane Katrina, 2005; and, L'Aquila earthquake, 2009. The research results demonstrate that the main vertexes of TH are: (1) local characteristics, including local potential and affected population features, (2) TH properties, which needs to be considered in four phases: planning, provision/construction, operation, and second life, and (3) natural hazards impacts, which embraces intensity and type. Accordingly, this study offers decision-makers the opportunity to discover the main vertexes, their subsets, interactions, and the relation between strategies and outcomes based on the local conditions of each case. Consequently, authorities may acquire the capability to design a customizable method in the face of complicated post-disaster housing in the wake of future natural disasters.

***Keywords*—**Post-disaster temporary accommodation, urban resilience, natural disaster, local characteristic.

I. Introduction

TH, which is applied to provide secure and safe conditions as pre-disaster ones [1], [2], is a considerably criticized issue in terms of stakeholders' satisfaction. In general, according to [3]-[11], the problems of TH can be categorized into: economic, social, and environmental aspects. The unsuitable outcomes of most previous recovery programs, which have been considered by the mentioned researchers, are due to: (1) long delivery time, (2) cultural contradictions, (3) large public expenditures, (4) consumption of investment and resources assigned to permanent buildings, (5) delay on permanent building delivery, (6) inappropriate second life, (7) environmental pollution, (9) change of strategy several times, and (10) top-down approaches [3]-[11]. During the permanent housing construction processes, DPs need to have access to safe accommodation despite the mentioned problems of TH provision. The authorities could officially provide these TH, as most previous recovery programs do, such as homes of relatives, rental accommodation, temporary housing unit (THU), shipping container, etc. Moreover, temporary shelter like tents can be used for the TH phase to link the emergency shelter phase to the permanent housing phase directly. An example of it was the recovery program in the wake of the Lorestan earthquake in Iran, 2006 [7]. Otherwise, the DP are forced to provide unofficial self-built TH for protection against adverse climate conditions and other risks as was the case of, the Colombian recovery program after the Armenia earthquake, 1999 [12].

The importance of the suitability of TH strategies has increased due to the expected increasing in the urban population in the coming years, as well as an increase of the population living in areas with a natural hazard risk. Additionally, as diverse areas with different prosperity and living standards need individual strategies [13], [14], consequently, a response to different naturally affected-areas requires applying a particular approach [15]. Meanwhile, although suitable researches have been conducted to consider post-disaster recovery programs, there are few or no studies that offer a customizable model (platform) to deal with this issue. Additionally, a huge number of factors influence with antithetical impacts on each case, making it a complicated challenge for decision-makers. Therefore, in order to solve this paradox, currently decision-makers need to use the experiences of previous cases of natural disaster-prone areas. However, an individual response is required for each case in order to determine the particular factors involved in a previous case, which can lead to the special outcomes based on a chosen strategy. Indeed, the connection between a chosen strategy and its outcomes, is a missing link of this process, and needs to be determined to achieve a customizable model. Thus, this paper aims to consider the following five case studies: Marmara earthquake, 1999; Bam earthquake, 2003; Aceh earthquake and tsunami, 2004; Katrina Hurricane, 2005; and, L'Aquila earthquake, 2009. These cases, which are

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representative of different prosperities, are assessed in terms of the chosen strategies, outcomes, and the links between these two. In general, this study responds to the following questions:

1. How are the specific outcomes obtained by applying the chosen strategy(s) for each considered case?
2. What would happen if another strategy(s) was applied to the assessed cases?
3. Which are the general (main/universal) vertexes of TH which yields different results?

II. Methodology

This study is conducted based on the primary and secondary sources of the five case studies. The information of each case is organized into three sections: input, processing, and outcomes, as shown in Fig. 1. The *Input* section embraces (1) disaster, which includes hazard types and intensity, range of damages and casualties, and social resiliency; (2) population takes into account the affected and non-affected people of the area, which faces a natural disaster; and, (3) strategy, which is chosen for dealing with a natural disaster by decision-makers.

