Modular Units in Post-Disaster Housing Reconstruction

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Introduction

An utmost issue in the United States is the timely provision of post-disaster housing. The US Federal Emergency Management Agency (FEMA) officially provides funding for rehousing displaced people up to 18 months after a disaster. However, resettling processes often take up to five to ten years (C. Barton, personal communication, March 6, 2023; Evans-Cowley & Kitchen, 2011; Shahzad et al., 2022). Modular units or prefabricated homes (a.k.a. “prefabrication” or “prefabs”) have great potential for post-disaster housing provision and relief from the flooding damage caused by hurricanes, when time, quality control, and site selection are the most crucial factors (Wilson 2020). Furthermore, the site of modular units can be selected strategically to ease the negative socioeconomic impacts on the receiving community (Barton et al., 2018). For example, after Hurricane Sandy, New York City developed the POD prototype housing for the next big disaster. These stackable pods could be installed in the Ikea or Fairway parking lot, grafted onto the side of existing New York City Housing Authority (NYCHA) properties, set up between other buildings as infill, or even floated on barges along the city’s 520-mile coastline (BC Housing et al., 2014; Chaban, 2015; PlaNYC, 2013).

Several examples of prefabs being successfully deployed after disasters include the Kobe earthquake in Japan in 1995; the Gujarat earthquake in India in 2001, the Central Java earthquake in Indonesia in 2006, and the Slave Lake flooding in Canada in 2011, in addition to Hurricane Katrina in 2005 (BC Housing et al., 2014). The Katrina Cottage, designed by Marianne Cusato, was introduced after Hurricane Katrina. In 2006, Congress developed the Alternative Housing Pilot Program (AHPP) and gave FEMA $400 million to collaborate with states to develop alternative forms of housing. In 2008 the Katrina Cottage was designed and developed as an alternative temporary housing constructed with FEMA’s trailer quality and cost of between $48,500 and $51,400. The Katrina Cottage was built to match the FEMA trailers’ resistance to hurricane-force winds of approximately 150 miles per hour (Hurricane Katrina’s winds were approximately 140 miles per hour). Cusato’s design inspired a version sold by the home improvement store Lowe’s, while another was used by Habitat for Humanity (Evans-Cowley & Kitchen 2011).

In 2021, the median price for contractor-built single-family homes was $343,600 (U.S. Department of Commerce 2021). With its construction cost from $31,000 to $125,000 a piece (Abulnour 2014), prefabs in the post-disaster housing recovery could house displaced residents more efficiently and swiftly. Prefabs are also efficiently streamlined because they can be built to adhere to existing local building codes, reducing the issue of housing construction being held up by permitting processes. Having been built in factories based on a predefined plan, they can be quickly transformed into homes, hospitals, schools, and other institutions vital to a community’s post-disaster recovery (Wilson 2020). After the displaced return to their permanent houses, these modular units can be easily dismantled, reused, or converted to affordable housing. Although modular housing is primarily used as a temporary emergency shelter, it has
been occasionally upgraded to permanent housing after certain disasters (BC Housing et al., 2014). Prefabs can be implemented in any stage of post-disaster lodging as emergency shelter immediately post-disaster, temporary housing during recovery, and permanent housing. Salt Lake City and Chicago have recently acknowledged modular building as a viable housing solution (Modular Building Institute, 2021).

Nevertheless, modular units are not as widely adopted as one would anticipate. For example, after Hurricane Sandy made landfall in 2012, New York City’s local housing recovery program, the Build it Back program (BiB), only introduced prefab housing units several years later in 2017. Given the conditions and the benefits of prefabricated housing in post-Hurricane situations, it is unclear why prefabs were not used from the program's inception. Announced seven months after Sandy, BiB had ambitious goals and a $2.2 billion budget funded by federal Community Development Block Grant Disaster Recovery (CDBG-DR) dollars, which provided funds for repairing damaged homes, rebuilding them in place, and acquiring properties so the city could “strategically redevelop” them. BiB was administered by the Housing Recovery Operation (HRO), the New York City Department of Housing Preservation and Development (HPD), and the New York City Department of Design and Construction (DDC). It was the first time the city attempted a partnership between the government, contractors, and homeowners to rebuild damaged homes to be better equipped for the next storm (Mayor’s Office of Housing Recovery Operations, n.d.).

Sadly, this rebuilding program could not have gone more array from its original intent. As former Comptroller Scott Stringer put it in his 2015 financial audit of HRO, he called it a “case study in dysfunction” (Nonko 2017; Stringer and Landa 2015). Through BiB, New York City promised housing reconstruction funds to eligible victims of Sandy seeking to rebuild their homes. This was facilitated by using a city-selected developer with pre-approved plans or choosing a contractor to build a home following BiB guidelines and cost restrictions. Yet BiB directly paid the contractor in both rebuild options. Direct payments to contractors often led to payment disputes and the placement of liens on owners' homes, which further delayed housing relief (Bascome 2019; Nonko 2017).

Known as the POD or “the prototype”, in spring 2014, five residential pods manufactured in an Indiana facility were unloaded at Cadman Plaza East. On the first two stories, two pods are bolted together to form three-bedroom flats, while on the third floor, a single pod becomes a one-bedroom apartment. The POD prototype was launched from a design competition in 2007, and after picking ten finalists in 2008, it commissioned a pilot project to be constructed in the city. It took six more years and one hurricane for the project to be funded and constructed in Brooklyn (Chaban, 2015). The pilot cost $1.7 million, with the government agency covering approximately 70 percent of the expense (Smith et al., 2018).

Therefore, this thesis explores the possibility of modular units as post-disaster housing in New York City. This study will explore if prefabs could help bridge the gap of insufficient housing between different stages of post-disaster lodging in New York City. Thus, the central research questions are:
1. Who could have control of the production, stockpile, and provision of prefab housing related to disaster recovery in NYC?
2. How do New York City's flood plan map, existing building codes, and other factors hinder the use of prefab housing?
3. Why did Build it Back adopt prefab housing as a solution in 2017?

This thesis adopts a qualitative approach and focuses on New York City’s local housing recovery effort after Hurricane Sandy to further grasp the nature of a modular housing solution in the post-disaster setting. This thesis will utilize semi-structured interviews with professionals at the Office of Emergency Management, such as Cynthia Barton, Thad Pawlowski, and James McConnell; Deborah Gans from Gans Studio to better understand housing recovery at the second, fifth, and ten-year anniversaries of Hurricane Sandy. Other intended interviewees include employees of the NYC Department of City Planning and the NYC Department of Design and Construction. Additionally, interviews will be held with employees of Garrison Architects, the firm that designed the POD, including James Garrison. Tom Hardiman, the chair of the Modular Buildings Institute, has declined the request for an interview. Interview questions will examine their roles in assisting disaster recovery.

