

# Research on sustainable temporary shelters for climate refugees-taking New York as an example

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**Abstract.** As homelessness in New York has become increasingly serious in the aftermath of the epidemic and government-provided housing is far from adequate to meet the needs of the homeless, this paper applies the concept of sustainability to how housing is provided for the homeless to solve the problem of homelessness as quickly as possible while protecting the environment and reducing unnecessary pollution. For sustainability, this paper focuses on two main aspects, namely the use of materials and water recycling systems. As for the environment of the homeless shelter, the main factor considered is the airflow within the building. Out of consideration for the different needs of different people, this design will be built in a modular way to allow for the regeneration of the shelter and the building to meet individual needs. The paper, therefore, concludes with ideas, designs, and proposals for providing housing for the homeless in New York to meet the needs of sustainability in today's environment. Also in response to the growing environmental crisis, the research in this paper will also serve as an attempt to address the issue of future refugees caused by the environmental crisis.

**keywords:** sustainability, climate change, refugees temporary building, growable building, materials.

## 1. Introduction

Homelessness in New York City has reached its highest levels since the Great Depression, with 67,150 homeless people, including 21,089 homeless children, sleeping in municipal shelters each night in November 2022. This marks a 37% increase in the number of homeless New Yorkers in shelters compared to 10 years ago. Additionally, the number of single adults who are homeless has risen by 117% over the same period. As a result, addressing the housing needs of both families and single adults has become the city's primary goal, requiring shelters to be designed to meet the diverse needs of homeless individuals and ensure they have a safe place to live [1]. The reason why the shelters have to be designed with sustainable development theory is that today's ecology is poor, with carbon dioxide being released into the atmosphere faster than at any time in at least the last 66 million years [2]. 93% of the extra heat captured by man-made global warming pollution goes into the oceans. Worldwide, air pollution kills 9 million people each year [3]. Climate change has become the greatest global health threat of the 21st century" [4]. So shelters must be designed with sustainability in mind, especially in a city as polluted as New York. This paper seeks to find a solution to the proliferation of homelessness that can also lead to sustainable development and the protection of New York City's fragile environment. This study attempts

to assess the viability of this approach to addressing climate refugees by building sustainable shelters for refugees in major cities [5]. As the environmental crisis is intensifying in the 21st century and the number of refugees displaced by the environmental crisis is increasing worldwide, it is hoped that this paper will provide a viable solution to future environmental crises based on solving the problem of homelessness in large cities [6].

## **2. Analysis of the principles and steps of shelter construction**

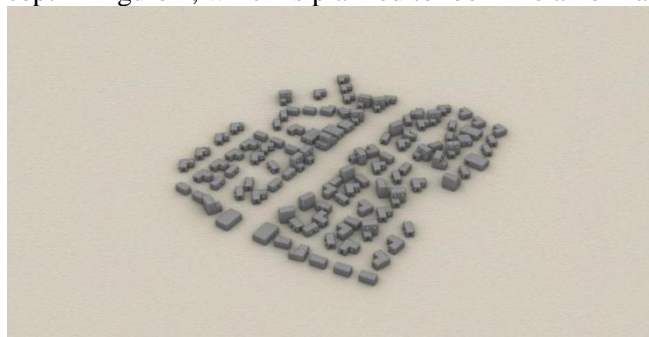
### *2.1. Principles of shelter construction*

This study aims to make innovative adaptations in the design of today's shelters, while previous studies have experimented with sustainability aspects. Based on the conclusions of the previous design concepts, some criteria can be drawn about how to develop a design that meets the goals of sustainability: the use of local materials, reusable materials, low-energy systems, and ensuring that the building has a small footprint [7, 8]. These indicators are measures to minimize the carbon footprint and thus the negative impact on the environment. Minimizing the distance over which materials have to be transported is therefore taken into account [9]. Based on those four conclusions, Shigeru Ban's research becomes an excellent example. Shigeru Ban used paper and several local materials to build shelters for Kenyan refugees. This shelter made of paper tubes is light, safe, and cheap. According to Shigeru Ban's previous research, the paper tube material is already completely waterproof and fireproof. After redesigning the construction method according to NYC's needs, the paper tubes, which were the entire material used to build the shelter, will be used to build the structure of the shelter in this design, and by assembling them, the paper tubes will become the basic structure of the shelter before filling the walls and floor [10]. The design was inspired by another team that chose local materials to assemble the structure based on the geography of Africa and used mineral water bottles to fill the walls [11]. The structure and wall fillings will be changed to suit the different needs of the people due to the modular design [12].