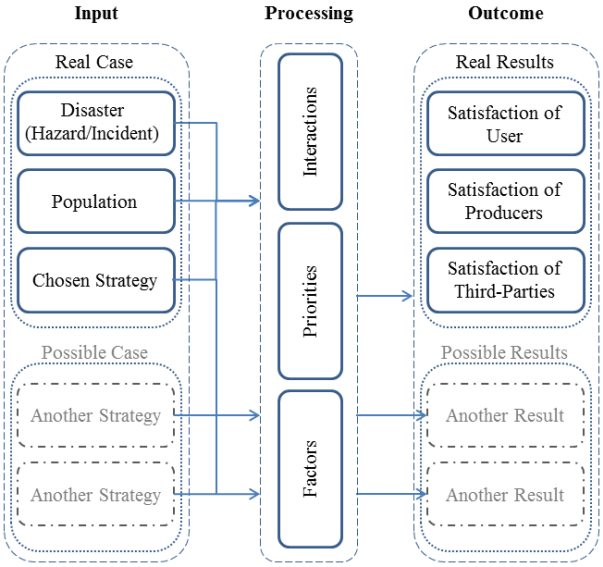

Fig. 1 Methodology for considering the PDA process including input, processing, and outcome

The *Processing* section is the main object of this paper and includes the elements that lead to the final results. These elements are: factors, priority of each factor, and interconnections. The *Outcome* section, takes into account the satisfaction range of people, who are involved in this process in some way. This study organizes these people in three groups: users, producers, and third-party. Users need assistance and a place for residing due to the natural disaster. Producers are involved in providing suitable accommodations and conditions for the affected population to return to the pre-disaster conditions, such as authorities, investors, engineers, workers, etc. Third-party are all the other people that are involved in post-disaster recovery programs (except the first and second groups). For instance, NGOs for supportive environment, host of DP and neighbours are categorized in the third-party group.

In general, this study aims to realize the elements of the *Processing* section for the five case studies. This has the purpose to discover potential results by applying another alternative strategy for the same case or using the same strategy for another case, as shown in Fig. 1. This is accomplished by analysing the five cases and deriving influential factors. Consequently, the factors are arranged into explicit vertexes for the simplification of this decision-making process.

III. TH Approach

According to [12], [16], post-disaster housing phases generally have the following four stages: (1) emergency shelter (within hours), (2) temporary shelter (within days), (3) TH (within weeks), and (4) permanent (within years) [12], [16]. In the first stage, emergency shelter, the DPs reside in a public building, which is named *collective centre* by [17]. In the next stage, temporary shelter, which embraces the period time from the initial days after the natural disaster until the next few weeks (e.g. tents or plastic sheets are erected by Red Cross/Red Crescent and the army [12], [14]). In general, third-parties such as the authorities, international organizations, NGOs, and so on are in charge of providing the basic needs of life consisting of immediate shelter, food, water, etc. in these two stages.

All types of accommodations that are applied after the two aforementioned stages until moving the DPs to the permanent housing called TH. The TH phase, which assists the DP to return to the activities of regular life [1], [14], normally starts a few weeks' post-disaster and finishes in a couple of few years. In this third stage, DPs live in temporary accommodations, such as hotels, rental accommodations, THUs, mobile homes, containers, etc. Finally, the last stage is permanent housing, when the DP move from the TH to permanent housing with a higher life quality and more initial responsibilities compared to the last phases.

Post-disaster recovery programs in terms of TH provision also can be organized into (1) *separate (individual) stages* and (2) *joint stages*. In the first approach, a particular accommodation is applied for each recovery phase including the emergency, temporary, and permanent housing phases. However, the next housing phase or complete unit can use some material from the previous housing phase. In the second approach, joint stages, an accommodation that has been applied for the initial recovery phases with or without modification can be used for other next phases. These accommodations have been part of a unique additive process.

IV. Case Study

This paper considers the five different case studies with various level of development, which experienced diverse natural hazards and recovery programs. Although, the separate stages approach has almost always been applied for the

studied cases, the second one, joint stages approach, was also used somehow for these five programs with different accommodation types and delivery times, as shown in Table I. The Indonesia´s recovery program also applied the joint stages approach partially in addition to the separate stages. Additionally, the decision-makers of L'Aquila, Italy, desired to conceal the TH phase like the joint stages approach and consequently, the DPs stayed in winterized tents until completion of the THUs, which were high quality constructed as permanent housing. Therefore, those winterized tents played the role of temporary shelter and housing for the L'Aquila case.