Summary of findings

Modular construction has the potential to greatly benefit post-disaster housing reconstruction, but only if it is scaled up. Disaster recovery in dense urban settings can take up to ten years, and greater governmental responsibility in disaster planning, mitigation, and recovery could reduce disaster capitalism. Contracting manufacturers to maintain a minimum quantity of materials in stock, instead of stockpiling modular units, could help alleviate the difficulty of storing finished modular units before a disaster. It is not a good idea to stockpile modular units before the disaster, hinting challenges provide adequate repairs and storage. Temporary solutions need a clear purpose and deadline, or they risk becoming permanent. Despite being identified as a potential solution in 2007 and 2013, modular housing was not adopted until 2017 after testing out a prototype the POD in 2014. Modular construction has been hindered by zoning regulations and a lack of space for new construction. The Rapid Repair and Build it Back programs, aimed at homeowners, resulted in a loss of housing stock in New York City. With an urgent need for affordable housing, scaling up modular construction requires a strong regulatory framework and political will. Without a concerted effort from policymakers and the industry, the potential benefits of modular construction may not be fully realized.
Figure 1: Build it Back Modular Map
Source: Gans, 2023

BUILD IT BACK MODULAR HOMES DESIGNED BY GANS AND CO.
Background: New York City, Hurricane Sandy, and Build it Back

Following disastrous events, particularly in less developed regions of the world, there is often a proposal to create something more manageable and utilize it to aid ongoing improvement efforts. An example of this is the "roof first" approach to transitional housing, which emerged from the government's response to the earthquake that struck Central Java in Yogyakarta in 2006 (Johnson & Olshansky, 2016). According to this strategy, residents were allowed to gradually complete the construction of the building. In Chile, Villa Verde is a unique community where residents built their own homes after the 2010 earthquake. The government provided concrete foundations, plumbing, and electricity, but residents constructed the rest. This approach allowed residents to create a more personalized and suitable living space, representing an innovative solution for low-cost housing. After Hurricane Katrina in 2005, the occupants of temporary Katrina Cottages planned to have the chance to construct their own homes during this period. Katrina Cottages were typically built to be permanent and provide a higher standard of living and greater safety levels than alternatives such as trailers (BC Housing et al., 2014). Another example is New York City’s Repaid Repair program, allowing home repairs while people were sheltered in place.

Superstorm Sandy’s Landfall and Damage

Superstorm Sandy's landfall in October 2012 exposed New York City's disaster preparedness as vastly inadequate despite the extensive measures in place. The storm caused devastating flooding, resulting in the deaths of forty-three individuals, many of whom drowned due to rapidly rising water levels. The majority of these deaths occurred in Staten Island, particularly in Midland Beach, with the remaining fatalities spread across Queens, Brooklyn, and Manhattan. The tragic toll of the storm was particularly heavy on the most vulnerable members of society, including a 2-year-old child and a man and woman in their 90s. The city's response was criticized as slow and inadequate, leaving many residents without necessities such as electricity and running water for days or weeks after the storm (PlaNYC, 2013).

Several storms have struck New York with winds exceeding Sandy's peak gusts of 80 miles per hour. In New York, numerous storms have produced more precipitation than the half-inch that Hurricane Sandy dumped. Yet, Sandy's storm surge and the resulting damage were unprecedented. In New York City alone, Sandy left 2.5 million residents without power, resulted in $19 billion in damages and lost economic activity, rendered 35,000 residents temporarily or permanently displaced, and caused damage to more than 9,100 homes (NYC Office of the Mayor, 2022).

The surge, together with the subsequent flooding and waves, had a significant impact on the city. The Lower East Side was inundated with 8 feet of water. Multiple transportation infrastructures were flooded, including highways, roads, trains, and airports. It also caused extensive damage to various
The subway tunnels, including the six East River subway tunnels connecting Brooklyn and Manhattan, the Steinway Tunnel carrying the 7 train between Queens and Manhattan, the G train tunnel under Newtown Creek, and the PATH and Amtrak tunnels beneath the Hudson River. The Long Island Railroad and Amtrak tunnels beneath the East River were also affected. The South Ferry subway station in Lower Manhattan and the subway viaduct connecting Howard Beach, Broad Channel, and the Rockaway peninsula were significantly damaged. In addition to the subway and ground transportation, private ferries, the Staten Island Ferry, and the East River Ferry were also impacted. The loss of transportation services left approximately 5.4 million weekday subway riders and around 80,000 regular daily ferry riders stranded during and after the hurricane (PlaNYC, 2013).

Sandy exposed outdated FEMA maps: flooding exceeded 1983 floodplain by 1.5x, inundated Brooklyn and Queens equal to 1983 citywide floodplain. Over 50% of affected buildings lacked flood protection standards due to being outside the 100-year floodplain.
Not only was the extent of flooding substantial in many locations, but also the depth of floods. Water levels several feet above the ground were common in many coastal regions. According to the city’s 2013 report A Stronger, More Resilient New York, near Sea Gate, on the Coney Island peninsula in Brooklyn, the water level reached 11 feet above ground level, while in Tottenville, Staten Island, it reached 14 feet (PlaNYC, 2013). An unprecedented 51 square miles of New York City were flooded, or 17 percent of the city's total land mass. FEMA's flood maps during Hurricane Sandy suggested that 33 square miles of New York City might be swamped during a so-called "100-year" flood or a flood with a 1 percent chance of occurring in a given year. Nonetheless, the storm tide created by Hurricane Sandy exceeded the citywide 100-year floodplain by 53%. In Queens, the area inundated by Hurricane Sandy was nearly twice as vast as the region depicted on floodplain maps. In Brooklyn, the flooded area was far larger than the floodplain. In some localities, the number of flooded areas exceeded the floodplains depicted on FEMA maps several times (PlaNYC, 2013).

Sheltering the Displaced and Policy Revisions

Right after the disaster strike, there were two major hurdles to using modular units for temporary housing. First, in Sandy’s case- seldomly would a hurricane hit so late in the season. Therefore the urgency to shelter Sandy survivors- given that winter was right around the corner, and people could freeze to death without adequate heat and electricity. Second, given the dimensions of modular units to be assembled on-site, the need for sufficient vehicles to quickly transport the parts (T. Pawlowski, personal communication, January 7, 2021). These predicaments drove the city to implement FEMA’s Rapid Repair, a shelter-in-place program that uses FEMA’s Public Assistance Fund. Although the repairs were done quickly, they were not always up to standards, creating conditions for Build it Back. New FEMA maps were published months after Sandy required new and updated building codes for existing housing. The upsetting fact is that the repairs were not to new standards, and everyone knew about it. Furthermore,
flood insurance premiums would go up as affordability goes down, putting people at risk of further flooding as well as extreme economic disadvantages. Brad Gair, former deputy of OEM, originally opposed modular units competition but wanted to finish Build it Back in two years.

