

THE ROLE OF LOW-COST HOUSING IN THE PATH FROM VULNERABILITY TO RESILIENCE

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Abstract

It is well known that low-cost housing not only reflects, but also greatly influences the vulnerability of a community. This means that post-disaster housing programs can improve the living conditions of affected families or make them even more vulnerable. However, it is still unclear how different post-disaster housing strategies enhance community resilience. This article seeks to bridge the theoretical gap that exists between vulnerability and resilience theories and to clarify how post-disaster housing programs can potentially enhance community resilience. Four different housing strategies used after the 2003 earthquake in Bam, Iran, illustrate the role of housing in the path that can potentially lead communities from a vulnerable state to resilience. These strategies include: (A) Prefabricated units built on temporary camps located in the city and in the outskirts and developed by the central government, (B) Masonry units built by a public stakeholder on the yards of destroyed houses (C) Prefabricated units built by the central government in partnership with a private firm and located in the yards of destroyed houses, and (D) High-tech imported units built on the outskirts of the city. Analysing these strategies through the lens of a new framework based on a systems approach permits to identify the different impacts of post-disaster housing programs. Whereas strategies A, C and D had negative consequences in various sub-systems of the affected community, strategy B positively enhanced community resilience. The findings of the study provide insightful information that can help architects and decision makers identify the appropriate housing strategy to be implemented after disasters.

Keywords: post-disaster housing; resilience; Iran; reconstruction; vulnerability; systems.

INTRODUCTION

First contributions in disaster management literature (and in architectural studies interested in this field) attempted to explain why disasters occur. They ultimately created the vulnerability theory, which demonstrated that disasters are not 'natural' but created by societies (Adger, 2006; Cutter *et al.*, 2003b; Gallopín, 2006). According to this theory, societies accumulate unsafe conditions (such as poverty, unsafe use of land, lack of insurance) that become disastrous when triggered by a natural hazard. Nonetheless, later contributions noted that some communities do not necessarily accumulate unsafe conditions but also develop appropriate mechanisms of adaptation to the environment (Adger, 2000; Coles *et al.*, 2004). This argument has been consolidated in the emergent theory of resilience. Some authors now argue that rather than being contradictory, the two theories can in fact be complementary (Cutter *et al.*, 2008; Cutter *et al.*, 2003a). This implies that it is theoretically possible for a community to evolve from a state of vulnerability to a state of resilience. However, the relationship between enhancing resilience and effective vulnerability reduction has been insufficiently explored in disaster literature (Djalante *et al.*, 2011; Miller *et al.*, 2010). In response, this article seeks to illustrate how housing can contribute to move communities from a state of vulnerability to resilience. In order to do this, the study examines the case of post-disaster housing solutions developed after the earthquake that destroyed the city of Bam, Iran, in 2003.

However, this objective implies developing an analytical framework that combines the concepts of vulnerability and resilience and that relates them to post-disaster housing. This framework is explained in the first section. General Systems Theory has been usefully applied to the understanding of vulnerability (Cutter *et al.*, 2008; Cutter *et al.*, 2003a), resilience (Alexander, 2013) and post-disaster housing (Johnson *et al.*, 2006; Lizarralde *et al.*, 2009). Given this common approach and the advantages of examining the complex relationships between elements and their environment (Von Bertalanffy, 1973), this framework adopts a systems approach. The second section presents the qualitative research methods used for the empirical work. We then present the results in the form of a qualitative assessment of community resilience. Finally, in the section of discussion, we present practical and theoretical implications of this study and the principal findings in the section of conclusions.

Vulnerability

Although different definitions of vulnerability exist, the term is broadly used to define the potential and the degree of loss for a given system resulting from the occurrence of a natural phenomenon (Cutter, 1996). The vulnerability of a system corresponds to sensitivity to disorders and difficulties to recover the functions of a system (DHA, 1992; Mehta *et al.*, 2008; Pelling, 2003). Several contributions in the field attempt to identify and assess the conditions that make people and assets vulnerable to natural events (Anderson, 1995; d'Ercole *et al.*, 1994; Thouret *et al.*, 1996).

The vulnerability theory - and notably the Pressure and Release Model - presupposes that root causes (often historic economic, political and social conditions) lead societies to dynamic pressures (such as rapid rural migration, lack of infrastructure and poverty) that eventually materialize in unsafe conditions that put people and assets at risk (Blaikie *et al.*, 1994; Hewitt, 1997). These unsafe conditions (created by the society itself) can be sparked by a natural hazard to create a disaster.

Post-disaster low-cost housing

Post-disaster housing interventions often take three distinct forms: emergency shelters, temporary units and permanent houses. Emergency shelters (often more or less sophisticated tents), attempt to deal with, and moderate, the particularly hostile post-disaster conditions. However, the long-term use of the tents, their uncomfortable conditions, their elevated cost (compared with locally produced houses) and difficulties in their distribution are frequent drawbacks found in this first stage of recovery (Davis, 1977; Duyne, 2010; UNDR, 1982).

Temporary housing is often simultaneously regarded as a challenge for long-term sustainable reconstruction and as a necessary step to settle temporarily the affected families during and after a disaster (Fayazi, 2011; Johnson, 2007). In fact, it is often an expensive investment that can delay the construction of permanent solutions. Besides, it usually consists of sub-standard solutions that become permanent, perpetuating vulnerable conditions and stigmatization. However, it might also enable the families to resume daily activities (Jha *et al.*, 2010; Johnson, 2007), to plan for future living solutions and to create the conditions for recovery (Quarantelli, 1995). In order to succeed, temporary housing must not only provide a roof, but also enhance community capacities that create income, consolidate social ties, avoids social segregation and permit long-term development in general (Fayazi *et al.*, 2013; Lizarralde *et al.*, 2009).

