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Diagnostic of Habitability of Emergency Temporary Housing in Peru

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***Abstract*—In Peru, emergency temporary housing (ETH) is currently facing environmental, social, and economic problems. From an environmental perspective, no studies have explored the habitability and internal comfort of these units or the impacts of the materials used. From a social perspective, this type of housing does not generally consider the population's characteristics and socio-cultural relationships in its settlement patterns or interior design. Finally, ETHs are expensive for the government owing to the lack of planning or the difficulty in adapting the units. This enables us to assert that the current response is insufficient. By conducting a field analysis of three types of ETH units in the three major geographic regions of Peru, a diagnostic methodology is used to identify problems and possible solutions in response to each region's habitability condition. The resulting conclusion contributes to organizing a comprehensive response plan to natural phenomena.**

Keywords—emergency temporary housing, habitability, thermal comfort, post-disaster housing

I. Introduction

According to the United Nations Office for Disaster Risk Reduction (UNDRR), disasters are not natural but the result of oversights as well as the lack of planning and prevention related to natural phenomena. The danger, according to its source, can be caused by a natural phenomenon or by human actions. In Peru, the natural phenomena that can cause disasters can be grouped into four types: earthquakes, tsunamis, rain (landslides) and floods, and extreme temperatures (droughts, freezing, and cold) [1].

The housing infrastructure is physically vulnerable to natural phenomena, and the country has no adequate contingency plans in case of an emergency. In addition, the majority of disasters in developing countries occur because the population is settled in vulnerable and high-risk areas [2], with self-built housing units that are unplanned and lack technical management. According to the Metropolitan Urban Development Plan of Lima and Callao [3], 60% of homes are vulnerable to large-scale earthquakes in the capital of Lima, and this city has the most threats of economic loss from earthquakes among 301 cities [4].

Given this scenario, emergency temporary housing (ETH) for victims is central to the success of an emergency response. An emergency response must occur quickly and efficiently as well as have a specific solution for each type of disaster according to the environmental, social, and economic situations. However, after reviewing the available literature and consulting NGOs and the Ministry of Housing, Construction and Sanitation, we determined that there is no necessary ETH-type classification according to the aforementioned requirements. While there is no updated information regarding the living conditions of the ETHs in use, preliminary visits demonstrate that these are not ideal, as the physical and socio-economic conditions of their location have largely been overlooked.

This study uses a qualitative and quantitative method and examines three cases with different post-disaster scenarios (Trujillo, Arequipa, and Iquitos) to assess the habitability of ETHs currently used in Peru. The resulting conclusion contributes to organizing a comprehensive response plan to natural phenomena. This study presents the initial qualitative findings of an in-progress study, with its main sources comprising field observation and interviews. For the field observation, a checklist based on a recent literature review was applied. In the second stage, and in subsequent field visits, a quantitative evaluation is conducted using instruments and mechanisms to measure physical conditions. Furthermore, a psychometric evaluation of community perception, unit perception, and ideal housing is conducted. Finally, it is important to mention that this paper is part of the initiative "Toward healthy housing for the displaced," the world's largest study on the habitability of camps and ETHs [5].

II. Background

A. Definitions

ETHs are crucial in post-disaster scenarios. ETH units provide victims adequate physical and emotionally secure conditions, with a reasonable degree of privacy, protection from the weather, and protection of personal property. In addition, the units can be taken down at the end of their use [2]. Moreover, temporary accommodation solutions must provide the conditions and spaces required for people to complete domestic tasks and work as well as to socialize and attend school with the minimum conditions to live with dignity, privacy, protection, and comfort [6].

Audefroy [7] evaluated post-disaster construction experiences based on the basic rules of disaster response comprising strategic planning, physical planning, living space, design, construction, environmental impact, and housing rights. Clearly, the solutions proposed for ETHs must be understood in conjunction with the affected community's participation.

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For example, solutions must focus on including the affected population to consider ways to approach solutions and on establishing the architect's role as a facilitator, thereby making typically excluded populations visible [8]. Community participation with active and passive methods in a post-disaster scenario positively contributes to reconstruction. Identifying the individual skills and management structure that facilitate community participation is essential [9]. Davis emphasized the leading role of disaster survivors in providing their own shelter and the need for beneficiaries to participate in each stage of recovery [10].