The majority of the city's emergency shelters are located in public school buildings, which were selected due to their strategic location, accessibility, and overall suitability. Despite the fact that this decision may cause some disruption to schools, the City retains the authority to supervise shelter locations as a critical measure to ensure that they are available when required. The communal shelters are intended to provide temporary safety but are not designed to provide long-term housing or food. It is recommended that shelter stays not exceed three days, but this can be difficult to adhere to in the aftermath of a major disaster like Hurricane Sandy. Due to extensive flood damage and prolonged power outages, many people were unable to return home, resulting in longer stays in emergency shelters. Despite highlighting the need for improvements to emergency response, it is essential to recognize the obstacles the city faces in providing adequate support to those affected by such a catastrophic event. (Gibbs & Holloway, 2013).

Olshansky et al. (2012) remarked that “recovery is essentially urban planning and development at high speed.” Less than a week after Hurricane Sandy, the Department of Buildings (DOB) began preparing emergency building code adjustments, including flood-resistant construction standards, while the Department of City Planning (DCP) wrote corresponding language amendments to the Zoning Resolution. FEMA issued the city's new Advisory Base Flood Elevation (ABFE) maps for the National Flood Insurance Program (NFIP) on January 28, 2013, placing 7 percent of the city's 975,000 buildings in the one-hundred-year floodplain. Three days later, Mayor Bloomberg issued Executive Order No. 230, temporarily suspending height restrictions and other obstacles to FEMA-compliant rebuilding in these areas (Finn et al., 2023).

Yet, the city’s physical environment was too heterogeneous for citywide rules to properly support resilient reconstruction and safeguard each area from future threats. In July 2015, the city council adopted Special Rules for Neighborhood Rehabilitation to address specific, localized challenges. These interim, five-year zoning language amendments addressed problems such as nonconforming uses and shallow lots, which were prevalent in many Sandy-affected communities (Finn et al., 2023).

With the help of communities throughout the floodplain, New York City DCP identified zoning and land use strategies through long-term adaptive planning. The municipal council passed the Flood Resilience Text Amendment (Flood Text) in October 2013, just before the disaster’s one-year anniversary. This amendment established new datum lines for measuring building height based on freeboard requirements, permitted mechanical equipment and deployable flood barriers as permitted obstructions on roofs, side yards, and backyards, and modified floor area ratio calculations to accommodate stairways required for elevated structures (Finn et al., 2023). The five-year zoning amendment was initially adopted in 2013 on a temporary, emergency basis (NYC Department of City Planning, 2017).
Figure 5: Build It Back was audited in 2016; Source: Stringer, S., & Landa, M. (2015).
The Flood Text was part of New York City's extensive efforts to recover from Superstorm Sandy, stimulate reconstruction, and strengthen the city's resilience to climate-related occurrences. By requiring new and existing buildings to comply with new, higher flood levels provided by FEMA and the updated New York City building code, existing zoning was adjusted to eliminate regulatory barriers that impeded or prevented the rehabilitation of storm-damaged properties. In addition, the Flood Text incorporated additional regulations that address the potential negative effects of flood-resistant buildings in the public space. The text modifies height, floor space, and allowable obstruction requirements to maintain the vitality of floodplain neighborhoods. The Text recognizes that buildings in the floodplain cannot have sub-grade areas for both new and existing structures and that ground-floor use in residential buildings is confined to parking, storage, or access (NYC Department of City Planning, 2017).

**Shortcomings of Preparedness in NYC**

The ambiguous provisions of the Stafford Act, which requires the federal government to pay 75 percent to 100 percent of disaster response bills if FEMA has issued a disaster declaration, and the low damage financial threshold have created immense incentives for governors to seek federal disaster declarations rather than shoulder most of the recovery cost (Bucci et al., 2013).

According to a 2013 special report by the Heritage Foundation Emergency Preparedness Working Group (Bucci et al. 2013), neither the state of New York nor New Jersey had a disaster relief fund by Sandy’s landfall. Despite two decades of a more active and generous FEMA, governors have reduced preparedness budgets and depleted catastrophe emergency reserves during the past thirteen years. Governors assumed that the federal government would pick up the tab and thus slashed the states’ preparedness budgets and drained any disaster emergency funds. If FEMA would pay the bill, why shouldn't governors use their tax dollars elsewhere, especially during difficult economic times (Bucci et al. 2013)? The more FEMA stays in a constant state of response, the less time and resources for disaster preparedness. Hurricane Sandy revealed this problem. Some experts have called for a change in the way FEMA allocates its resources in order to address this issue. Bucci et al. (2013, pg.3) remarked: “Without a return of responsibility to the states, the federalization of routine disasters will continue to require FEMA to become involved with a new disaster somewhere in the U.S. at the current pace of every 2.5 days.”

In Sandy's aftermath, communities were hamstrung by countless predicaments during the recovery phase and suffered considerably. Currently, there is a lack of sufficient post-disaster coordination across federal agencies. For instance, when FEMA staff changed out, there was no handover of what was done (Smith, 2015). Moreover, money was not always well spent or coordinated; it was also unevenly distributed and slow to payout (Stringer & Landa, 2015).

Though, FEMA was not the only culprit: years of recovery efforts after Sandy's landfall revealed New York City's limitation on timely distributing the lofty disaster relief funds reserved for the City
Despite having received hefty disaster aid, a "funding gap" between FEMA and the bureaucratic black hole of local housing recovery programs evidentially led to a long-delayed recovery in New York City (Moskowitz, 2014; RPA, 2017; Carpenter et al., 2018). However, there is only so much a city can do without sufficient post-disaster coordination across the federal agencies, warranting an urgent need for a comprehensive national climate resilience strategy and a national dialogue to agree upon disaster recovery values. For instance, because it had no permanent housing solutions, New York City spent over $70 million to house survivors in city hotels as a part of the New York City Hotel and Interim Placement Program. Without FEMA's funding, the program came to a halt right before Sandy's first anniversary; over 300 families were evicted from hotels (NYC Department of Homeless Services, 2013).

FEMA's outdated FIRMs maps that misinformed the public of their flood risk were only partially to blame. To make matters worse, many who lived in the inundated area either did not purchase flood insurance or were unaware that they lived in a floodplain. Due to a lack of nationally coordinated disaster response efforts, market-driven post-disaster investments are guided by FEMA's official flood maps. To prioritize assisting the most climate-vulnerable impacted by a disaster, it would require a shift from relying on economic signals to more government intervention to ensure an equitable and just transition. One of New York City's former disaster recovery managers, Brad Gair once said, "without hard choices about how and where to rebuild, or even whether to rebuild, states and cities will keep reinventing a broken wheel — despite their best efforts" (Sullivan, 2016). Sadly, the lesson, “contracts are only as good as people who manage them” must be lost in translation (Office of Inspector General, 2014). Post-Sandy’s New York tells a story of laudable FEMA-led disaster response, but a far more troubling tale of the delayed local housing recovery.

In the initial response to the storm, despite suffering severe impact and substantial damage, New York City coordinated with FEMA to provide federal disaster aid and mobilize innovative solutions to address power restoration, transportation, fuel distribution, and housing needs (Bucci et al., 2013). However, in its aftermath, communities were hamstrung by countless predicaments during the recovery phase and suffered considerably.