Permanent housing often appears as a third step in the process. However, permanent solutions are often too expensive for poor households to afford and thus they must be largely subsidized. Other common drawbacks include the use of unfamiliar technologies, and of the rubberstamped repetition of a basic module, that often ignores different family size, income, priorities and expectations (Aysan *et al.*, 1987; Barenstein, 2010; Fayazi & Lizarralde, 2013). Duyne Barenstein (2010) identifies five approaches of housing reconstruction: cash approach, owner-driven reconstruction, community-driven reconstruction, agency-driven reconstruction in-situ and, agency-driven reconstruction in relocated sites. She highlights in particular the positive

effects of owner-driven reconstruction, a strategy that has proved to help reduce costs; improve safety; restore livelihoods; empower affected households, and enhance capacity building.

Resilience

The concept of resilience - first introduced in ecology and disaster-related research by Holling (1973) - has multiple definitions often used interchangeably (Klein *et al.*, 2003). Initial contributions emphasized preservation in ecological systems and adaptation enhancement in communities (Alexander, 2013). More recent contributions highlight the capacity of a system to withstand, mitigate, recover and adapt to a disturbing event (see Table 1). For many, resilience is a “measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables” (Cutter *et al.*, 2008).

Within the field of global environmental change, resilience is defined as the ability of a social system to respond and recover from disasters. It includes inherent conditions that allow the system to absorb impacts and to cope with them as well as adaptive processes that allow it to reorganize, change, and learn (Adger *et al.*, 2005; Klein *et al.*, 2003).

Resilience includes pre- and post-event measures (Bruneau *et al.*, 2003; Tierney *et al.*, 2007), hence implying inherent qualities that function well during non-crisis periods, and adaptive capacities in response to disasters (Cutter *et al.*, 2008). In fact, several authors now accept that community resilience emerges from adaptive capacities (Norris *et al.*, 2008) - that is, dynamic attributes of resources that are robust, redundant or rapidly accessible and that allow the system to adjust to change, moderate the effects, and cope with a disturbance (Brooks *et al.*, 2005; Burton *et al.*, 2002). Consequently, Norris *et al.* (2008, p. 130) argue that resilience is “a process linking a set adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance”.

Table 1: Relevant definitions of resilience - after Fayazi and Lizarralde (2013) (Source: Authors).

Authors	Definitions	Emphasis on the ability to:			
		withstand against hazard	mitigate impacts of hazard	recover after hazards	adapt community capacities
Brown <i>et al.</i> (1992)	The ability to recover from or adjust easily to misfortune or sustained life stress.	X			
Sonn <i>et al.</i> (1998)	The process through which mediating structures (schools, peer groups, family) and activity settings moderate the impact of oppressive systems.		X		
Adger (2000)	The ability of communities to withstand external shocks to their social infrastructure.	X			
Paton <i>et al.</i> (2001)	The capability to bounce back and to use physical and economic resources effectively to aid recovery following exposure to hazards.			X	

Bruneau <i>et al.</i> (2003)	The ability of social units to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes.		X	X		
Ganor <i>et al.</i> (2003)	The ability of individuals and communities to deal with a state of continuous, long-term stress; the ability to find unknown inner strengths and resources in order to cope effectively; the measure of adaptation and flexibility.				X	X
Ahmed <i>et al.</i> (2004)	The development of material, physical, socio-political, socio-cultural, and psychological resources that promote safety of residents and buffer adversity.	X	X			
Kimhi <i>et al.</i> (2004)	Individuals' sense of the ability of their own community to deal successfully with the ongoing political violence.	X	X			
Coles and Buckle (2004)	A community's capacities, skills, and knowledge that allow it to participate fully in recovery from disasters.				X	
Pfefferbaum <i>et al.</i> (2007)	The ability of community members to take meaningful, deliberate, collective action to remedy the impact of a problem.		X	X		
Tierney and Bruneau (2007)	Pre-event measures to prevent hazard-related damage and losses (preparedness) and post-event strategies to help cope with and minimize disaster impacts.		X	X		
Norris <i>et al.</i> (2008)	A process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance.					X
Martin-Breen <i>et al.</i> (2011)	For an object: Bouncing back faster after stress, enduring greater	X	X	X	X	X

	stresses, and being disturbed less by a given amount of stress. For a system: Maintaining system function in the event of a disturbance. For an adaptive system: The ability to withstand, recover from, and reorganize in response to crises.		
(Howell, 2012)	A national system of resilience has three attributes: Robustness, redundancy and resourcefulness. Its performance can be measures according the response and recovery.	X	X

Analytical Framework: The Process of Enhancing Resilience (PER)

A system adopts adaptive characteristics through sufficient performances during a continuous Process of Enhancing Resilience (PER). This process might start from a vulnerability state, which corresponds to limited or insufficient access to 'hard' and 'soft' resources (material and non-material assets) (Lizarralde *et al.*, 2009). The system is often composed by several subsystems including; economy, social, natural environment, built environment, governance, and information and communication. These subsystems correspond to adaptive capacities and dimensions of resilience that have been identified by Arner-Erly *et al.* (2013), Fayazi and Lizarralde (2013) and Cutter *et al.* (2008).

However, there are also different scales of vulnerability and resilience at which the system can be analyzed: individual, family, community, city and national scales. They eventually interact with each other; for instance, community resilience enhances or diminishes the resilience of individual families – and vice versa. Arguably, these dimensions are not static; they evolve before, during and after the disaster: physical destruction and loss of lives and damages, for instance, influence people's attitudes towards risk in the immediate phase after the disaster. Keeping in mind these dynamic attributes, and the scales of the system and its subsystems, we propose a first model that relates the different variables that must be considered in a holistic assessment of the system (see Fig. 1). This first model recognizes that the subsystems interact between each other at different scales - much like Russian puppets of different sizes embedded in each other (Lopez, 2013).