In addition to including the community, the environmental conditions and responsiveness of ETHs to such conditions must be considered [11]. This involves studying the location and examining the mechanisms offered by current legislation [12]. Accordingly, people from various regions with different temperatures usually require different types of ETHs, which may be more appropriate and comfortable depending on the environment. By understanding the location and proper design, ETHs can effectively function in accordance with climatic conditions [13]. Finally, there are housing and emergency shelter inventories that provide recommendations for policies, practices, regulations, and effective operating standards in emergency shelters [14].

B. Variables to Plan Emergency Temporary Housing

ETH is a type of housing that usually becomes permanent. The criteria from *Global Housing Strategy* [15], evaluated and reviewed by UN-Habitat, suggests the following prerequisites focused on housing: (1) housing development: urban and territorial design, economy, and basic urban features; (2) sustainable housing: design, technologies, materials, and components; (3) Home administration: possession of land, administration, and maintenance. In addition, minimum habitability standards can be referred to in freely accessible guides from internationally recognized institutions [16, 17, 18, 19, 20, 21]. Some of these minimum standards to consider include occupancy ratio (m^2/unit), access to water, proper location, and interior comfort of the ETH.

Furthermore, an initial variable to consider emerges from the idea of adequate housing. There is skepticism about introducing human rights language into disaster responses. In contrast to the use of rights-based approaches to development planning, few attempts have been made to use human rights as a regulatory or policy framework to provide shelter after an emergency. Human rights standards include a highly developed definition of the right to adequate housing, but this loses importance to immediate action following a disaster. The seven elements of the human right to adequate housing definition become essential in the transition from disaster response toward reconstruction and longer-term development [22].

The temporary nature of ETH is quantified using three indicators: immediate response time, construction timeframe, and occupancy period. Regarding an immediate response to a disaster, timely focus must be placed on the people hurt or affected, covering basic needs in a short timeframe at the peak of the emergency [6]. Furthermore, the construction timeframe must optimize set-up time and the personnel required. Emergency shelter programs generally take many months or, in some cases, years to be fully implemented [23]. Finally, ETHs are designed for an occupancy period between six months and three years. However, occupancy periods exceed the projected times after disaster and, in many cases, become permanent housing.

Sustainability is another variable that must be considered in an ETH's design. The outlook of sustainable, low-cost, energy-efficient housing using renewable or locally recycled materials has been studied recently [24], instead of focusing on some aspects of housing in isolation, occupants' spatial needs, or demographics. The approach used in this study determines the best practices for sustainable temporary housing that also considers local climatic conditions. Potangaroa introduced the term sustainability by design as a tool to face the challenge of post-disaster reconstruction [25].

In addition, various decision-making tools regarding ETHs evaluate the response's sustainability from economic, social, and environmental perspectives by identifying criteria and indicators. The factors involved in the decision-making process can be organized into three groups: characteristics (economic power, technology, facilities, population, climatic conditions, etc.); requirements (physical and psychological aspects needed to reverse the post-disaster situation and return to the pre-disaster state); and limitations (factors that cause difficulties or restrictions in reaching an optimal state) [26].

Knowing what resources are available during the disaster and considering this variable in the design proposal are essential. Inefficiencies in managing scarce resources after a catastrophe can trigger economic and environmental impacts. Based on the data collected from field research [27], three types of resource-based reconstruction strategies are set: government-driven, donor-driven, and market-driven. The success of resource management depends on the collaboration of multiple stakeholders and the development of policies, plans, and tools to allow market flexibility, donor management, and government intervention.

C. Measuring Habitability of ETH

Housing "is not just a piece of plastic hanging from a few sticks; it is a home, a refuge from violence, a private place, a place to protect oneself from the climate" [28]. Housing is more than a physical structure because in addition to holding valuable emotional contents, it is a status symbol of status, achievement, and social acceptance. Thus, inhabiting is a complex existential phenomenon that develops in spatial and temporal contexts. It develops by occupying a place in a physical structure that sometimes changes quickly. Despite this reality, it conserves its identity through a certain temporality [29]. Inhabiting means having a fixed place in space, belonging to that place, and being rooted in it [30].

Habitability has been primarily defined in the technical, legal, and political context to refer to the quality of a home's physical conditions. In addition, it is directly related to the quality of life and, therefore, can be quantified and controlled by design. That is, it refers to the possibility of satisfying an individual's needs of well-being in a specific physical context. Furthermore, habitability is an essential variable for ETH design. Several authors have proposed habitability measurement methods that depend on physical and socio-cultural conditions and have developed recommendations that are evaluated for future designs.