Issue started soon after the storm. Without any permanent housing solutions, New York City spent over $70 million (paid upfront) to house survivors in city hotels as a part of the New York City Hotel and Interim Placement Program. Without FEMA's funding, the program came to a halt right before Sandy's first anniversary. The City's local housing recovery programs Rapid Repair (RR) and Build it Back (BiB) were equally problematic (Foderaro, 2012; NYC Department of Homeless Services, 2013). Rapid Repair was riddled with communication errors, failure to follow up with victims, and widespread disorganization. Build it Back had ambitious goals and a $2.2 billion budget. Announced seven months after Sandy, it was the first time the city attempted a partnership between the government, contractors, and homeowners to rebuild storm-damaged homes to be more climate resilient. Sadly, this rebuilding program could not have gone more array from its original intent. Comptroller Scott Stringer sums it up
the best, the program is “a case study in dysfunction.” (Nonko 2017). BiB portrayed a timeline of dysfunction and corruption—absolutely nothing was built back in the first 14 months.

As a result, BiB was financially audited by the Mayor’s Office of Housing Recovery Operations (HRO) in 2015. While consultants were paid millions, Sandy victims waited years to be adequately compensated for their storm damage. Many remained homeless without any other safety net as federal aid was gridlocked. Despite of the size of the Sandy Relief Fund allocated to the city, the number of applicants languished—thousands either withdrew their applications, stopped responding to program officials, or were found ineligible for a rebuild (Nonko, 2017). Some were kicked out of their houses months before construction started; the delayed program outlived others. Both programs favored homeowners and renters, leaving NYCHA to fend for itself (Finn, 2020).

This further complicates the mismanagement of disaster relief funds for New York— not only was money not always well spent or coordinated; but it was also unevenly distributed and slow to payout. Evidently, there is a lack of sufficient post-disaster coordination across federal agencies. For instance, when FEMA staff changed out, there was no handover of what was done to city agencies. FEMA was not the only culprit: years of recovery efforts after Sandy's landfall revealed New York City's limitation on timely distributing the lofty disaster relief funds reserved for the City (OCS, 2018). The "funding gap" between FEMA and the bureaucratic black hole of local housing recovery programs evidentially led to a long-delayed recovery.

Small Business Association (SBA)’s structurally problematic process of determining program eligibility disqualified thousands of dire aid applicants, exposing underlying equity issues. Homeowners argue that the policy not only prevents them from receiving the assistance needed to complete repairs of their storm-damaged homes but more importantly, penalizes those who have refused the SBA loans in an effort to avoid additional debt during a time of hardship. Residents initially approved for SBA disaster loans were later deemed ineligible to receive grants under BiB even if the homeowner had not accepted the loan. (Lindsay & Boyd, 2016). At the urging of the New York congressional delegation, on July 25, 2013, HUD updated its policy guidance to allow greater flexibility for homeowners who initially rejected SBA disaster loan assistance. Prior to this arrangement, grantees were required to reduce CDBG-DR assistance by the amount of the homeowner’s approved SBA disaster loan (Lindsay & Boyd, 2016).

As a result, Sandy victims waited years to be adequately compensated for their storm damage; many remained homeless as federal aid was gridlocked. According to the city’s audit report (2015), after Superstorm Sandy, NYC’s HRO failed to properly monitor BiB contractors and paid $6.8 million to them for work that was flawed or incomplete—contributing to extensive delays in the delivery of aid to more than 20,000 people seeking help (Office of Inspector General, 2014).

But most importantly, the City is at risk of overpaying for inadequate services, with public money. The financial audit of BIB conducted by Comptroller Stringer revealed corruption by the subcontractors,
echoing a similar tale of Post-Katrina. “Immediately following the storm, the City contracted Boston Consulting Group (BCG) to design a relief program at the cost of $6.1 million dollars, and then contracted with Public Financial Management (PFM), a Pennsylvania-based firm, to provide oversight and management of various subcontractors, including URS Group, Inc., and Solix Inc. Under the terms of these contracts, the subcontractors were to provide intake assistance to victims seeking aid, process applications, determine their eligibility, offer customer support and help New Yorkers navigate a complicated system” (Sumberg, 2015). The same audit reveals that subcontractors who failed to deliver adequate services have continued to operate Build it Back for more than a year without valid contracts: When the City fired PFM in December 2013, it established informal agreements with subcontractors to continue operations. Since then, Solix and URS have continued to perform Build it Back services without registered contracts – with the expectation that the City will pay them. Valid contracts in place, the City has limited leverage over its vendors’ work and cannot hold them accountable for their performance. As a result, applicants remain vulnerable to further program failures, back to square one.

In 2017, the NYC Department of Investigation (DOI) concluded that “the submission of construction designs that led to months-long approval processes by the City, unforeseen site-specific conditions that resulted in construction delays, and poor coordination with utility companies to disconnect service” ultimately led to BIB’s delayed program initiation (Peters, 2017). Gair admonishes local governments that accountability and real oversight are their only levers to deliver federal disaster aids equitably (Nonko, 2017).

**Modular Solutions**

The rapid turnaround between "groundbreaking" and occupancy is one of the greatest advantages of modular construction. Consequently, building construction and site preparation activities occur concurrently. In addition, the risk of delays due to inclement weather, vandalism, and theft on the construction site is negligible in modular construction (Kamali & Hewage, 2016). Although in the case of NYC’s housing recovery after Superstorm Sandy, the implementation of modular units came too late, next time, New York City will respond and recover more equitably (Barton et al. 2018). NYC did not explore a modular option for its local housing reconstruction program until early 2017. Nevertheless, this does not erase the fact that there was a FEMA-funded 3-unit mockup post-disaster housing competition in 2006 after Hurricane Katrina. NYC had drafted a plan using modular units as early as 2011. However, with no budget or funding, the plan remained a proposal (T. Pawlowski, personal communication, March 14, 2023).

In order to facilitate the recovery process following Sandy in Queens and Staten Island, Build it Back eventually implemented a strategy involving the use of modular construction. According to Lou Mendes, chief operating officer of HRO, a thorough examination of the technologies involved in modular
construction led to the conclusion that the homes created would fit the structural and design requirements of the program. "Modular construction has evolved greatly and proven to be more logistically effective, allowing for a more exact recovery program schedule" (Nonko, 2018).

Only the last 70 flooded homes in Queens enrolled in the Build it Back program were rebuilt using prefabs. After the city commissioned GANS studio and Cragolin Engineering and Design to design prefabs shipped from a Pennsylvania factory, it took four months for the units to be delivered and set on their foundations, massively reducing reconstruction time from over two years using traditional building on-site method (Barton et al. 2018).

Because eligibility for BiB was primarily determined by home damage rather than individual vulnerability (i.e., income), it is unclear whether the program successfully addressed the needs of the most vulnerable. It was originally expected to end in 2016. Still, with a slow rollout, spending for BiB peaked in 2017 for the single-family program ($682 million) and in 2018 for the multifamily program ($132 million) (Carpenter et al. 2018). In an effort to fast-track rebuilding, the city finally turned to modular design in 2017, cutting construction time in half, down to four or five months.