A second model represented in Fig. 2 borrows a basic concept of the Pressure and Release model proposed by Blaikie *et al.* (1994) and Hewitt (1997), to illustrate that the complex system represented in Fig 1. can become vulnerable because of their deeply rooted economic, political, social and environmental conditions (originally called by the authors "root causes"). These conditions lead the system to dynamic pressures (such as inefficient government or infrastructure, increased social inequality), which eventually translate into unsafe conditions (such as instable building structures, informal settlements in flood-prone areas, and other dangerous situations). These unsafe conditions make the system more or less vulnerable to three types of exposures - that might happen separately or that interact with each other: (1) continuous exposure, including threats such as air and noise pollution; (2) recurrent exposure, that corresponds to periodic threats such as seasonal floods and tropical storms; and (3) sudden exposure which includes high-impact events that cause immediate severe damages, such as hurricanes, earthquakes and tsunamis (note that in Figure 2, the system of the first model is represented as a white circle).

For example, an informal settlement (certainly a complex system) located in a flood-prone area (in an unsafe condition) is vulnerable to seasonal floods (a recurrent exposure). Its sub-systems' vulnerabilities can include, for instance: 1) unstable structures and infrastructures (built environment subsystem), 2) flood prone shorelines (natural environment subsystem), 3) illiterate households (social subsystem), 4) lack of investment due to the threat of seasonal floods (economic subsystem), 5) unenforced urban planning codes and construction standards (institutional subsystem), and 6) lack of communication between households and responsible organizations (communication and information subsystem). Arguably, these conditions make the system vulnerable to others threats (earthquakes, hurricanes, droughts, or even man-made threats such as crime).

The exposures can spark or not a disaster. If a disaster does not occur, the system can benefit from actions that can lead to a state of preparedness, becoming less vulnerable and more resilient. These actions range in a continuum between institutionalized measures and vernacular ones. They might include policy-making and enforcement, plans, programs and projects that increase access to material and immaterial resources. If a disaster does occur, recovery might include three phases: emergency action, temporary solutions and permanent reconstruction (Warfield, 2008; Wisner *et al.*, 2002). Our model captures this principle and illustrates that the system requires a period of recovery before developing preparedness measures. The system ultimately becomes resilient when it adopts the following characteristics in the last step of the PER model: redundancy, robustness, and resourcefulness. Even though both processes are closely related, it should not be assumed that vulnerability reduction is equivalent to resilience development. In fact, resilience is enhanced by actions that help develop adaptive capacities of the system to withstand, recover from, and reorganize in response to crises, and maintain its function in the event of a disturbance (Howell, 2012; Martin-Breen & Anderies, 2011).

Vulnerability reduction occurs when there is increased access to 'soft' and 'hard' resources that create safe conditions for the system (within the system and its environment). Given this framework of analysis, what is the role of post-disaster housing in the different steps of the process of enhancing resilience?

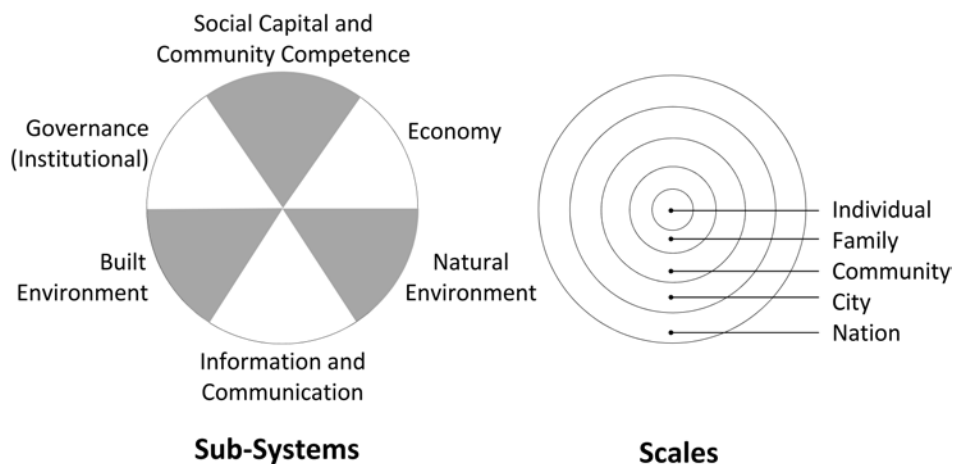


Figure 1: The variables of the system: scales and sub-systems (Source: Authors).

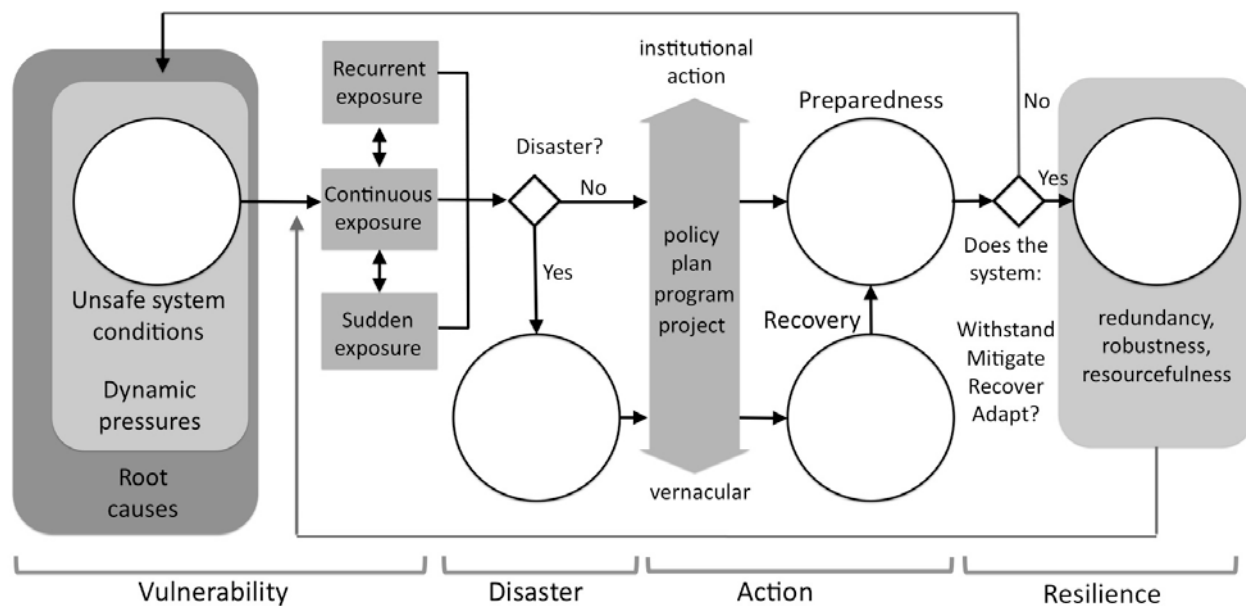


Figure 2: The Process of Enhancing Resilience (PER) Model (Source: Authors).