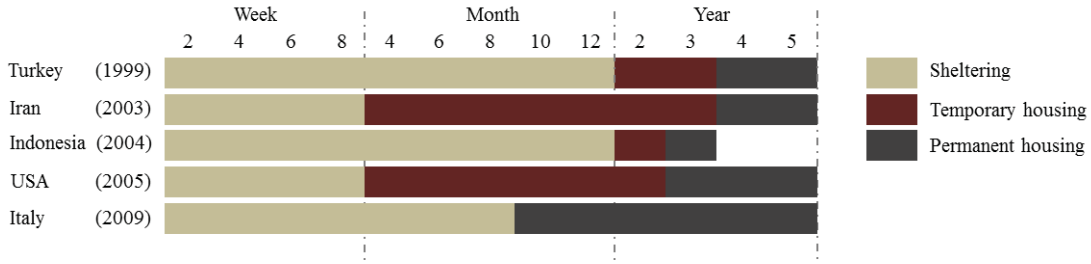

Fig. 2 The five case studies´ timelines for post-disaster accommodation

The five cases have been chosen because of their variety in the levels of prosperity, natural hazards, pre-disaster housing technology, and local characteristics, as shown in Table I. Moreover, these cases responded to the natural disasters in different ways and can be classified in the huge catastrophe group of the last decades. Additionally, almost all types of TH have been used in these cases. As shown in Table I and Fig. 2, the different local conditions and recovery programs of the five cases yielded diverse results in terms of timing. The general process time of each phase has been considered, meanwhile, the timing of some examples could be different. For instance, according to [18], there was a specific case in which the owner was living about eight years after the disaster in Bam TH until 2011. In this regard, the Turkish government enforced the users of THUs, tenants and new migrants, to leave by cutting off the services THUs of the Turkey housing program in 2005, while the earthquake happened in 1999 [19].

Finally, this study analyses each case by considering the individual conditions in order to determine the main vertexes of the recovery program. To this end, input, processing, and outcome phases are considered for each case in Figs. 3-7 based on the methodology of this study, which has been presented in Fig. 1. The common experiences of outcomes for almost all cases in the face of post-disaster housing are: (1) late delivery time, (2) cultural issues, (3) lack of coordination, (4) consume public expenditures, and (5) shortfalls in responding to tenants' requirements.

TABLE I
THE SIX CASE STUDIES´ INFORMATION

Case study	Natural hazard		Local potential						Affected population				References
			Building	Prosperity (2011)		Climate condition					DP		
	Type	Intensity	TECH (Pre-disaster)	GDP per capita ($)	HDI	MIN TEMP (C)	MAX TEMP (C)	Rainfall (mm)	Population	Death	(Nº)	(%)	
Turkey, 1999	Earthquake	Mw=7.4 and Mw=7.2	Reinforced concrete	13668	0.699	3.6	26	665.7	2300000	18373	300000+	13	[19]-[23]
Iran, 2003	Earthquake	Ms=6.5	Brick and Steel, adobe, others	11558	0.707	-2	44	62.5	142376	31383	65000	50	[20], [24]
Indonesia, 2004	Earthquake Tsunami	Mw=9.2	Timber, brick	4199	0.617	22	34	1600	4000000	167000	500000	12.5	[20], [25]-[28]
USA, 2005	Earthquake	Ms=6.5		45989	0.910	9	29	1520	460000	1570	253000	59	[5], [20], [29]-[31]
Italy, 2009	Earthquake	Mw=6.3	Masonry, Steel, RC	32430	0.874	-	-	-	72800	308	67500	NA	[20], [32]-[34]

A. Turkey, 1999

Two earthquakes happened in Turkey on August 17th and November 12th, 1999, which caused financial losses of about $5 billion [21]. A huge number of buildings were damaged or destroyed because of the two natural disasters; however, 95% of these losses were due to the first earthquake [21]. The government dealt with the post-disaster housing during the three phases using: (1) tents as temporary shelter, (2) prefabricated units as TH, and (3) permanent housing [19]. Other strategies, such as rental subsidies and self-built accommodations, for residing DPs during the TH phase were also used in this case [14]. In general, post-disaster housing was applied based on the top-down approach with minimum DP participation. Arslan and Unlu indicated that this poor participation led to damage and the bad maintenance of units [35]. However, as 180,000-240,000 people were living in tents, the Turkish government was forced to provide a large number of THUs as winter was arriving [14]; nevertheless, 2.5

per cent of the provided THUs for the DP in the aftermath of the earthquake in Turkey of 1999 remained empty [19].