Physical aspects have been particularly important due to the known and growing effects of climate change, such as the increase in temperature and the higher incidence of severe storms. These effects have been evaluated in relation to the social and environmental problems generated in refugee camps. Extreme temperatures usually raise mortality rates in the camps due to ETH inefficiency. Many times, the urban structure does not consider social needs or cultural behavior. Local vernacular construction traditions and settlement patterns must be revaluated when proposing adaptive measures in relation to the climate and social response [31]. In this context of extreme climates, examining the problem of ETH thermal efficiency and its impact on inhabitants' health is necessary. Examining thermal efficiency of ETHs and camps enables us to propose adaptation strategies based on observing how refugees live to cope with the heat and cold and their views on the shelter design and satisfaction [5].

Some instruments to measure habitability have been used in recent research on refugee camps, applying surveys related to social comfort, thermal comfort, and physical measurements in summer and winter. This requires the creation of a survey on thermal comfort specific to the context studied based on the ASHRAE scales. Once applied, it helps identify problems related to ventilation, privacy, security, and more. Based on these findings, recommendations for optimal ETH prototype designs that include climate and social variables can be proposed [32].

III. METHODOLOGY

The multidisciplinary research team in this study comprised three architects, an anthropologist, and a social psychologist. For this study, the team was initially introduced to the affected locations. Surveys, measurements of climate aspects, interviews and observations of the checklist variables were conducted. For the surveys and measurements, instruments designed and validated in similar contexts have been adapted to the research framework of University of Bath [33]. These have been translated into Spanish and applied in select case studies. For the interviews, the components of the wellbeing instrument were adapted and the Life Satisfaction section of the Emic Components of Wellbeing In-Depth Interview Protocol [34] was used. Furthermore, community perceptions, unit perceptions, and ideal housing were analyzed. For field observations, the status of ETHs was verified by using the checklist.

To select the cases, a bibliographic analysis was performed. The Ministry of Housing, Construction and Sanitation were consulted, in addition to internationally recognized NGOs. This process allowed for the identification of selection criteria for three ETH cases. As a selection criterion, the ETH must be provided by the government and must differ in one or more of the following aspects: climate, social context, type of disaster, type of response, and type of ETH. Finally, ETH set-up in the three major geographic regions of Peru was chosen. The field study included measurements from two times in the year with different climates (winter and summer). This paper presents the preliminary findings from the summer study.

Two survey types were applied in the summer fieldwork conducted in February and March 2019. The first survey evaluated and measured thermal comfort, contrasting the respondent's thermal feelings with measurements from the installed devices, requiring a representative sample of no less than 40 ETHs. The second survey was applied to one third of the population and evaluated social aspects such as reason for inhabiting. During the survey, the checklist for field observation variables were verified (see fig.1). Two types of interviews were conducted in order to have a more accurate interpretation of the community. For the first type, different people in the area were interviewed in order to understand their perception of wellbeing and the level of satisfaction with respect to ETHs. For the second type, key informants or community leaders were interviewed to understand the context in which they live.

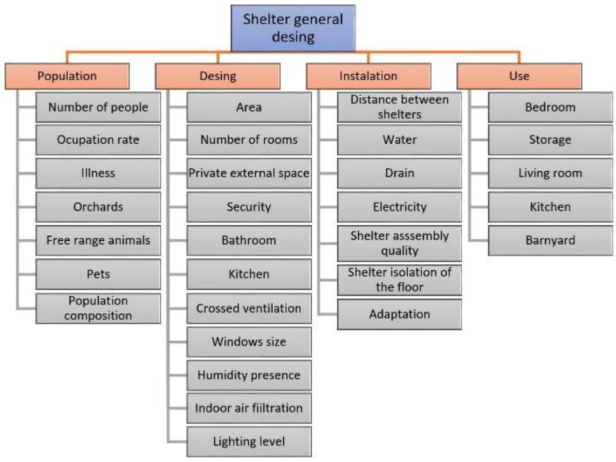


Fig. 1 Variables for checklist field observation

First, the location and number of ETHs set-up in each population studied were identified. The nonprobabilistic convenience sampling method was chosen to conduct the surveys and take measurements since inhabitants were not always available to grant interviews due to their different activities and responsibilities. Thereafter, a weather station was installed to obtain external climate data. ETHs with a high incidence of occupation and use were identified so as to measure internal environmental conditions. Devices were used to measure temperature, wind, and air quality (dataloggers). The surveys regarding thermal comfort, social surveys, observations of the checklist variables, interviews with people of interest, and those related to wellbeing were organized according to the following three case studies.