RESEARCH METHODS

In order to answer this question, we conducted an empirical study that examined the effects of different housing strategies used in the reconstruction after the earthquake that significantly destroyed Bam, Iran, in 2003. Case study methodology, through qualitative analysis, is the most suitable for this study because it allows an empirical approach to complex social and human phenomena within its own context (Yin, 2008). Information for building this case was obtained from the following five sources:

1. The Bam Reconstruction Documentation Project (BRDP), conducted by the Iranian Housing Foundation Organization (HFO). The HFO is responsible for providing affordable houses to low income families, and for post-disaster reconstruction in the country. The BRDP was published in eleven thematic reports¹; the first author of this article was involved in the BRDP and supervised the sub-project "Temporary Housing project after Bam earthquake 2003" between 2008 and 2012.
2. Additional printed information, including reports prepared by the directions of the ministries involved in the project, minutes of project meetings, contractual documents and agreements, press releases and construction documents.
3. Narrative reports which explain chronologically the phases of reconstruction.
4. Answers to 85 questionnaires (conducted within the sub-project "Temporary housing project after Bam earthquake 2003" of the BRDP) given by temporary housing residents. These questionnaires had three main sections: demographic information, questions related to the temporary housing process, and open-ended questions to address the residents' opinions.
5. Data obtained from 70 interviews aimed at understanding the planning, decision-making and implementation process. They include: twelve interviews with members of the

¹ The publications by the BRDP project include the following themes: 1- Relief and rescue process, 2-Debris removal process 3-Temporary housing process, 4- Participatory approach in Bam reconstruction, 5- Project management in Bam reconstruction, 6- Resource management in Bam reconstruction, 7- Permanent housing process (planning and designing), 8- Involved Non-Government Organizations (NGOs) in Bam reconstruction, 9- Needs assessment and damage assessment, 10- Control and monitoring techniques, and 11- Indexing resources.

Steering Committee for Reconstruction of Bam - SCRB², three interviews with HFO's managers, three interviews with officers of the local government, four interviews with presidents of private companies, three interviews with members of the city council and 45 interviews with affected families.

The qualitative analysis assessed specific indicators in each of the sub-systems (economy, social, natural environment, built environment, governance, and information and communication). These indicators were subdivided into variables that assessed the particular role of temporary housing in each sub-system, which were subsequently broken down into analytical criteria. See Table 2 for an example of the analysis of the economic subsystem indicator; this table compares the four strategies of temporary housing according to the chosen variables and criteria. A similar table was prepared for each of the subsystems but they are not presented in this paper. They are included in Fayazi and Lizarralde (2013).

Table 2: Example of the analysis of the economic subsystem indicator, including a comparison of the four strategies (Source: Authors).

Indicators	Variables of temporary houses	Criteria of analysis of the variables		Strategies				Comments on the criteria
				A	B	C	D	
Equity in the distribution of the resources	Duration of the benefits	Only during temporary housing phase		X		X		The program led to inequity of resource distribution.
		Remained after temporary housing phase	Use as secondary space		X	X		
			Use as secondary living space		X			The affected families did not have the same opportunity to receive temporary housing units at the same time. Affected families and native landowners received temporary units after passing several months on emergency shelters.
			Use as permanent houses				X	
	Waiting time for receiving temporary houses	Less than 2 months		X				
		Between 2 and 6 months		X	X	X		
		Between 6 months and one year			X			
		More than one year					X	
Level and diversity of resources	Level & diversity of temporary houses	Location	Camps outside of city	X			X	Allocating different types of
			Camps within the city	X				
			The yard of destroyed houses		X	X		
		Material	Complete units				X	

² The SCRB consisted of the Iranian vice president, the ministers of interior, housing and urban development, transition, information technology and communication, health, agriculture, power and suppliers, economy and finance, the governor-general of the Kerman province, parliamentary representatives of Bam, the president of the Housing Foundation Organization, and additional experts.

		and structure	installed in situ			temporary houses to distinctive groups of vulnerable communities reinforced differences between social groups and exacerbated vulnerabilities.
			Prefabricated units assembled in situ	X	X	
Fairness of risk and vulnerability to hazard	Risk and vulnerability of affected communities	Natives	Masonry materials		X	
			Landowner native residents		X X	
			Native tenants	X		
		Non-natives	Vulnerable affected families	X		
			Temporary non-native residents	X		
			Low-income non-native immigrants	X		

Research Results

On December 26th 2003, a 6.7 magnitude earthquake severely damaged the city of Bam, Iran (Ghafory-Ashtiany *et al.*, 2008). The majority of houses were destroyed, and more than 75000 residents were left homeless (Gharaati, 2006). Because of the earthquake intensity, the time of occurrence and the instability of traditional mud-straw houses, the event led to high rate of casualties and damages: approximately 25500 people died, more than 75000 residents were left homeless, and nearly 93% of urban buildings were destroyed (Statistic Center of Iran, 2003).

During the emergency phase, several camps of tents were set up to settle survivors. Afterward, the adverse conditions (including harsh climate conditions) forced the national and the local authorities to move affected families to temporary units until permanent reconstruction could be completed. However, demographic changes complicated the temporary housing efforts. A large number of low-income families arrived in Bam from other settlements and villages with the hope of obtaining financial aid. They were settled among affected families in the camps of emergency tents in the primary weeks after the earthquake. The rapid arrival of so many immigrants made difficult the assessment of needs and, consequently, led to poor management of the limited resources available. Around 37900 houses were ultimately built by adopting four distinctive strategies to settle affected families (Fallahi, 2005), each of them are explained below. Table 3 summarizes the main characteristics of the units built in each strategy.