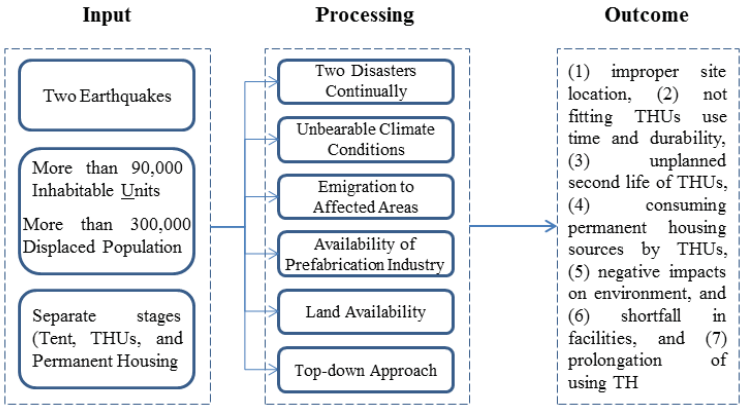

Fig. 3 Considering the PDA process of Turkish TH aftermath of the earthquakes

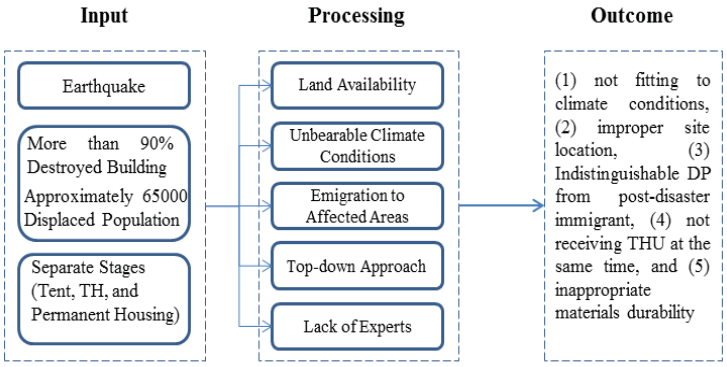

Fig. 4 Considering the PDA process of the Bam TH

B. Iran, 2003

An earthquake occurred in December 26th, 2003, in Bam, Iran, which destroyed more than 90% of buildings in urban areas [36]. In order to respond to the DP´s accommodation needs the government decided to apply three phases, tents as temporary shelter and prefabricated and in-situ units as TH, and permanent housing. The locations of the temporary accommodations were based on camp (grouped) and the yards of the DP´s housing (dispersed). The Iranian government selected the Foundation of the Islamic Republic of Iran (HFIR) and the Minstry of Defence as the responsibile of the THU provision. These two organizations constructed the THUs directly or with hired contractors. Diverse THU types, such as pre-fabricated and masonry technology were constructed on the camp site and the DP´s private properties. Finally, 9,005 units from 35,905 THUs were erected on the camp site and 26,900 in the private yards of the DP´s pre-disaster properties [24]. Some of the THUs erected at the camp site remained vacant. Khazai and Hausler stated that the THUs distances from the DP´s pre-disaster properties lead to the vacancy of some units [37].

As with most natural disaster affected-areas, Bam faced shortages of building materials and increased prices. Therefore, many houses were not completed because the reconstruction loans were not sufficient due to the increase in construction prices [38]. However, this situation did not only impact low-income homeowners, but middle range income DPs also had difficulties in finishing the permanent houses [18].

C. Indonesia, 2004

Approximately 220,000 people lost their lives and 10,000 were injured in the wake of the earthquake and tsunami that occurred on December 26th, 2004, in Indonesia [25]. Firstly, decision-makers intended to bridge the gap between primary shelter and permanent housing by preparing tents and barracks for the DP. However, Da Silva declared that, less than half of the population in need were housed in the designated barracks after one year [26]. Furthermore, the decision-makers forced to change the initial strategy because the tents could not resist the tropical climate conditions [25]. In this regard, Da Silva stated that changing the recovery program strategy for Aceh led to increased expenses, long delivery, and unsuitable quality [26]. In order to provide permanent housing most organizations involved in the recovery program initially decided to use self- or community-built programmes [26].