A modular team was set up, which issued procurements and vetted sites for modular viability and logistics. Then in April of that year, a selection of modular vendors occurred. From May to July, over 100 design meetings and approvals took place. This pilot program reduced traditional reconstruction costs by one-fourth and cut the construction schedule in half to as little as four months (NYC Office of Housing Recovery Operations, 2017). Gans & Company was commissioned to create a series of twenty housing prototypes tailored to meet the specific guidelines of BiB, the applicable zoning regulations, and local fire codes. Ultimately, 83 houses were constructed utilizing these prototypes, with the individual modules being fabricated in Pennsylvania, transported to the affected coastal neighborhoods, and installed on-site (Achrati, n.d.).

The renewed drive for modular construction is occurring at a time when other local agencies are responding creatively to the mayor's quest for affordable housing. Many city departments are involved in modular construction, from the Department of Buildings approving permits to the Department of Transportation enabling modules to be moved on city streets prior to stacking (Nonko, 2018).

Roger Krulak, CEO of FullStack Modular, New York City's only modular manufacturer, asserts that the active participation of local government is essential to the success of modular. Krulak cites London, where Mayor Sadiq Khan in 2017 said that the city would spend $32 million by 2021 on at least 1,059 compact, affordable modular apartments. Krulak explains that government-owned land must be developed using modular construction techniques in Singapore. "When modular is promoted at the government level," Krulak explains, "people rush into the industry" (Nonko, 2018).

With the toolkit of the Urban Post Disaster Housing Prototype Program, New York City has built and tested a modular solution for disaster victims displaced from their homes. As a crucial resource, this program not only effectively extends the city’s Coastal Storm Plan, but also constitutes a preemptive step
in the city’s effort to get ahead of the long-term post-disaster housing recovery. There is another reason New York City looked into alternative housing reconstruction methods than the single-family homes or FEMA trailers traditionally used for post-disaster housing as early as 2007. Due to its high population density, lack of open space, and desire to resettle as many residents as possible in or near their former neighborhoods, NYC needed to develop a better approach to interim housing (Chaban, 2015).

The New York City Office of Emergency Management (OEM) commissioned Garrison Architects to design and implement a housing prototype for city inhabitants displaced by a natural or manmade catastrophe. This program resulted in the first urban post-disaster housing prototype being introduced in the United States. One of the primary objectives of this research was to investigate the viability of swiftly constructed housing in restoring a feeling of community and belonging and to ensure that all post-disaster housing could fulfill this objective. The U.S. Army Corps of Engineers oversaw the installation of this multifamily, multistory modular project on an unused city-owned property. On April 26, 2014, the assembly and testing of the prototype were completed in less than 15 hours (NYC Emergency Management, 2018).

Ensuring that interim housing complies with the site’s zoning is also important. Under the Urban Playbook, interim housing will be considered multi-family housing. Currently, only residential zoning R6-10, and commercial zoning C1, C2, and C4-6 can allow for interim housing. Furthermore, the soil condition of the site must be able to support structures, and the slope must not exceed 12% (NYC Department of City Planning, 2017).

The prototype is designed to facilitate people to stay in their neighborhoods, even when they cannot remain in their homes. The prototype originated as a “What if New York City…” competition in 2007. The competition challenged contenders to create innovative temporary housing solutions for new yorkers. Consequentially, a “playbook” was created. NYCEM and DDC also developed the Urban Post-Disaster Housing Prototype Design Guidelines and Performance Specification to serve as the foundation of a Request for Proposals in urban post-disaster housing if it is needed. It outlines a reliable, start-to-finish approach to house residents quickly, comfortably, and safely. It doesn’t have to look like the prototype but equal or better quality (NYC Emergency Management, 2018).

The prototype consists of five modules fabricated by Mark Line Industries of Pennsylvania in Indiana, transported to NYC with trucks, and then installed onsite by the project's general contractor: American Manufactured Structures and Services. The site for the prototype is a 40’ x 100’ parking lot. This project aims to augment federal capacity to deliver multifamily, multistory housing to urban areas post-disaster (NYC Emergency Management, 2018).

James Garrison, head of Garrison Architects, says: “The beauty of the units lies in their inherent flexibility. They can be stacked like Legos to create row housing or interspersed between existing homes and structures. These modules aren’t just for New York City - they were designed to meet the strictest
zoning requirements in the US, meaning they can be quickly deployed to any corner of the country” (NYC Emergency Management, 2018).

Since NYC building codes require non-combustible construction, the interim housings are made of steel. Its cost and durability are similar to conventional buildings. Materials and components must be ordered and delivered to the factory before production can begin. The unexpected soil condition of the site poses some additional challenges. Prototype fabrication costs about $250 per square foot; when producing over 100 units after a disaster, the cost per square foot is reduced to about $185-200. The prototype is designed to be assembled and taken apart quickly for future relocation. The initial investment might seem high, yet the units can be deployed multiple times over a 50+ years lifespan (NYC Emergency Management, 2018).

The transportation of the modules was easier than expected- it took merely two days. “Any module below state-mandated shipping dimensions can travel by land or sea along well-established routes.” Since oversized deliveries are permitted to drive down the center lane of all bridges, transport is allowed only overnight. This limitation could be reconsidered during an emergency. The drivers indicated that of the 700-mile journey, the last 15.4 miles through Manhattan was the hardest part and took over three-and-half hours to complete (NYC Emergency Management, 2018).

The prototype modules were specifically designed to fit within the parameters of NYC’s infrastructure, therefore, require as few permits as possible. The largest module is 40 feet long and weighs 34,000 pounds, just slightly below the maximum legal module length of 42.5 feet and over a ton below the 36,000 pounds limit. Although five module units required oversized load permits, the permits were acquired within two days. The stair and balcony sections were tolled by three trucks, all of them light enough and thus did not need a special permit (NYC Emergency Management, 2018).

In April 2014, although it took only one day for the prototype modules to be craned into place, work done after delivery took two weeks more than expected. This is due to delays in scheduling required inspections that must be done before the certificate of occupancy (C of O) can be granted, and people are allowed to move in. The optimized schedule is nine days, but it took several months for the prototype to receive a C of O (NYC Emergency Management, 2018).

A modular solution has many advantages in a post-disaster context. The most substantial one is that even though local supply chains and labor pools may be imperiled, production facilities outside the disaster area will presumably be available (NYC Emergency Management, 2018). BiB has accelerated dramatically since 2016 after implementing measures to streamline building and zoning standards, expand the pool of contractors, and introduce modular homes to streamline and accelerate the design and construction process. In 2017, New York City resorted to modular housing as a faster and less expensive option compared to on-site reconstruction. The replacement homes are part of the city's controversial, federally-funded $2.2 billion Hurricane Sandy reconstruction program BiB for homeowners (Hu, 2017).
In the New York City Department of Housing Preservation and Development (HPD), however, the government prioritizes multi-family development and specialized locations that can allow modular construction — for instance, staging space is required before modules can be placed. A spokesperson for the NYC HPD commented on future modular construction projects: “We're looking for sites within the city's jurisdiction, in appropriate neighborhoods for a medium-density project, and with the right site conditions to assist with staging concerns,” that modular projects between eight and ten stories are the agency's "sweet spot" (Nonko, 2018). However, a recent conference on modular construction revealed that currently post-disaster modular housing can go as high as two-to-three stories; any higher vertically would risk structural integrity (Gans & Shen, 2023).