### *2.2. Steps of shelter construction*

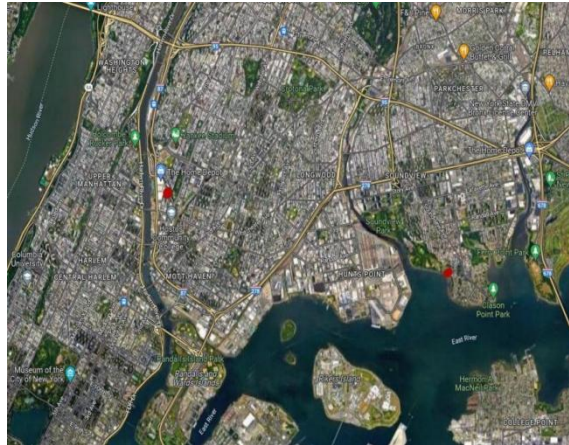
#### **Part One: Site Selection**

It is important to choose a site where there is a high demand for shelters and a suitable location in the area. The ultimate goal of siting is that the area where the shelter is built becomes a community where the homeless do not feel special, but are treated as normal and live in a normal community, just like the community concept in Figure 1, which is planned to look like a normal urban community.



**Figure 1.** Effect picture for community.

The Bronx contains 5 of the 10 neighborhoods in the city that have the highest levels of homelessness in the entire NYC. So our shelter sites were chosen based on this data. Based on the distribution of homeless people, two areas were selected as the most suitable for shelter use, namely Hunts Point and Upper Manhattan, as shown in Figure 2.



**Figure 2.** Map of NYC.

At Hunts Point, the site of the shelter was chosen to be an open area by the sea, part of a park, not completely separated from the surrounding residential area, but kept at a distance so as not to interfere with the lives of the local residents and to provide a degree of privacy for the homeless. The shelter area, as shown in Figure 3, has a variety of different shelters for different needs, mainly along the road, with some space left free for people to move around.



**Figure 3.** Map of the site selection in Hunts Point.

In Upper Manhattan, the shelter is located in the city, as shown in Figure 4, next to the PATH DHS Assessment Shelter, so this shelter is primarily responsible for supporting the PATH DHS Assessment Shelter in providing shelter for more homeless people. There is no shelter building in the middle of the shelter area in order to provide an outdoor space for the homeless to move around.



**Figure 4.** Map of site selection in Upper Manhattan.

#### Part Two: Experimental Site Selection

The experiment was not conducted in crowded and expensive NYC. For cost-containment reasons, a small-scale investigation will be conducted in Princeton, New Jersey, eighty kilometers from New York, which has essentially the same temperature environment as New York, with four distinct seasons, and a large amount of land available, compared to the limited land resources in New York.

#### Part Three: Materials

The experiment was based on a study in New York and the decision was made to use mineral water bottles for the walls, which were filled with waste sediment from the site to ensure the shelter was windproof and stable. Considering the geographical location of NYC, with four distinct seasons, waterproofing is also extremely important for the shelter. And also, the sand-filled mineral water bottles are well insulated to ensure that the temperature inside the shelter is appropriate [11]. The outer skin of the shelter is made of a material that is very common in New York, coffee cups. The waterproofing of coffee cups is an essential feature of the shelter. Paper, plastic water bottles, and coffee cups are the most common recycled materials used in NYC, keeping costs down and not wasting or using too many unsustainable materials.