However, some of these organizations also changed the self- and community-built strategy and housing technologies by hiring contractors. Steinberg mentioned that although the quality of post-disaster housing was often poor, the prefabricated housing, which was constructed after the disaster, could improve the housing quality and resistance to earthquakes in Indonesia [25].

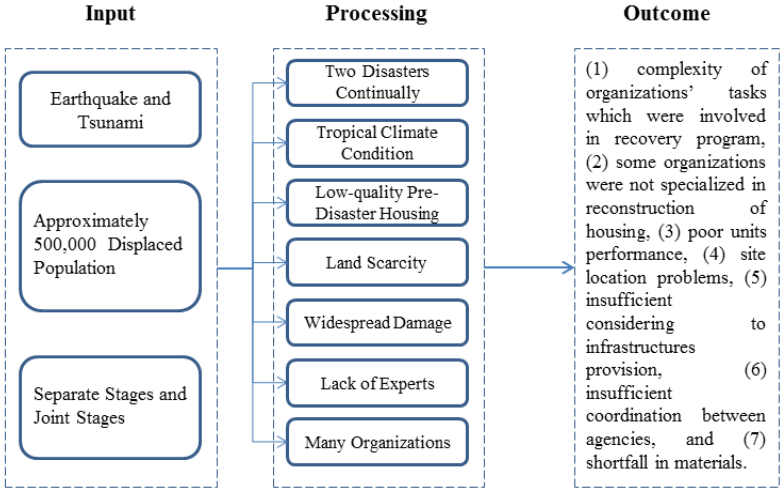

Fig. 5 Considering the PDA process of the Aceh TH

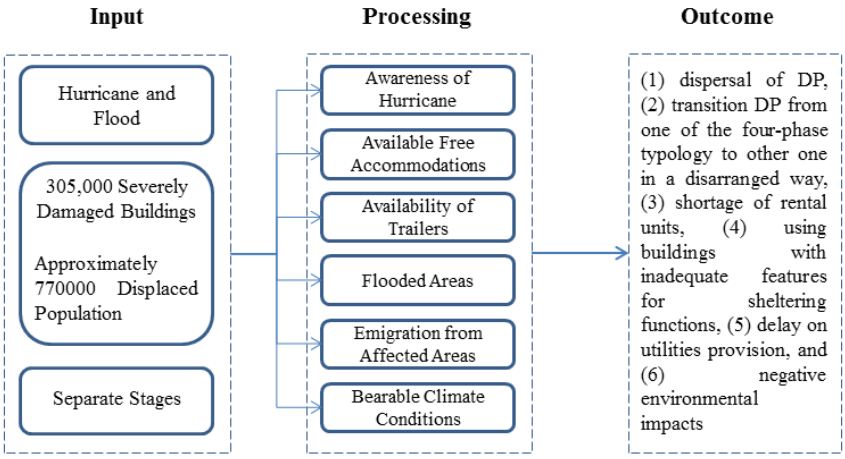

Fig. 6 Considering the PDA process of the TH aftermath of the Hurricane Katrina

D. USA, 2005

Hurricane Katrina happened on August 29th, 2005, in New Orleans resulting in 1,570 deaths and $40-50 billion in losses [29]. In the wake of this Hurricane, 770,000 people remained homeless and more than 305,000 buildings were severely damaged [39]. In this recovery program, a four-phase typology developed by Quarantelli was applied [16]. As the authorities already were aware about the hurricane several pre/post-disaster shelters were considered, such as: The Superdome, the Convention Center, evacuation centres by the American Red Cross, the Reliant Arena, hotels, and rental homes. For example, high-rise hotels in New Orleans accommodated many evacuated tourists [30]. In addition, a group of DPs resided in hotels/motels and apartments in 48 and 32 states, respectively [40]. Some of this group were placed 250 miles away from their pre-disaster locations during the emergency phase [30]. Then, mobile homes and trailers were employed for the DP as TH when the area was pumped dry, which was by the September 20th [5].