Strategy A: In order to facilitate the removal of debris in affected urban areas, national authorities first opted for the construction of temporary shelters in camps. About twenty sites in the city and in the outskirts were selected for building 9050 prefabricated units. The majority of these units (around 8100) were assembled by the national government in partnership with the Defense Industrial Organization (DIO) and a private company called Consulting Engineers of Rashestan Co. They were located in 16 camps developed six months after earthquake. The rest of the units (around 950) were assembled by the regional government of eleven provinces³ in four sites located in the city (see Figure 3).

³ Tehran, Yazd, Khorasan, Kordestan, Isfahan, Gilan, western and eastern Azarbaijan, Mazandaran, Boshehr and Sistan-Balochestan



Figure 3: Camps of prefabricated units (Source: Authors).

Strategy B: Despite the large number of prefab units built by the government, the majority of native families refused to move to the camps, stayed on their emergency tents, and requested to live near their remaining assets and destroyed houses. In response, authorities proposed, almost three months after the earthquake, the construction of temporary shelters on the yards of destroyed houses. Around 5800 masonry units were then built by the HFO during a period of five months. The specific location of these units within existing yards was selected by the landlord with the supervision of a representative of the municipality and HFO experts (see Figure 4). Despite their modest design, the units were designed to be used after the temporary housing phase besides the permanent reconstructed houses (Ghafory-Ashtiany & Hosseini, 2008).



Figure 4: Units made of steel frame and masonry walls in the yard of destroyed houses (Source: Authors).

Strategy C: In response to the beneficiaries' refusal to settle in the camps, the national government also opted - about six months after the earthquake - to transfer about 2500 units developed in strategy A and that were not occupied by the beneficiaries to the yards of affected houses (see Figure 5). Moreover, the government built additional prefab units (identical to the ones built in strategy A) in the yards of new beneficiaries.



Figure 5: Prefabricated units assembled in the yard of destroyed houses (Source: Authors).

Strategy D: Three donor countries donated 1400 high-tech units imported from Turkey, Japan, and South-Korea. They were built at "Dosty", a camp located in the outskirts of the city, about 2kms away from the Bam city center. These units arrived in Iran about 15 months after the

earthquake, when temporary shelters were no longer needed. Inevitably, these units settled permanently the families who did not have had access to any sort of temporary shelters and had stayed on their emergency tents up to that time (see Figure 6).



Figure 6: Complete high-quality units (Source: Authors).

Table 3: Main characteristics of the units developed in strategies A, B, C, and D (Source: Authors).

	Strategy A	Strategy B	Strategy C	Strategy D
Number of units built	9050	5800	21655	1400
Location	20 camps in the city and outskirts	Yards of destroyed houses	Yards of destroyed houses	Camps in the outskirts of the city
Beginning of construction	Two months after the earthquake	Three months after the earthquake	Six months after the earthquake	12 months after the earthquake
End of construction	Six months after the earthquake (all dismantled by 2009)	Eight months after the earthquake (remained permanent)	Nine months after the earthquake (some dismantled)	15 months after the earthquake (remained permanent)
Built area	19m ² (6×3.17)	18 m ² (6×3) and 20 (6×3.34) m ²	19m ² (6×3.17)	45 m ² (5×9) (units provided by Japan and Turkey). 36 m ² (4×9) (units provided by South-Korea)
Area of the plot	Users do not own the land	Units in existing yards	Units in existing yards	Users do not own the land
Number of bedrooms	1	1	1	1
Indoor kitchen	No	Yes	No	Yes
Indoor washroom	No	Yes	No	Yes
Area for washing clothes	Yes (outside of the unit)	No	No	No

Foundations	10 cm thick slab-on-grade	Spread footing in concrete	10 cm thick slab-on-grade	Spread footing in concrete
Structure	Frame of rectangle box profiles	Frame of rectangle box profiles	Frame of rectangle box profiles	Various pre-fab systems
Walls	Sandwich panels of galvanized sheets and polyurethane foam	Clay brick with mortar and covered with plaster (a few units built with panels)	Sandwich panels of galvanized sheets and polyurethane foam	Sandwich panels of galvanized sheets and polyurethane foam (units provided by Japan and Turkey) Cement panels (units provided by South-Korea)
Roof	Sandwich panels of galvanized sheets, polyurethane foam and plaster	Sandwich panels of galvanized sheets, polyurethane foam and plaster	Sandwich panels of galvanized sheets, polyurethane foam and plaster	Sandwich panels of galvanized sheets and polyurethane foam (units provided by Japan and Turkey) Clay roof tiles (units provided by South-Korea)
Access to running water	Yes	Yes	Yes	Yes
Access to electricity	Yes	Yes	Yes	Yes
Access to public sewage	Yes	No	No	Yes
Access to telephone line	No	No	No	No
Access to schools in the camps	No	N/A	N/A	No
Access to health care centers in the camps	Yes (just in eight camps)	N/A	N/A	Yes
Access to public transportation in the camps	No	N/A	N/A	No

In the following section, the four strategies will be compared through the lens of the PER framework with a particular emphasis on the recovery and reconstruction phases. This empirical comparison explains the potential contribution of different post-disaster housing strategies on the different steps of the PER model. Table 4 summarizes the indicators that were used for the analysis and the most relevant references that have previously examined them.

Table 4: Indicators used to assess each of the six subsystems of the PER framework ((Source: Authors).