**Terminology: Modular Construction V.S. Prefabrication**

According to a book published in Switzerland called *Prefabricated Systems: Principles of Construction* (2012), the origin of the term "module" in architecture is from the Latin word "modulus," meaning "measure.” In ancient times, the term referred to standardized measurements or dimensions, such as the Japanese tatami mat. Le Corbusier, a famous Swiss-born French architect, created a universal measuring system called "Modulor.” Le Corbusier believed that components of houses should be factory-produced just like automobiles and viewed the house as a "machine for living in.” This idea is reflected in his 1922 manifesto, *Toward an Architecture* (Knaack et al. 2012, 16). In architecture today, this term represents a standard unit of measure used to determine the size of building components, which can be further divided into separate elements. This is not to be confused with the contemporary use of the term referring to the fully fitted-out boxes, sometimes interlocking, produced as finished products people work or live in.

Prefabrication is inspired by building techniques dating back to the Mesopotamian civilization in ancient southwestern Asia. What Roman forts, the Eiffel Tower, and post-World War II housing have in common is that they are all built with a specific construction technique called prefabrication (Redshift Videos 2019). Light-frame, slab, modular, and mixed construction are the three types of building systems used in home construction, and on-site and prefabrication (factory-built) are the two methods of building systems. Knaack et al. (2012) describe "prefabrication" as a subcategory of building systems, including all systemized off-site components and elements manufacturing. One of the characteristics of prefabrication is that their construction involves grouping similar construction tasks and leveraging assembly-line techniques to increase efficiency on time, cost, and labor required. Standard industrialized components are frequently found in prefabricated buildings, but a bespoke home composed of these components is only sometimes a prefabricated system. A systemized building method ensures central quality control (Knaack et al. 2012, 38).
While most "modern" building systems suffered from weak branding, the most successful strategies generally depended on the conventional external appearance applied to a fundamentally novel design idea. In Europe, prefabricated architecture was establishing its modern architectural footprint. For instance, Walter Gropius's contributions and, in 1919, the founding of the Bauhaus- the most famous school of art and architecture in the 20th century- gave contemporary European architecture a tremendous boost. Architects closely partnered with various industries, including home goods, painting, and plastic arts, experimenting with new architectural forms for industrial production (Knaack et al. 2012, 16). Despite these attempts, prefabrication took some time to become widely accepted.

Both prefabrication and modular construction include assembling building components off-site. However, there are some significant distinctions between the two ideas. When building components are manufactured in a factory or workshop and then transported to the construction site for assembly, this process is known as prefabrication. Everything from prefabricated walls and roofs to preinstalled plumbing and electrical equipment might fall under this category. Prefabrication aims to increase the effectiveness and speed of construction by minimizing the work that must be done on-site. On the other hand, modular construction refers to a type of construction wherein complete structural components are produced in a factory and brought to the construction site for assembly. These pieces, or modules, are made to fit together to form a whole structure.

Because most of the work is done in a controlled environment, modular construction allows for speedier construction timeframes and greater quality control (Knaack et al. 2012, 7). About 85–90% of modular construction is completed off-site, while the remaining 10–15%, including foundations and utility connections, is performed on-site (Kamali & Hewage 2016). To sum up, modular construction focuses on complete building sections, whereas prefabrication concentrates on specific building components.

**History of Modular Units**

One of the first known prefab houses was a panelized wood home for a fishing fleet shipped from England to Massachusetts in 1670s (Modular Building Institute, 2021). As prefabricated kit houses became more popular in the 1800s, there were examples of prefabricated houses exported from the UK to Australia in 1837. In 1889 in Paris, the iconic Eiffel Tower was erected quickly assembled out of prefabricated iron elements (Redshift Videos 2019; Wilson 2020). Within the United States, in 1849, more than 500 prefabricated kit houses were shipped by rail from New York to California for settlers during the California Gold Rush (Wilson, 2020).

Modern prefab homes were first used in the UK during the First World War. The Austin Village in Birmingham, UK, a WWI housing estate consisting of 200 red cedar wood bungalows, was imported from Bay City, Michigan, where the factory was located (McKenna 2005). After WWII, high-rise slab
blocks and towers were built in the post-war UK in the 1950s, partly due to a labor shortage and reduced construction costs. According to the Modular Housing Handbook (2020), only with innovations such as modular construction could the UK build 5 million public housing units between 1945 and 1980.

Since the early 1960s, prefabrication with concrete has also manifested among social housing programs. The “Plattenbau,” a German word translated as “panel/slab” + “building/construction,” was the response to the post-war housing shortage in the German Democratic Republic (Knaack et al. 2012, 19). In Sweden, 84% of new houses are built using prefabricated units; in Germany, 20%; in Japan, 15% (Koones 2019). In Sweden, short daylight hours and inclement weather frequently impede work on conventional construction sites, making modular methods a reasonable alternative. A small number of large corporations provide robust economies of scale. Most manufacturers are in rural areas near timber resources (Bertram et al. 2019). Large concrete panel systems accounted for 60% of all housing in the German Democratic Republic in 1970, half in Finland in the 1980s, and a remarkable 75% in the Soviet Union by the 1990s (Knaack et al. 2012, 22). Prefabrication has become the predominant building method in the Netherlands because prefabricated concrete elements have become technically perfected and standardized. However, problems due to technical problems such as cracking, leaking, and corrosion led to the abandonment of the technology in Germany and the UK. Primarily due to the need for more planning and development, they directly resulted from inconsistent government support (Knaack et al. 2012, 32).

Modular construction has historically gained momentum in housing markets with a high demand for housing and labor scarcity in the construction industry (Bertram et al. 2019). In the UK, the Ministry of Work in 1948 found that the large concrete panel was the cheapest of the new systems. Hence 1945-1948 prefabrication accounted for 157,000 temporary housing. Later in 1970, it was proven that system building was cheaper than traditional building for all house types (Knaack et al. 2012, 38).

Across the pond in America, while prefabrication also enabled a post-war suburban housing construction boom, modular units were utilized even earlier. In 1906, Oklahoma Cottages were erected in Oakland and San Francisco after the earthquake in order to accommodate refugees. Little, green, transportable "earthquake cottages" were installed in parks and other public areas (Bolton & Unger, 2011). Sam Kullman began manufacturing the popular "Kullman Diners" along the northeastern coast in the 1920s. In 1933, Arthurdale, West Virginia was one of the first of Franklin Roosevelt's New Deal communities to be established. Post offices, stores, apartments, and schools, among other sorts of modular structures, were transported there (Modular Building Institute, 2021).