E. Italy, 2009

In the aftermath of the earthquake, which occurred on April 6 in L'Aquila, Italy, 308 people lost their lives and 67,500 lost their homes [32]. The decision-makers intended to conceal the intermediate stage and directly move the DP from emergency shelter to permanent housing. For the emergency phase, the DPs were evenly distributed into the three different accommodation types [32]. Some DP remained in hotels and tents during the summer [41]. Then, instead of intermediate accommodation, semi-/permanent housing was constructed as: (1) C.A.S.E (Anti-seismic, Sustainable and Ecologically

Compatible Housing Complexes) project as new towns, and (2) MAP (temporary housing prefab) project [42]. However, this approach led to lengthened emergency shelter usage time due to the construction period required for high-quality buildings. The first semi-/permanent buildings were delivered to 200 DPs 167 days after the earthquake [43]. The C.A.S.E project, with minimum participation of the beneficiaries, hampered the return to their normal lives, and was very expensive [42]. In general, the L'Aquila recovery strategy was conducted based on a top-down approach with economic, social, and environmental problems [32], [44]. Additionally, the houses in the historic centre, which were used by the DP before the disaster, became second homes for temporary use [43]. Nonetheless, the local potential (e.g. building industries) for speedily providing the semi-/permanent buildings based on the demanded standards needs to be considered in this case.

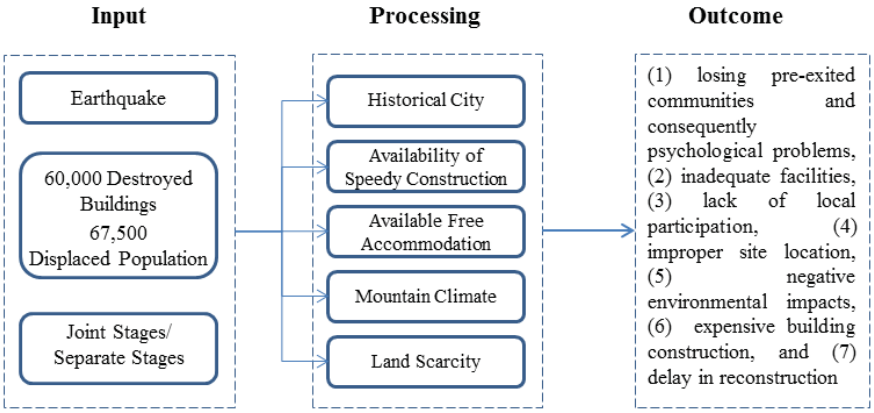

Fig. 7 Considering the PDA process of the TH aftermath of the L'Aquila earthquake

V. Results and Discussion

The cases with different prosperities, led to the implementation of diverse recovery programs and different TH types and quality. The analysis of these cases and aforementioned particularities demonstrates that almost all the DPs, in all cases, were unsatisfied. This is evident because natural disasters compel decision-makers to choose options, which would not be selected as optimal in normal conditions; likewise, the DPs are forced to live in undesirable accommodations for up to several years.

One of the main the factors which has considerable impacts on the decision-making process and which creates some limitations is the hazard type. For instance, in the case of Hurricane Katrina, some DPs were evacuated in rental accommodation in other states before the disaster, because emergency managers had been aware of the impending disaster. However, the decision-makers had to wait until flooded areas were pumped dry to erect the TH. On the contrary, after the Bam earthquake, suppliers could provide temporary shelters for DP´s on their private properties. On another hand, as most Bam's buildings were damaged, there were no or little possibilities to offer rental accommodation alternatives. However, in the wake of the Bam earthquake, the DPs refused to leave their properties and move to TH camp sites established on the outskirt of the city. The same situation happened to the DPs of Pescomaggiore, Italy, who refused the THUs provided to replace the loss of the previous community [44]. Therefore, the availability of rental accommodations and DP´s desires need to be considered, in addition to the impact of the disaster.

The rejection of THUs by the DPs leads to negative economic, social, and environmental impacts. Sometimes, the THUs are refused by the DPs due to their lack of knowledge of new technology. For instance, the lightweight blocks system, which needs less mortar and speeds up construction compared to bricks, was no longer applied in the Aceh recovery program due to the preferences of the local culture [26]. Additionally, sometimes inattention to other TH properties, such as durability for a second life, coerces decision-makers to change the initial strategy. As an example, in the Aceh case, although tents were cheap and easily prepared, they could not withstand the tropical climate conditions. In contrast, the high-quality buildings of the L'Aquila program led to an extended shelter phase. On the other hand, according to Johnson, high-quality TH could be a reason to make it difficult for the DPs to move to permanent housing [14]. However, this is completely related to the DP's characteristics, and an example is how the high-quality THUs of Pescomaggiore and New Orleans did not attract the DP [44], [40]. Therefore, not only individual mentioned factors, such as TH properties, etc., need to be considered, but also the integration of these factors need to be assessed in order to obtain correct results.