Economy	Social (Social Capital and Community Competence)	Natural Environment	Built Environment	Governance (Institutional)	Information and Communica tion
Equity in the distribution of resources (Norris <i>et al.</i> , 2008)	Citizen participation (Norris <i>et al.</i> , 2008) Community action (Norris <i>et al.</i> , 2008)	Environmental risk mitigation, particularly disaster mitigation (Lizarralde, 2008)	Flexible and adaptable functions (Cutter <i>et al.</i> , 2010) Appropriate access to community services such as; schools, health centers, community centers, mosques, recreational facilities, etc. (Lizarralde <i>et al.</i> , 2010)	Allied institutional arrangements in risk management process (Cutter <i>et al.</i> , 2008) Empowered and coordinated institutions (Norris <i>et al.</i> , 2008) Connection with auxiliary (assistance) institution to maintain function (Norris <i>et al.</i> , 2008) Experienced institutions (Cutter <i>et al.</i> , 2008)	Reliable information sources (Norris <i>et al.</i> , 2008) Effective narratives (Norris <i>et al.</i> , 2008)
Fairness of risk and vulnerability to hazard (Norris <i>et al.</i> , 2008)	Flexibility and creativity (Norris <i>et al.</i> , 2008) Collective efficacy empowerment (Norris <i>et al.</i> , 2008)	Reduction of environmental impacts (Adger <i>et al.</i> , 2005; Lizarralde, 2008)	Optimization of resources and conservation of natural resources (Bell <i>et al.</i> , 2008; Lizarralde, 2008)		
Level and diversity of resources (Norris <i>et al.</i> , 2008)	Social capacities to respond to the alerts received (Norris <i>et al.</i> , 2008) Place attachment (Norris <i>et al.</i> , 2008) Sense of community (Norris <i>et al.</i> , 2008) Critical reflection and problem solving skills (Norris <i>et al.</i> , 2008)		Appropriate access to infrastructure such as; roads, water, sewage, electricity, etc. (Lizarralde <i>et al.</i> , 2010)		

Housing and Economy

Arguably, housing solutions - as a primary physical and financial aid distributed to affected families - have economic impacts on economic resilience. "The capacity to distribute post-disaster resources to those who most need them seems vitally important for resilience" (Norris *et al.*, 2008, p. 137). Three indicators (equity of resource distribution, level and diversity of resources, and fairness of risk and vulnerability to hazard) are examined in four distinctive variables: benefit duration, waiting time for temporary houses, level and diversity of temporary houses and vulnerable affected community.

The pre-existing diversity of vulnerabilities in Bam was exacerbated after the earthquake by the new immigrants. It was then necessary to respond to two target groups: the native affected families (landowners, and tenants), and the temporary low-income immigrants (Farhoudian *et al.*, 2006). This demographic distortion led to fictitious assessments of needs, increased demand and a competitive atmosphere. It eventually kept out of the program hundreds of affected families, many of which lost the head of the family and faced psychological problems (mostly in strategy

D). This diversity of beneficiaries also reflected on different attitudes towards the various types of temporary houses. Whereas native landowners preferred to settle near their destroyed houses (mostly in strategies B and C), native tenants and low-income immigrants (mostly in strategies A and D) did not have any choice but to accept the temporary units in the camps. Hundreds of immigrants - mostly in strategy D - were settled permanently in the high-tech units provided by donor countries (Fayazi, 2012).

Allocating different types of temporary houses to distinctive groups of vulnerable communities ultimately reinforced differences between social groups. All affected families did not have the same opportunity to receive temporary units timely. Instead, there was unequal benefit duration, and inequity of resources distribution, greatly affecting overall resilience.

Housing and the Social Sub-System

Two capacities are analyzed in this subsystem: Social Capital and Community Competence. The former is, according to Norris *et al.* (2008), a capacity that forges a sense of community, place attachment, and creative and active public participation. The latter is a critical resource that enables the community to learn about their risks and options, and work together flexibly and creatively to solve problems (Edelstein, 1988; Norris *et al.*, 2008).

Considering social capital, it can be argued that the pre-existing sense of community helped the native affected families expose their concerns about the temporary units provided in the camps and eventually challenge (in strategies B and C) the authorities. It also helped them present their own solution to live temporarily in proximity to their destroyed houses. These temporary houses built besides the destroyed houses facilitated the native inhabitants' emotional, physical, and financial connection to place. In contrast, the lack of sense of community among immigrant families led them to inevitably occupy the camps (mostly in strategies A and D).

Moreover, the large number of immigrants exacerbated the already hostile conditions. Native tenants expressed their preference to live in proximity to their rented houses and even besides their pre-disaster landlords. However, the mix of opportunistic immigrants and native (affected) tenants did not permit to identify deserving beneficiaries and thus the solution was rejected by the authorities. The immigrants were less prepared and could not support native tenants' attempts to challenge the authorities, to expose their needs and to propose alternative solutions.

Place attachment and connection to place also helped the native affected families (mostly in strategies B and C) to keep their connection with their previous social organizations and to continue their livelihood activities⁴. Whereas native owners who settled beside their destroyed houses had a quick adaptive recovery process, the other groups of families (immigrant families, temporary residents and native tenants) struggled with security problems, public health issues (including an epidemic of cholera), lack of jobs, and social troubles in the camps.

Not surprisingly, native owners also had increased participation on formal decision-making processes and their involvement in formal organizations eventually accelerated the recovery process. Results show that temporary units built besides the destroyed houses were the most successful to enhance social capital capacities and that proximity played an important role in creating emotional, physical and financial connection to place.

Not always, but typically, a community is a social entity that shares geographic boundaries and common features (Norris *et al.*, 2008; Sliwinski, 2010). The different responses given by communities to the housing strategies became themselves indicators of community competence. The community action against the inconvenient camps reflected the collective effort in identifying common problems and reacting to them. Expansion and modifications to the units are additional indicators of community competence among the residents of units built in the yard of destroyed houses (see Fig. 7). The residents of units built besides the destroyed houses (strategies B and C) were more easily involved in the reconstruction process, and played critical roles on planning,

⁴ Most traditional houses in Bam include a "Date garden" which plays a critical role on livelihoods.

designing, managing and building their permanent houses. They were responsible for choosing the plan and structure (among solutions provided by private companies), managing the allocated financial aids and loans, buying the materials, contracting companies and controlling the construction process. This involvement allowed them to learn about construction and disaster mitigation and thus to further promote their capacities. The flexibility and creativity demonstrated by native residents contrasted with the immigrants' and native tenants' lack of choices to make decisions about their own living conditions (Fayazi & Lizarralde, 2013).