As early as 1908, Sears Homes were sold in a kit by mail-order company Sears, Roebuck, and Company based in Chicago, which showed that “homes could be standardized and affordable, but attractive and well-built” (Griffin 1999). From 1908 to 1940, over 100,000 well-constructed houses made-to-order were sold and mailed to American families, ranging from pocket-sized English cottages to three-story, five-bedroom suburban houses. Sears Modern Homes was not the first; its primary competitor
Aladdin Readi-Cut Houses began in 1906 and was operational until 1987. Aladdin homes were much more localized and specialized in comparison. However, Sears’ Modern Homes concept stood out from its competitors in offering a complex package over a widespread network. Sears had its own factories. Although most Sears houses could fit into two boxcars via rail, they were usually delivered in sections as the construction progressed (Cooke & Friedman, 2001).

Sears’ houses were sold pre-cut rather than fully panelized. The package includes pre-cut and notched lumbers, nails, building paper, paint and varnishes, lath, shingles, roofing, and windows were all included. The package did not include the foundations, masonry cladding, or plaster. This was quite a remarkable advantage at a time when power tools were not a household item, and local sawmill prices were unaffordable. Cutting lumber and boring holes manually or building the conventional way would take 231.5 hours- or over 28 working days for one person- according to a Sears catalog. All material mailed was numbered and keyed to specific blueprints of each part of the house, and openings such as windows and doors were pre-assembled and trim-precut and shaped. Also included was a seventy-seven-page construction manual. What is more, as a part of the “Ready-Cut” packages, customers assembling the houses themselves could have their labor counted as cash towards the value of the Sears house while seeking financing (Cooke & Friedman 2001).

Maintaining a consistently high sales volume to support pre-cut house production was accessible during the housing crisis, but not so much during the Great Depression in the 1930s. Another significant challenge was the misconception that prefabricated meant substandard. Both government institutions and potential clients certainly had biases against prefabrication, which resulted in the slow pace of change at governmental and financial levels. Sears homes’ biggest failure manifested as it leaned on financing as a marketing tool. In its full determination to achieve the highest sale volume possible, the company offered to finance the kit houses it sold with remarkably ungrudging mortgages, which ultimately sealed its demise. Sears had greatly underestimated the risk of selling at any cost. From 1906 to 1934, Sears sold prefab homes totaling $87,052,000, with a profit margin of $4,295,000. Even so, when the mortgage loan losses are factored in, this profit yielded a net loss of $2,617,000. Furthermore, Sears failed to scale back its sales and production sectors during the Great Depression as the post-WWI housing crisis was petering. Therefore, inappropriate financing decisions, shortsightedness, not poor marketing strategy, nor a subpar product led to Sears’ homes’ demise. In 1940, the Sears Modern Homes program became financially insolvent due to loan defaults and pre-World War II shortages of building materials due to the Great Depression (Cooke & Friedman 2001).

In the late 1950s, modular construction began to be used for schools and healthcare facilities. In the 1960s and 70s, modular construction began to be used to build large-scale hotel projects. Paul Rudolph created the Oriental Masonic Gardens in 1968 for low-income households in New Haven, Connecticut. Cranes positioned trailer-like boxes into double-story pinwheel arrangements defining garden sections after they had been trucked to the location. This prefab co-op is a systematized residential project on two
levels, representing a nonhierarchical democratization of modules and places. First, Rudolph adopts a
social position by accommodating people's demands with room-sized modular components grouped
around a core for each dwelling. It is also an example of a spatial system—a layout with protected areas
scattered throughout the complex and the capacity to "stretch out." (Knaack et al. 2012, 36). In 1969,
Zachry Construction completed a 21-story modular hotel on San Antonio's Riverwalk using modular
building technology. In 1972, Disney Corporation's Contemporary and Polynesian Resorts, constructed by
U.S. Steel, were completed (Modular Building Institute, 2021).

The popularity of modular building has fluctuated in the United Kingdom and the United States and
remained an uncommon approach. Although the Modular Building Institute was created in the early
1980s, government agencies in the Western hemisphere have not legally recognized and officially
regulated the term modular (Ortiz 2019). However, it has become mainstream in some parts of the world.
Japan has capitalized on synergies with other industrial industries, for instance. The enormous volume of
modular units guarantees economies of scale and reduced production costs. It has also become a premium
product, with modular homes frequently selling for a higher price due to a significant emphasis on quality,
especially seismic resistance. In lieu of a general construction code, inspections by industry-specific
qualified personnel have been one of Japan's primary enablers. Hong Kong, Singapore, and mainland
China have used prefabricated/precast components to construct private and public high-rises for over two
decades (Xu et al. 2020). In China, 30% of all new constructions in 2017 were prefabs (Curry 2016). In
2016, the market share of permanent modular construction was the largest in the office and administrative
(4.86 percent), commercial and retail (3.53 percent), and education (3.50 percent) sectors. In 2017, the
estimated overall market share for permanent modular construction rose to 3.27 percent from 3.18 percent
the year before (Wilson 2020).

The ecosystem in the western United States is characterized by fragmentation and small-scale
operations, with approximately 200 manufacturers of low capacity. However, a recent shift toward offsite
manufacturing has been driven by high and increasing wages in skilled trades such as electricians, which
are related to a sustained construction boom exceeding capacity and driving up wages. As a result,
modular construction has become a cost-effective alternative. Significant investors, including SoftBank,
Alphabet (Google's parent company), and Amazon, have invested in prefabricated home developments
and builders, such as Katerra, RAD Urban, and Factory OS (Bertram et al. 2019).

In 2020, MBI reported market shares of modular construction: Office & Administrative = 25.8%;
Multifamily = 20.7%; Education = 15.9%; Other (hospitality, equipment shelters, bathroom pods) =
15.6%; Institutional & Assembly = 8.1%; Retail = 7.4%; Healthcare = 6.5% (Modular Building Institute,
2021).
Dubious Reputation Leads to Limited Applications and its Rebirth

Despite their demonstrated benefits, numerous barriers prevent modular construction's wider application. For instance, in a modular approach, many decisions must be made earlier in the design process. Furthermore, since much of the work is performed off-site, a higher level of coordination between parties involved becomes critical to address matters such as construction tolerance and scheduling (Wilson 2020).

Prefabricated homes took a while to catch on since they gave people a tense sensation and are thus often associated with bad connotations. Since WWII, the reputation of modular construction has suffered substantially. The commercial use of building systems exceptionally has had a troubled history. As early as 1946, prefabrication had developed a notorious reputation. During the post-WWII housing crisis, many prefabricated structures were erected to house returning veterans. Although they were meant to be permanent dwellings, little attention was paid to structural durability. It did not help that the buildings looked banal, unappealing, and lacked individuality (Cooke & Friedman 2001). Even though site-built homes were the standard in the middle of the 20th century, the general public frequently saw prefabricated buildings as poor quality and lacking in personality. In the UK, prefabs also inherited a notorious reputation. The negative impact of poorly planned prefabricated buildings using exposed concrete made “prefab” almost synonymous with everything wrong with public housing, most notably, the Aylesbury Estate in south London (Bayliss & Bergin, 2020). As a result, the building industry did not develop other innovations for the next two decades. This belief persisted throughout the 1960s and evidently stifled the industrialization of architecture. A unique product is still seen as a handcrafted masterpiece, and the industrialized house must evoke visions of a lovely residence despite its repetitive nature (Knaack et al. 2012, 8-16).