A. *Case Studies*

Coast: La Esperanza in Trujillo (8.2° S, 79.3° W) had a temporary camp on government land for 91 families displaced by a flood caused by El Niño. Two ETH types were found: the first was provided by the central government, and the second was provided by the local municipality. In this research, we studied the first type, for a total of 74 ETHs. The structures were made of wood, enclosed with Superboard cement boards and wide corrugated sheets. Each unit's area was 19 m^2, and they did not have thermal insulation materials. They had three windows and a door at the front and two elevated windows in the rear. The area's urban design was based on three squares, and the ETHs were arranged around them without considering the direction of the sun or wind. Here, 60 thermal comfort surveys, 40 social surveys, 3 interviews with people of interest, and 20 wellbeing interviews were completed.

Mountains: Yanque (15.39° S, 71.39° W) had a type of temporary housing provided by the government and placed on the land of those affected by an earthquake in 2016. The ETHs were made of polyethylene sheet panels coated on both sides, with metal sheets painted in white to form the walls and the roof. The houses were placed on a concrete slab made by the owners themselves, and they had two windows on the side and a door at the front. The units could not be modified. Each of them had two interior rooms measuring 9 m^2, totaling 18 m^2. Here, 30 thermal comfort surveys, 20 social surveys, 3 interviews with people of interest, and 24 wellbeing interviews were completed.

Mountains: Chivay (15.38° S, 71.36° W) had two types of temporary housings provided by the government to the site. The first type was similar to that described above in the town of Yanque, and the second comprised panels made from the same material, in addition to the roof. The difference was that the eaves of the latter were larger, so they could better protect inhabitants when it rained. Moreover, they were not placed on concrete but on a platform with a rectangular base framed on a metal tract and suspended by wooden supports. The finishing touch was a wood-colored vinyl floor. The size of these units was 18 m^2, and they had two internal spaces like the previous ones; however, they had the door and two windows on the same side. A total of 58 thermal comfort surveys and 25 social surveys were conducted.

Rainforest: The city of New Belén in Iquitos (3.5° S, 73.3° W) had a type of permanent housing and a type of temporary housing. Due to the need to relocate part of Belén's district, the government completed a project 13 km from the city of Iquitos, planning to build approximately 2,700 homes. The ETHs that were set-up were similar to those in Chivay. Here, 80 thermal comfort surveys, 27 social surveys, 2 interviews with people of interest, and 27 wellbeing interviews were completed. Additionally, in all locations, the checklist variables were verified (See Table I)

TABLE I. INSTRUMENTS APPLIED FOR EACH LOCATION

Instrument / Place	La Esperanza	Yanque	Chivay	Nueva Belén
Number of shelters	74	109	65	75
Thermal survey	60	30	58	80
Social survey	40	20	25	27
Wellness interview	20	24	0	27
People of interest interview	3	3	0	2
checklist - Shelter	60	30	58	80
Checklist - Site	1	1	1	1

Next, the cost, optimal occupancy time and ratio, assembly time, and number of people required to set-up the ETHs are discussed. On the coast, the ETHs studied cost 10,529.00 soles; the optimum occupancy ratio was 5 m^2 per person or 3 to 4 people, projected for a maximum occupancy period of 3 years; and they took 8 hours to be assembled by 6 people. In the mountains and the rainforest, the ETHs studied cost 15,000.00 soles; the optimum occupancy ratio was 5 m^2 per person, projected for a maximum occupancy period of 3 years; and they took 4 hours on average to be assembled by 4 people. None of these units had bathrooms. See the information sheets for the three cases in "Fig 1."

Fig. 2 ETH information sheets for coast, mountains, and rainforest.

B. Analysis Variables

In the first stage of qualitative recognition, using information from social surveys and interviews, a preliminary assessment of each study site was outlined. This assessment was divided into two main categories: general design of the ETHs and their adaptation to the location. Within the first category, we identified the variables of population, design, set-up, and use. For the adaptation to the location category, the variables were climate and ETH location in relation to the environment.