In general, assessing the process of the five cases demonstrates that all factors of influence can be organized into a few main groups. To this end, the TH provision process could be defined as two comprehensive steps for simplifying the intertwined problem. At first, the integration of natural hazard impacts and local characteristics create a natural disaster and then, the consequences force decision-makers to find a strategy for dealing with this problem. This strategy, which has considered the integration of local potentials and

limitation due to the natural disaster, yields diverse results based on the combination of DP´s expectations and requirements, TH properties, and local conditions, such as climate. Thus, all influencing factors on the TH process can be categorized into three main groups: local characteristics, natural hazards impacts, and TH properties, as shown in Fig. 8. The local characteristics vertex, which can be broken down into material and immaterial aspects, is formed by local potentials, conditions, and population characteristics. The natural hazards impacts vertex considers limitations and requirements due to natural hazards by considering the intensity and types. The TH properties vertex, embraces all related factors during these accommodations life cycle including planning, provision/construction, operation, and second life phases.

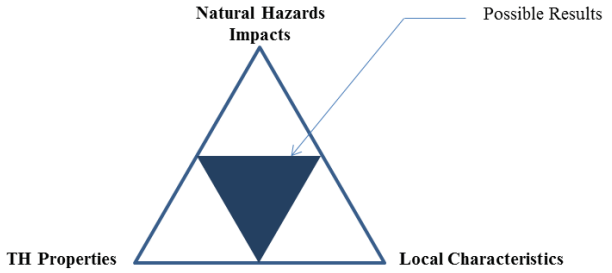

Fig. 8 Main vertexes of TH

VI. Conclusion

This paper analyses the five different case studies to determine missing links between the chosen strategies in these cases and their outcomes. To this end, this study considers the differences of the five assessed recovery programs to present the relations of outcomes and factors of influence -in other words, probable results in the case of applying another strategy for these cases. This research concludes that all effective factors on the recovery programs' outcomes could be categorized into the three main vertexes: local characteristics, natural hazards impacts, and TH properties. The local characteristics vertex embraces local possibilities for providing temporary accommodation in terms of material and immaterial aspects, beside the local resilience in the face of the natural disasters. The natural hazards impact vertex takes into account effects of hazards on TH provision by considering intensity and types. The TH properties vertex considers diverse TH types in terms of numerous factors, including the requirements, impacts, cultural accordance, and so on, during the planning, planning, provision/construction, operation, and second life phases. Finally, this research demonstrates how the outcome of the recovery program is obtained from the integration of these three main vertexes for each case.

Additionally, besides the exposed main results of this study, the following conclusions are derived from this paper by considering the five case studies:

- Post-disaster accommodation provision can vary (not only) from case to case, and also from scenario to scenario for each case. Therefore, this study does not present a specific model for decision-makers that could fail to meet the challenges of local demands. On the contrary, this research project addresses a platform which includes all aspects involved in this area as headlines without dictating a specific strategy. Finally, decision-makers, who have been informed of this issue´s environment, including possibilities, limitations and the outcomes of various approaches, can be able to choose a more specialized and suitable strategy based on the particular local situation.
- Each factor involved in a TH program can be important and is necessary to be considered. Additionally, negligible indicators for a specific case can have great effects on the others. Furthermore, some factors of post-disaster accommodation can completely be in conflict, such as proximity to pre-disaster private properties and protecting the DP from future hazards. In this situation, decision-makers should apply comprehensive solutions based on most stakeholders' priorities and other related factors to these accommodation provisions.
- To analyse previous TH programs, the three defined vertexes of TH for each case should be considered. Then local experts of a new case would be able to determine the outcomes by localizing the previously implemented model.
- Negative impacts of THUs can be reduced when these units are used as whole or part of permanent housing. Additionally, besides the considerable impacts of THUs, the site location of all post-disaster accommodation types in general has substantial impacts on the economic, social, and environmental aspects.

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