However, at the end of the temporary housing phase, and after the Statistical Center of Iran and the Iranian Red Crescent had finally distinguished between tenants and immigrants, the native tenants recovered their community competence and demanded that the authorities recognized their differences and particular needs. They eventually pushed the national and local authorities to allocate resources for building housing projects especially for them. These residential projects were ultimately built on land owned by the local government on the eastern side of the city (Fallahi, 2007; Fayazi, 2012).



Figure 7. Left: modification of temporary units according to the inhabitants' values and use of space. Right: expansion of temporary units using local materials (Source: Authors).

Housing and the Natural Environment

The resilience of a natural environment is, according to Cutter *et al.* (2008), influenced by factors such as biodiversity, redundancies, response diversity and spatiality. However, in order to analyze the particular role of housing in the resilience of this subsystem we adopted indicators that involve the fragile relations between the natural, the built and the human environments. They include environmental risk mitigation, reduction of environmental impacts, optimization of resources, and conservation of natural resources and ecosystems (Bell & Morse, 2008; Cutter *et al.*, 2008; Lizarralde, 2008). All these indicators assess the pressure of the intervention on the ecosystem and natural resources.

In strategy A, the government built two crowded camps (one in Amir-Kabir with 750 residents, and one in Golestan with 248 residents) that negatively impacted vital water sources in Bam (Fayazi, 2012). In fact, sewages polluted the soil and, according to a health report and to Kouadio *et al.* (2012), also water sources. The disposal of non-recyclable materials of the dismantled prefab units also polluted pieces of land in the outskirts of the city. Arguably, the relentless pressure on natural resources through building masonry units (in strategy B) also had an irrecoverable impact on the natural environment (particularly due to the extraction of sand and gravel from the edge of the Poshtrood River in the north of Bam and the production of clay bricks).

Housing and the Built Environment Sub-System

Three indicators are particularly examined here: (1) flexibility and adaptability of uses, (2) appropriate access to community services, including schools, health centers, community centers, mosques and recreational facilities, and (3) appropriate access to infrastructure, including roads, water provision, sewage and electricity. In terms of flexibility, there was an important contrast between strategies B and C and strategy A. The capacity of masonry units (strategy B) and prefab units built on the yard of destroyed houses (strategy C), to be adapted to permanent

secondary living spaces, storage, or parking augmented the useful lifespan of these solutions. Instead, the prefabricated units built in the camps (strategy A) were dismantled in the following years (Fayazi & Lizarralde, 2013).

All strategies address the access to services and infrastructure in a different manner. The camps located in the outskirts of the city (in strategy A) involved some sort of community services –health centers, community centers, prayer rooms, and primary schools. On the other hand, the beneficiaries of the camps located inside the city (strategy A), and the dispersed units (strategies B and C) used the community services that were provided in temporary prefab buildings located besides the destroyed or affected facilities. The residents of the permanent camps –in strategy D– suffered the lack of community services (except a health care center and a prayer room located in the camp).

The camps located in the outskirts of the city (strategies A and D) were provided with new roads and sewage systems at the time of the delivery of housing units. Electricity and running water were provided temporarily (through diesel portable generators and tanks of drinkable water) until connection to public services and network was completed. On the other hand, the residents of temporary units located within the city (in strategies B, C, and partially in strategy A) benefited from traditional water supply systems (water wells and aqueducts) before the reconstruction of the water supply network. In addition, they had access to the electricity network, which was repaired before building the units in strategies B and C.

Housing and Governance

Resilience can be enhanced through institutional empowerment in planning, inter-organizational collaboration, the development of flexible and adaptable structures, and the consolidation of necessary resources (Cutter *et al.*, 2008; Tierney & Bruneau, 2007). We adopted the following indicators in this subsystem: organizational structure, organizational collaboration, and organizational experience and knowledge (Tierney & Bruneau, 2007).

Strategy B was developed by a performing organizational structure within the HFO. The local units of the HFO received the collaboration of eleven auxiliary departments (ad-hoc contributions by other regional offices) that worked under the supervision of a local department in Bam and the national headquarters in Tehran. The integration of auxiliary departments and the local and national departments reinforced the HFO institutional capacities, notably by reinforcing organizational experience, training, and structure. Moreover, the organizational capacities of the HFO were also enhanced through its official responsibility for building permanent houses. In fact, its continuous responsibility from the temporary to the permanent housing phases created a good opportunity to learn from the effects of different temporary housing strategies on the reconstruction program. This experience reinforced the professional experiences, knowledge, and organizational structure of the HFO, and subsequently its institutional resilience. In contrast, the private companies and the organizations deployed by donor countries (notably in strategy D) had a negligible effect on enhancing the capacities of local institutions to respond to disasters flexibly and adaptively.

Housing and Information and Communication

Information may be one of the most important primary resources that enable community members to recover adaptively. By means of communication (where there is opportunity for members to articulate needs, views and attitudes) the community is also able to create common meanings and understandings (Norris *et al.*, 2008). Yet, the different housing strategies in Bam promoted different levels of access to information and communication.

The communities who had access to the formal information resources (such as national or local media) were able to receive timely important announcements from the authorities. Access to reliable information helped the affected families to be consciously aware of the new challenges and opportunities. In fact, the families who had access to reliable information were more able to adapt to the post-disaster challenges than the families who only had access to fictions or

incomplete information. Access to reliable information published by responsible organizations played a critical role on reducing the uncertainties of residents. Indicators show that the native owner families – mostly in strategy B - were constantly informed about the reconstruction plans, the amount of financial aid available (including loans), time tables, involved companies and contractors, and about the process of design and construction of permanent houses. They also enjoyed access to HFO technical support, something that beneficiaries of strategies A, C and D did not have.