IV. RESULTS

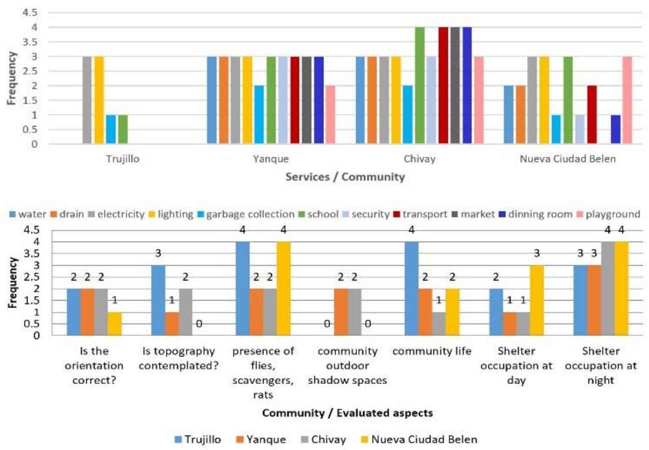
The first response phase aimed at the relocation of the people to shelters and the donation of tents. Thereafter, the ETHs were donated in three situations: the population's relocation to a new camp, establishment of a new city, or placement of the unit on inhabitants' own land.

A. Common Findings

For the population variable, the reason for inhabiting was not considered. They were not involved in designing and assembling the ETHs. The ETHs were designed by private companies and assembled by the army, with poorly accurate results. In addition, the ETH area was not suitable for family structures, and families were stretched by housing more than one generation. Thus, ETHs with up to 12 people were found in the rainforest, representing an occupancy ratio of 1.5 m^2 per inhabitant and 1.9 m^2 on average. In the mountains, the minimum ratio found was 1.9 m^2 and 2.3 m^2 on average. Finally, on the coast, the maximum ratio found was 2.6 m^2 and 3.1 m^2 on average. At public level, bathroom units did not work properly, causing health and privacy issues. Finally, there were no dining halls and medical or security centers.

The ETHs' design, set-up, and use did not include bathrooms or kitchen areas since there was no connection to the water system or drainage. In most cases, due to lack of resources, cooking was done outdoors using firewood. Moreover, there was a privacy issue because of few subdivisions. On the coast and in the rainforest, there were no private roofed social areas for ETHs, where the residents spent the most time (*ramada* shelters). No manuals were provided on how to set-up or take down the ETHs. Their assembly required many trained people and substantial time. Moreover, ETHs were not designed to be part of a new home or to be taken down and then reused as part of a new permanent home. The design was closed and did not allow for expansion according to residents' needs. Finally, the ETH materials caused acoustic and thermal comfort problems, and the openings were insufficient for proper cross-ventilation.

Finally, in terms of climate and location, ETHs were found to have ventilation issues and inadequate thermal performance. In the mountains and the rainforest, the temperature was very high during the day, which caused condensation inside the units. Rainwater was not collected. Additionally, permanent garbage collection systems did not exist; however, there were collection sites, which attracted scavenging birds, rodents, and flies and caused health problems. There were no spaces to raise animals or grow crops. In addition, some findings related to community and location can be seen in "fig. 2", for example, the ETHs in the camp and the new city had no shady areas or trees.



The numbers correspond to Likert Scale, where 0 is never, 1 rarely, 2 sometimes, 3 often, 4 always

Fig. 3 Results of the checklist for Location in relation to the environment, climate and Community Services

B. Findings for Each Region

The specific qualitative findings for each location are presented below. In the next stage, the winter fieldwork was conducted, studying the temperature measurements and including the quantitative wellbeing study at the census level in the three sites studied. See Table II.