#### Part Four: Construction

##### Roof

Previous research has shown that the strongest wind-resistant structure is a pyramidal roof and the best protection against strong winds is a circular roof. However, given the low probability of strong winds in Brooklyn, New York, and the general height of the surrounding buildings, some of the wind pressure on the shelter can be relieved, and given the cost, speed, and simplicity of erection of the shelter, a more balanced flat roof was chosen for this design [13].

##### Wall

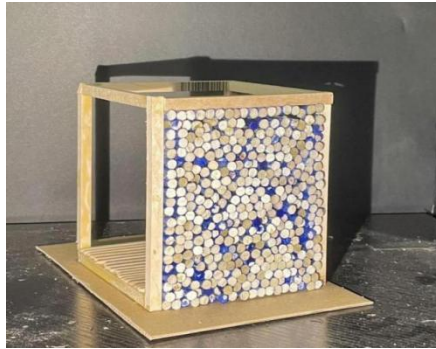
The construction of the wall is divided into four steps:

The first step is to build the structure, which consists of recycled cardboard tubes, based on those used by Shigeru Ban in his designs, which are strong, durable, and waterproof [14]. The waste recycled cardboard boxes are extruded and reconstructed into paper tubes. The paper tubes are responsible for the structure and load-bearing in the construction of the shelter. First, using a small square shelter as an example, the structure is expected to measure 3.6m x 3.6m in plan. The paper partition system consists of eight individual cardboard tube frames with large drilled holes at the ends of the tubes, connected by smaller tubes, while draping fabric over the structure to ensure privacy [15].

The second step is to fill the wall. Based on research into recyclable products in NYC, plastic mineral water bottles, a reusable item found everywhere in large quantities, became the main material used to build the wall. The sand-filled mineral water bottles were placed into recyclable waste cardboard boxes - another type of waste found everywhere in NYC - and stacked according to a structure built from paper tubes. The wall. Overall, mineral water bottles filled with sand and gravel will be filled with discarded paper boxes, and different paper boxes will be formed into walls. This modular design makes the shelter a growable building, where everyone can design their own shelter.

The third step is the construction of the waterproof part of the wall and the water circulation system. As a shelter, the water circulation system could not be made complex and cumbersome due to structural strength and other issues, and it was also necessary to meet the waterproofing requirements of the shelter. The material used to construct the waterproofing and water circulation system consists of coffee cups, the most common trash found in NYC. By using the internal waterproofing properties of the coffee cups to keep out rainwater, and then by cutting the cups in half and using the half-curved shape of the coffee cups to mimic the tiles in traditional Chinese architecture, the outer skin of the wall is made to allow rainwater to flow down into a barrel prepared on the ground to store rainwater. This rainwater can be reused to reduce water consumption.

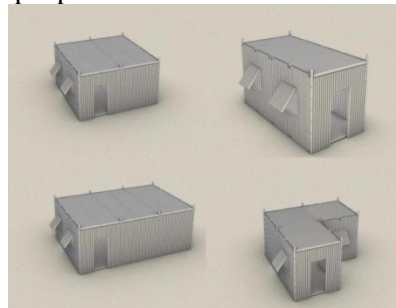
As with the model in Figure 5, roughly shows the actual rendering of the shelter. According to the calculations, a wall of 3.6 m x 3.6 m and a mineral water bottle with a radius of three centimetres, for example, would require approximately 4,800 mineral water bottles for one wall.



**Figure 5.** Model.

#### Interior Design

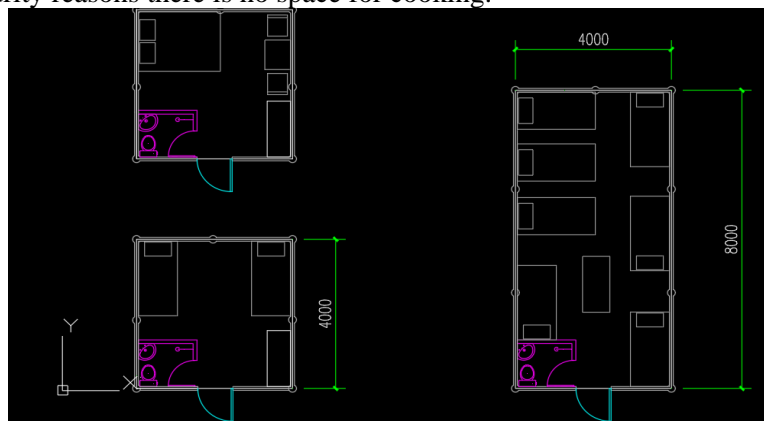
Taking into account that different groups of homeless people may have different needs, several different shelters have been designed for use by people with different needs. As Figure 6 shows, there are four different types of shelters, each responding to a variety of needs, such as gender, religion, family and other factors, so that homeless people can be treated with the utmost respect.



