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Sustainable Temporary Housing: Global Trends and Outlook

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Abstract

The concept of sustainable housing can take many forms or definitions. The view embraced in this study for sustainable housing was a structure that is low-cost, energy efficient, and one that uses local renewable or recycled materials, while at the same time being safe and providing shelter to its occupants from the elements. Rather than focus on a few aspects of housing in isolation from spatial necessities or occupant demographics, the approach used in this study was to seek best practices for sustainable temporary housing that also accounts for local climatic conditions. The global need for temporary housing may be expected to increase due to multiple factors: increasing severity of natural disasters resulting in large number of displaced peoples; an increase in the number of climate refugees as a result of a changing climate; and the inability of developing countries to provide sufficient infrastructure in pace with their rapid population growth. Novel developments and promising products and methods in the field of temporary disaster relief housing have been reviewed in the study. To date, an engineered solution to the problem that is low-cost, quick to construct, environmentally and socially sustainable, takes into account the needs of the occupant, and accounts for local climatic conditions has not been found. On the contrary, every major disaster proved the inability of governments to cope with the challenges posed with providing for the large numbers of displaced peoples.

Keywords: sustainable housing; temporary housing; low-cost housing; disaster relief

1. Introduction

In the world today the severity of natural disasters are increasing, the number of climate refugees are increasing, and the inability of developing countries to provide sufficient infrastructure is becoming more common due to a

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demographics that indicate rapid urbanization trends in almost every country. The former creates large numbers of displaced peoples in need of shelter and housing, whereas the latter inherently requires rapid solutions to the housing problems to sustain a standard of living in urban centers. The need for low-cost temporary housing can only be expected to rise due to the combination of these factors. Two examples can be provided to illustrate the importance of sustainable temporary housing, and sustainable temporary disaster relief housing.

Nigeria, with a 2014 population of 178 million, is expected to more than double its current population by mid century if current population increase trends continue. Moreover, 84% of the population was living below the $2/day poverty level after adjusting for purchasing power parity. Nonetheless, 51% of the population was living in urban areas, and the shift from rural to urban regions continues today [1-2]. The state however, is having difficulty in keeping pace with the infrastructure development needs of a rising urban population.

The need for temporary housing is not limited to developing countries as revealed by a closer look at recent natural disasters that happened in the United States. Hurricane Katrina caused billions of dollars worth of damage, and caused the temporary or permanent displacement of hundreds of thousands of people. No country, independent of their income, is immune to the effects of natural disasters and the need to provide temporary housing for its population. In this study, the term housing was used in a broader sense; it was used to represent even the most basic shelters. Still, the post-disaster step forward from nothingness, lies within temporary housing.

The concept of sustainable disaster relief housing was investigated through the lens of new/innovative materials and techniques and reused or recycled materials and their effectiveness. The work begun by examining current low-cost sustainable and disaster relief housing, which was followed by discussions and recommendations on sustainable temporary of disaster relief housing. Recommendations emphasized how current practices could be improved; sustainable housing methods pertaining to different climates; sustainable disaster relief housing relating to different types of disasters; and last resort emergency relief shelter.

2. Background

2.1. Displacement of Peoples Linked to Increasing Severity and Frequency of Natural Disasters

The Center for Research on the Epidemiology of Disasters has been maintaining an Emergency Events Database (EM-DAT), which was supported by the World Health Organization and the Belgian Government. The database provides the most in-depth data on natural disasters and their impacts, dating back to 1900. Analyzing the global number of natural disasters from the EM-DAT database, it can be observed that while the number of natural disasters have remained relatively flat between 1900-1940, they have increased exponentially until the year 2000 despite fluctuations, with numbers increasing form 5 to 527 during that timeframe. The most recent decade has seen a decline in the number of natural disasters, with 2014 recording 344 such events which was comparable to 1997-1998 levels. There was much greater fluctuations in terms of economic damage as a result of natural disasters. Just in the most recent decade, the range spans $40 billion in 2006 to $380 billion 2011 [3]. For the U.S., the Federal Emergency Management Agency (FEMA) provides detailed information on the number of natural disasters and a preliminary damage assessment report if available. Based on the FEMA database, there were 128 disasters on average in the U.S. in the last decade [4].

As cities grow and population increases, the consequences of natural disasters are growing proportionally. Table 1 presents the direct economic cost of the top 5 disasters that struck since 1980. Only insured damages were taken into account in the table, and hence the actual economic as well as social cost can be expected to be much higher than reported results. In the case of Hurricane Katrina for example, the damages caused by the hurricane exceeded 200 billion dollars' worth of damage. The number of people displaced, either temporary or permanent, as a result of the disaster have also been provided in Table 1. It is interesting to note that most of the major natural disasters have occurred in the last decade. The number of people displaced exceed the populations of a vast majority of urban centers in the world. An immediate need that arises following population displacement of such magnitude is the need to provide shelter for the displaced in a very short period of time. The environmental problems associated with recovery efforts and actions only add to the total environmental impacts of the natural disaster, hence requires further attention [5-10].

Table 1. The top 5 costliest natural disasters since 1980 and number of people displaced as a result [5-9]. Cost values were based on insured loss only.