Communication among the community of native owners became an important asset. It is important to underscore here that social scientists agree that community recovery depends partly on collectively telling the story of the community's experience and response (Landua *et al.*, 2004). The variables explain that native owners– in strategy B- adapted quickly to post-disaster challenges by sharing their understandings of reality and experiences among their neighbors. In contrast, families living in camps had limited chance to make narrative communication with their unfamiliar neighbors, and thus to adapt to the new challenges. Isolated tenants and immigrant families, according to Farhoudian (2008), suffer strongly from post-traumatic stress disorder and its symptoms (Farhoudian *et al.*, 2006). This argument is supported by our own study. In fact, the tenants who lived among the immigrant families in camps had limited possibilities to make communication with others and thus to reduce their post-traumatic stress disorder.

DISCUSSION

Resilience has been defined in different manners in the literature, with varied emphasis on immediate recovery, redundancy of systems and long-term adaptation to the environment. Norris *et al.* (2008) assume an adaptive-systems approach and underscore the importance of adaptive capacities in the development of community resilience. Despite these important contributions, insufficient knowledge still exists about how the recovery process, particularly the housing process, can enhance community resiliency. In fact, recent studies demonstrate that the assessment of community resilience and the identification of units of measure is still one of the main gaps in the field (Cutter *et al.*, 2013; Howell, 2012)

The variables presented in the PER framework attempt to assess the role of post-disaster housing in the construction of community resiliency. The results show that housing strategies that addressed housing solutions closer to the original affected units (such as the units made of masonry materials and built in the yard of destroyed houses in strategy B) were more successful in enhancing community resilience in Bam. The prefabricated units assembled in the yard of destroyed houses (strategy C) had the second highest capacity to enhance resilience. In contrast, the prefabricated units built in remote camps (notably in strategies A and D) represented the lowest capacity to enhance community resilience.

These results demonstrate that not all low-cost housing strategies influence in the same manner short-term recovery and long-term development. In fact, proximity to the destroyed units plays a fundamental role in the development of social capital and community competence. Information and communication also influence the capacity of the housing program to achieve community resilience. Furthermore, an unequal distribution of resources with unequal advantages for different groups of beneficiaries can exacerbate social differences and thus lead to greater social and economic gaps. Moreover, housing strategies have significant environmental impacts notably through disposal of non-recyclable materials used for temporary solutions and through relentless pressure on natural resources due to exploitation of construction materials. Flexibility and adaptability also play a fundamental role in building resilience, notably by optimizing the use of resources and allowing a smooth transition from temporary solutions to permanent ones. A continuous organizational engagement from the temporary to the permanent housing phases (as seen in strategy B) creates an opportunity to reinforce professional experiences, knowledge, and organizational structures, enhancing in this way institutional resilience. Finally, results also show that low-income immigrants (some would say “opportunistic immigrants”) might cause demographic distortions and logistic difficulties. They certainly create ethical debates regarding

who is a deserving beneficiary of post-disaster housing projects – an issue that still needs further analysis in the literature.

The cause-effect relationships between the characteristics of housing strategies and the development of adaptive capacities cannot be easily demonstrated by this study (it is difficult to distinguish the direction of causality between these variables). However, the study identifies relevant relationships between these variables, which eventually have both practical and theoretical implications. From the practical point of view, the study shades light on the advantages and disadvantages of different housing strategies. From the theoretical point of view, the results not only illustrate the importance of the theoretical framework for the analysis of housing strategies but they also open the door to additional studies that can explore the cause-effect relationships between the different variables.

One of the most important limits of this study is that it is based on data developed by the BRDP project. However, we are confident that the primary – and neutral - role played by the first author in the collection of data guarantees the scientific rigor that validates the results. Most of the data and information was gathered five years after earthquake (between 2008 and 2012). Hence, equal access to different types of inhabitants was difficult. This limitation was partially reduced by the use of data provided by 85 questionnaires that were completed by households.

CONCLUSIONS

This study presents a framework for assessing the impact of post-disaster housing programs on community resilience. By doing so it adopts an adaptive systems approach and examines six dimensions of adaptive capacities identified in the literature (and adopted here as subsystems). The low-cost housing program conducted after the Bam earthquake clarifies how different physical and social aspects impact community adaptive capacities and resiliency. The study finds that the housing process and its final outcome have important effects on resilience by affecting the primarily resources and capacities of the affected community.

Four types of housing strategies were used in Bam, each with different benefit duration, timelines and outcomes. These strategies were all affected by a demographic change that eventually distorted the assessment of needs and thus the scope of the housing program. The inequity and diversity of houses led to increased social and economic differences among beneficiaries and generally decreased the capacity of economic development in the city. The strategy that opted for constructing permanent units in the yard of destroyed houses had a positive relationship with community resilience; this strategy eventually brought opportunities to owners to increase their social capital. This was in part the result of their possibility to settle within their own land and community. This proximity to their community helped them to adapt quickly, sharing their understandings of reality and their experiences. Furthermore, access to reliable information, through closed relationship with responsible local organizations, facilitated their recovery process. This strategy also helped involve the affected families in making decisions collectively and flexibly, and subsequently enhanced community competence. The permanent structures and appropriate location of low-cost units in this strategy permitted flexible and adaptable uses after the temporary housing phase. Also the continuous engagement of the HFO in this strategy (from providing temporary units to developing permanent solutions) created a good opportunity for reinforcing institutional frameworks and structures.

On the other hand, the strategies that relied on construction of camps in the outskirts of the city brought negative consequences to the development of social capacities (notably to the development of collective narratives and meanings and thus psychological recovery) and in environmental impacts. Even though they provided community services and infrastructure, these strategies did not create a smooth transition from temporary solutions to permanent ones.

Architects and other decision makers are responsible for examining the long-term consequences of low-cost housing strategies. As such, they must consider the capacity of the strategy to enhance adaptive capacities that can conduct to long-term resilience. If resilience is to be achieved in post-disaster action, scholars and advocates still need to refine frameworks and

units of assessment of community resilience and to adapt them to the particular context of housing development.

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