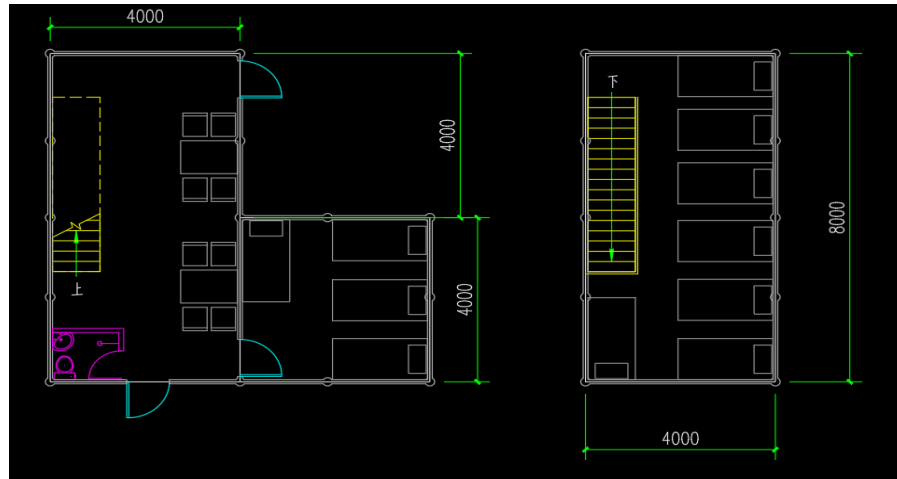
**Figure 6.** Effect picture for shelters.

According to a presentation about the homeless in NYC, the main problem for homeless people is that they cannot cook for themselves and have to rely on the government to distribute food, which makes it more difficult for the government to manage. This makes it very difficult for the government to manage them. Also, bathing and toilets are communal and the sanitary conditions are very poor, which makes them prone to diseases.

Therefore, according to the needs of the homeless, in Figure 7, Figure 8 and Figure 9 a separate washing area has been added to the interior of the shelter to ensure that each person's privacy is respected. However, for security reasons there is no space for cooking.



**Figure 7.** Interior design.



**Figure 8.** Interior design.



**Figure 9.** Interior design.

### 3. Conclusion

In conclusion, this study proposes a forward-thinking approach to addressing homelessness in New York City, taking into account the climate crisis and climate refugee issues. This study focuses on the quality of life of homeless people while paying attention to sustainability issues, selecting suitable areas for homeless people with housing needs to live and live in, designing different styles of shelters for humanitarian reasons, taking into account the different needs of homeless people, and enhancing the quality of life of residents by considering factors such as air flow, access to natural light and water circulation systems. This holistic approach to shelter design promotes the health and wellbeing of the homeless, as well as a more inclusive and liveable environment. With the growing impact of climate change and natural disasters, there are already many climate refugees today, and this number will only increase in the future as the number of displaced people seeking shelter increases significantly. In the future, sustainable shelters can be created in response to demand, minimizing negative impacts on the environment, conserving resources and reducing pollution, while also providing a place for these refugees to live and secure their livelihoods. By designing sustainable temporary shelters, this experiment hopes to not only solve the immediate problem of homelessness, but also proactively prepare for future environmental crises and potential climate refugee problems by designing more inclusive and environmentally responsible solutions that are more in tune with future needs, not only for the benefit of the homeless, but also for the environment and society, as well as for the future survival of humanity. solutions.

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