Year	Specific Disaster	Country Affected	Insured Loss (billion $)	Number of People Displaced
2005	Hurricane Katrina	U.S.	73.7	1,500,000
2011	Tohoku Tsunami	Japan	42.3	300,000
2012	Hurricane Sandy	U.S. and Caribbean	30.6	1,172,000
1992	Hurricane Andrew	U.S.	28.8	353,000
2008	Hurricane Ike	U.S. and Caribbean	20.4	1,000,000

Other significant natural disaster events that occurred in the U.S. that ultimately displaced a large number of the population were: the Mississippi River Flood of 1993, the Loma Pietra and Northridge Earthquakes, and Hurricane Floyd [11]. Natural disasters do not only have a large impact on developed countries such as U.S., but in developing ones as well. Such is the case of the earthquake that devastated the island of Haiti back in 2010, five years after Hurricane Katrina. This earthquake killed approximately 316,000 people and injured many more. The ultimate damage however was that the 7.0 magnitude earthquake left over a million Haitians homeless. At the time the earthquake hit, Haiti was labelled as the poorest country in the Western hemisphere. That being said, the country faced the challenge of dealing with a large displaced population following the earthquake. The temporary solution employed were makeshift tents, which provided a shelter somewhat but brought other troubles such as diseases [12].

Typhoon Haiyan made landfall in the Philippines in 2013. A total of 1.1 million homes were reported damaged and 550,000 homes destroyed [13]. Another example for large displacement following a natural disaster was Sri Lanka, which was hit by an earthquake-induced tsunami in 2004. The tsunami flooded coastal areas killing over 30,000 and displacing 520,000 people. Floods in 2011 also displaced another 690,000 people on the island [14].

A joint study between the Internal Displacement Monitoring Center (IDMC) and The Norwegian Refugee Council reported that there were an estimated 32.4 million newly displaced people due to natural disasters in 2012 and nearly 144 million newly displaced people over the past five years. The IDMC estimates that over 19.3 million people have been forced out of their homes due to natural disasters in 2014 [15-16].

2.2. Increasing Number of Climate Refugees as a Result of a Changing Climate

A climate refugee is defined as a person who is driven from their habitat because of an abrupt or gradual change in local climate [17]. A change in local climate may change the habitat physically, as in the case of sea level rise, or may change the productivity of the region through droughts or desertification thus making it less likely to be able to support the existing population [18].

While the end of century range for sea level rise varies, what is certain is that sea levels have been rising, and the rate has accelerated in recent decades. This fact does not bode well especially for island nations. The island nation of Tuvalu in the Pacific Ocean consists of land that is less than 2 m above sea level. Paired with a limited infrastructure, shallow freshwater lenses, high population densities, and a low national income makes the ability of the country to adapt to sea-level rise dependent on international assistance [19-20]. The rising sea level is also expected to take a toll on water availability throughout the globe through saltwater intrusion that would degrade both the soil and freshwater sources [21].

3. Low-Cost Sustainable Temporary Housing for Natural Disasters

While there have been many different types of temporary housing around the world, an ideal solution to the problem still has not been found. One of the factors complicating the problem is the intended use of the shelter. Temporary housing may be in use for a few weeks, or may go up to months or years. The design of a structure from sizing to material selection inevitably varies based on its design lifetime. Hence, the majority of environmental impacts of temporary housing are determined during its design phase. Past cases of temporary housing from across

the globe reveal that what initially starts as a temporary shelter for a short period of time may end up being used for many years following the incident, years to even decades in some cases [22].

Temporary housing can be broken down into two broad categories: prefabricated kit supplies; and prefabricated ready-made shelters. The benefits of prefabricated kit supplies are the easy transportation and possible local/volunteer construction efforts. On the other hand, while prefabricated ready-made shelters are hard to transport, they can be more quickly integrated into the emergency effort due to their preconstruction. However, poor engineering design in both categories create a similar problem; a lack of environmental, economic, or social sustainability. This stems from poor decision-making, a lack of understanding of user's needs, and lack of realization and adaptability to local conditions. Prohibitive costs could also limit their implementation. The need for specialized labor or tools could also prove problematic following an emergency situation [23].

There are some novel approaches and designs for sustainable temporary housing both in academic and non-academic literature. One of the prominent designs was proposed by Humanitarian House International (HHi), a non-profit organization. Following the 2010 earthquake in Haiti, which left over a million people homeless, HHi aspired to create a temporary housing that could be assembled quickly and at a low cost. The model they develop consisted of two options, Emergency Shelter (ES) and a Long Term Dwelling (LTD) that lasts up to 10 years. Both models consisted of PVC tubes, prefabricated wall panels, and fasteners. What is interesting about their model is that it is possible to upgrade an ES to a LTD unit if the need arises. There are numerous examples from around the world where what started as emergency shelters for a short period of time end up being used for years after the disaster. In Haiti, there were still an estimated 172,000 people living in temporary housing four years after the earthquake devastated the area [24]. There is also the option to install a kitchen and bathroom components which can be added during or after the upgrade. The model was designed to include rainwater collection systems, waste management systems, waste treatment systems, and solar power systems [12].