TABLE II. ETH FINDINGS

Coast: La Esperanza, Trujillo	
POPULATION	Bathroom designs were not planned and ETHs were adapted. Health and privacy problems.
DESIGN, SET-UP, USE	Improvised roofs were built between homes, eliminating ventilation inside homes. In addition, cross-ventilation did not work because tall windows were closed due to flies.
	The materials used (Superboard and wood) were not perceived as safe to prevent vandalism, causing women to stay inside all the time looking after the ETH.
	The concrete bases on which the ETHs were supported settled because they did not have foundations.
CLIMATE, LOCATION	ETHs were placed in a grid pattern without considering the direction of the sun or the wind. In addition, their location near a road was dangerous for children and exposed the community to theft.
	There were no community spaces. There was no public dining hall or a communal room.
	The camp set-up was temporary in nature; there were no basic services (water, sewage, and streetlights). The water supply came from tanks filled by tankers. Expensive. ETHs were not directly connected to water.
Mountains: Yanque and Chivay, Arequipa	
POPULATION	Residents did not feel safe inside the ETHs if there was thunder because they associated aluminum with a metal that attracts electric shocks.
	The ETHs did not have spaces for raising animals or spaces to store crops or farm tools.
	There was a high incidence of breathing problem due to humidity and extreme temperatures.
DESIGN, SET-UP, USE	No adequate solution to separate ETHs from the ground was considered. Residents built concrete slabs to receive their units without technical advice. Outcropping of saltpeter and moisture occurred due to rainwater, directly onto the concrete slabs due to poor or nonexistent sealing.
	Units raised on concrete bases had better thermal performance and did not have problems with humidity or floor leaks.
CLIMATE, LOCATION	The units that had the longest eaves did not have problems with leaks.
	ETH location on the plots of land was at the residents' discretion without considering their proper direction.
Rainforest: New Belén, Iquitos	
POPULATION	The primary income of the residents who were relocated to the new city was from selling at Belén's market. Travel time to the new location was almost one hour per day. Transportation costs resulted in inhabitants opting to stay in the new city without a major source of income. A market was not established in the new city.
DESIGN, SET-UP, USE	The ETHs were directly placed on a slab without checking the land's slope, which caused constant flooding and water leaks.
	At present, two stages of permanent housing are already built. The ETHs that were initially donated remain in the yards of the homes from the first stage. They were used as a bedroom, a kitchen, for storage, as an animal pen, or as a covered patio.
	In most cases, the ETHs were altered either by removing some of the walls to integrate the space with permanent housing, or they were completely dismantled and used as improvised material for expansions.
CLIMATE, LOCATION	In its first stage, the city of New Belén introduced ETHs to respond to the emergency. The ETHs set-up were temporal and sheltered the first relocated families for two years while permanent housing was built.
	The ETHs set-up had the same model and used the same materials as the ETHs in the mountains.
	They did not have good rainwater drainage systems. There was a ditch, but it was cut off by each separate ETH.
	The drains did not percolate, and wastewater came to the surface, causing health problems. This was due to poor understanding of the land's composition and topography.
	Despite being in a natural environment, there were no plans to plant trees to provide shade or community gardens to provide basic food to the population.

V. DISCUSSION

When an emergency occurs, there is a response from the authorities; however, after ETH units are deployed, different scenarios are possible. Despite the temporary nature of this housing, in many cases, their occupancy exceeds the number of years planned. Thus, ETHs end up functioning as permanent housing, with a certain level of internal and external adaptation by the inhabitants. The ETHs are not designed to be expanded or modified, making adaptation difficult. In the camps, no outdoor community spaces are provided and community life is overlooked. Spatial organization should include relationships among individuals, communities, and environmental components, with physical support from settlements and buildings [28].

Temporary housing should have the capacity to become permanent through a series of processes: taking units down and relocating them, taking them down and reusing the pieces, and expanding or modifying them. This would imply that its design is evolutionary and progressive to become a permanent home; thus, ETHs can be the basis of a long-term solution [35]. This would help to increase the flexibility and adaptability of ETHs, simplifying the problem of land and making better use of resources, by reducing those that are diverted to provide permanent dwellings instead of temporary ones [36]. In addition, construction techniques and local materials should be incorporated, as in the case of ETHs deployed by CARE with the support of United States Agency for International Development on the Peruvian coast. These housing structures are developed to be assembled by the residents, revaluating local construction techniques and reducing assembly and transportation costs.

This solution involves participation of the population as a local workforce and as a strategy to allocate appropriate space. Community networks have demonstrated a great capacity to react to the work inherent to managing and self-producing housing [37]. At present, when not considering the rationality of inhabitants, which varies from region to region, the responses observed have been inadequate. Ignoring cultural behavior is a mistake, and considering the relation among formal, social, and symbolic spatial expressions is essential because whoever inhabits a space constructs it, gives it meaning, uses it, or makes it obsolete [38]. Thinking about the same area, distribution and placement in the space of standardized units cannot offer satisfactory solutions given the complexity of post-disaster problems. Adapting units to different regions should not be limited to changing materials or configurations but should aim to respond to the social and individual distinguishing features of each community.

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