One proposed design named as "Blog House", allows a 17 m^2 house for about $2,500. The design does not require craftsmanship skills but involves mantling the structure via bolts, making the construction of the product simple, and thus allows the potential occupants to mantle the structure themselves. Prefabricated light-weight cardboard tubes were used for walls and ceiling; the foundation was made up of sandbag crates; a tented fabric served as a roof; and a roof hatch allowed airflow during hot seasons [25].

Hurricane Katrina provided insight towards U.S. ability to respond to a disaster of such magnitude. Foremost, the severe natural disaster and its aftermath have revealed the vulnerability of infrastructure and have prompted FEMA to prepare for future incidents, which has resulted in the National Disaster Housing Strategy for the U.S. The post hurricane emergency housing consisted of two main options that were designed to be used for only 18 months. The first option was a temporary travel trailer; these travel trailers were found ineffective due to their shorter than expected life expectancy, use of unsustainable materials, and their negative impacts on human health due to high concentrations of indoor volatile organic compounds and low air exchange rates [26]. However, FEMA had also provided 25,000 Building America Structural Insulated Panel homes that utilized prefabricated insulated panels to provide energy efficiency and durability. The housing units had 3 bedrooms and 2 bathrooms each, and could be joined together to create a larger unit. In addition, photovoltaic systems could be integrated to provide power. Although these temporary houses were not intended for long-term use, having a life span of 18 months, about 60,000 people were still living in their temporary homes two years after the disaster. The popularity for these shelters have surpassed the disaster, and are labelled now as Katrina Cottages [27].

A technology that holds potential for emergency shelter would be 3–D printing of homes or components. While further research is required to manufacture shelters, temporary homes, or their parts, there are already some examples of 3-D printing in the construction industry. The main advantages of this technology would be a reduction in production waste, a decrease in construction time, and a decrease in labor costs [28]. In that sense, the technology could prove to be the environmentally preferable alternative due to its ability to reduce waste and recycle or downcycle construction materials. 3-D printing and manufacturing shelters on-site at the disaster region could prove to be more feasible and practical than shipping containers or parts across long distances should the technology further progress.

After the 1999 earthquake in Turkey that displaced 600,000 people, a temporary housing camp was created in Duzce. A total of 63,500 temporary homes were constructed in response to the disaster [29]. The sheer number of people displaced and the need for housing and other infrastructure emphasize the need for proactive planning, rather

than reactive haphazard projects. In essence, the number of temporary homes in the housing camp was comparable to the population and number of homes in existing cities in the country. The temporary housing project piloted the use of recycled materials to create the housing, and designs enabled the ability of housing units to be either deconstructed or upgraded to a fulltime residence should the need arise. Each shelter had the ability to replaces its "temporary" aspects with more permanent ones through deconstruction. The deconstructed material was then used for either permanent reconstruction or recycled. Introduction of smart design in temporary housing provides a sustainability aspect that can be applied to other types of temporary and emergency housing [29].

General-purpose (GP) shipping containers have become a viable option to enable the transformation of devastated areas due to their resistance to weathering. The large number of unused containers offers an economical and yet durable solution to the shelter problem following an emergency. These shelters also encompass an ease in transportation, which is important during any disaster; due to their modular and uniform design they can be transported by rail, ships, and trucks. They also provide the ability of being combined with one another, to increase the living area of the shelter. However, the most substantial benefit to using the GP shipping containers as temporary housing is the ability to either recycle or reuse the structures or their parts [30].

4. Conclusions

An increase in the severity of natural disasters combined with an increase in human populations and high density urban populations specifically, results in large numbers of displaced peoples following a natural disaster that strikes an urban region. Furthermore, with a changing climate, severe natural disasters can only be expected to occur more frequently compared to the majority of the 20th century. Numbers presented in the study indicate only the direct economic and social impacts of disasters. The importance of and need for temporary disaster relief housing is increasing globally, as no nation is immune from the effects of natural disasters. An important step governments should take around the world would be to prepare for disasters in terms of adaptation and infrastructure resilience. Waiting to plan and act until a disaster strikes is not a viable option.

Another effect a changing climate would have on global societies would be an increase in the number of climate refugees. Lands inundated by the effects of sea-level rise, combined with saltwater intrusion near coastal areas, and a declining agricultural productivity could facilitate further populations to be displaced, and thus relocated, perhaps in temporary shelters or housing.

A sustainable solution to disaster relief or temporary housing needs to have a multi-factorial approach. Understanding user's needs and wants based on cultural or regional norms, adaptability to local geographic and climatic conditions, affordability of housing by governments or those affected by the disaster, the ease of mantling and dismantling the housing unit are some of the factors that determine the success of any proposed temporary housing.

In the case of FEMA's response following Hurricane Katrina, initial homes provided had shorter actual lifetime than design lifetime, and emitted harsh chemicals into the indoor environment where there was already a lack of air circulation. In the end, the disaster revealed the vulnerability and lack of resilience of the state. Soon after, the National Disaster Housing Strategy was developed by FEMA.

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