Due to technology advancements like automation and computer-aided design, however, prefabrication has had a rebirth. Modular construction has grown in popularity recently (Knaack et al. 2012, 28). As a result, prefabricated buildings are increasingly viewed as a financially sensible and environmentally friendly choice for building dwellings. Their popularity has also grown thanks to the capability of building homes off-site, away from the effects of the weather and other site-specific difficulties (Knaack et al. 2012, 16). Despite these fluctuations in perception, prefabricated modular construction has consistently demonstrated its usefulness as an effective means of building, especially in disaster-stricken areas (Knaack et al. 2012; Schoenborn 2012).

The difficulty in determining the benefits that off-site construction brings to a project is a major factor in clients' reluctance to accept innovative construction methods. Kamali and Hewage’s research (2016) confirmed that despite the numerous well-documented advantages of modular construction processes, their applicability is currently limited. Between 2000 and 2014, the US modular industry accounted for only 2–3% of all new single-family homes and equal to or less than 1% of all new multi-family homes. The advantages of utilizing off-site construction procedures were unclear for many
individuals involved in the construction process. Consequently, judgments concerning modular construction generally rely on anecdotal information instead of rigorous statistics (Kamali & Hewage 2016).
Figure 6. : Mapping of the Literature Review
The Disaster Paradox

A disaster multiplies human needs in the community as a result of "disruption to the public health, health care, behavioral health, and social services systems that collectively support human recovery…and diminishes a community's capacity to help individual community members and families recover" (Institute of Medicine et al. 2015, 14). There have been notable hiatuses, isolation, and fragmentation in the systems that support post-disaster recovery. Specifically, transparent, accountable leadership and a national strategy or framework for meeting human recovery needs are notably lacking. Despite its tragic and elongating impacts, a disaster should not change the long-term vision of a community, just the steps to achieving it (Smith 2015).

Statistics (Parry et al., 2007; FEMA, 2013; NCDP, 2015 & 2016) show that communities and individuals often have the most interest in mitigating the risk of natural hazards after a disaster has made the risk more salient. Before a disaster, that risk is often dismissed or simply not a priority. A flood draws attention to substantial risk and creates the political will to address it (Kousky & Shabman 2017). This is also known as the “disaster paradox.” Researchers have long observed that most aid and recovery programs have focused on short-term relief, with little connection to long-term development, various socioeconomic conditions, or local needs and capacities. Normally, disaster aid increases immediately following a disaster. As disasters lose relevance in the media and public and policy attention wanes, so does disaster aid. This instability in disaster relief has ramifications for long-term recovery, particularly for people that rely on this assistance (Esnard & Sapat, 2014).

Moreover, aid distribution may not have been adequate, especially for displaced populations who depend on it for their long-term survival in terms of shelter and other essentials, and typically neglected renters (Esnard & Sapat, 2014). The US government’s current structure of funding disaster recovery fails to address urban problems holistically. For instance, FEMA does not spend enough money on mitigation, creating a funding gap. This mitigation gap increases as time goes on. Historically, the government has separated long and short-term actions: temporary housing built without community recovery planning. This divide/time gap can be addressed by implementing modular units.

Comparisons between disaster relief and recovery expenditures and mitigation expenditures illustrate the costs associated with recovery. A 2009 study indicates that disaster relief expenditures are significantly larger than disaster prevention and mitigation expenditures. From 1985 to 2004, the federal government spent an average of $3.05 billion annually on disaster relief and $195 million annually on disaster preparedness. Furthermore, research conducted by the Multihazard Mitigation Council (MMC) and financed by FEMA between 1993 and 2003 revealed that every dollar spent on mitigation saves society an average of $4 (Esnard & Sapat, 2014).
Local Government’s Role in Post-Disaster Housing

An examination of the literature on U.S. disaster recovery reveals that a disproportionate amount of emphasis has been paid to local and federal government actors, while less effort has been made to comprehend the roles that state, especially state agency officials and governors, play in this process (Smith et al., 2018). Moreover, Smith et al. (2018) concluded that despite modest progress, the extent to which states and FEMA engage in coherent, coordinated pre- and post-disaster recovery planning remains highly varying. This is due to the absence of a clear national policy that addresses larger, more systemic challenges, such as enhancing the capacity of state and local governments to plan for recovery.

Providing post-disaster housing for cities in a timely manner can be challenging due to the lack of available stockpiled urban units. It is not recommended to store these units due to high storage costs, and varying code requirements make it challenging to have a one-size-fits-all solution. In most cases, the production of urban dwelling units does not start until after a catastrophe occurs, according to the NYC Emergency Management in 2018. Nevertheless, the city must have a plan to provide prefabricated units to meet the housing needs of displaced residents after a disaster.

What exactly is “interim housing”? As defined by NYC, interim housing is the “period of time between when a resident is displaced and when they obtain housing they can afford without disaster assistance” (Wener 2014). FEMA’s National Disaster Housing Strategy recognizes that “identifying interim housing solutions for disaster victims...is arguably the most demanding facet of disaster housing” (Department of Homeland Security, 2015). According to a report by the Regional Catastrophic Planning Team (2015), interim housing grapples with the planning gap in housing for those who cannot return to their homes when emergency shelters close. Through financial or direct assistance such as the Individual and Household Program (IHP), whereas FEMA supports temporary housing for up to 18 months unless an event of a disaster is recognized as a Catastrophic disaster, IHP is available for 24 months or more.

Johnson (2007) emphasized the importance of matching design to local resources and drawing on local industry. She concluded that regardless of the sort of temporary housing, it must first be readily available and then utilize local resources and industries to avoid delays in transportation if purchased internationally. This would enable the government to offer desperately needed temporary homes while bolstering the prefabricating industries.

Prefabricated temporary housings can be decommissioned and stored for use in future crises. In Turkey, there is a large storage and restoration facility in Ankara for temporary housing; numerous container-type units were transferred there for repair and reuse in the next natural disaster or for donation to nations affected by earthquakes. In the United States, the government provides temporary housing as trailer houses that are recovered, refurbished, and stored until the next natural disaster. Nevertheless, transport, refurbishment, and storage may cost as much as a brand-new item, making rehabilitation and storage not always cost-effective. For instance, in Greece following the 1986 Kalamata earthquake, one of
the justifications for the use of temporary housing was that it might be preserved for future use; however, the poor state of the buildings after their first use and the storage expenses rendered this impractical (Johnson, 2007).

Factors Hindering the Use of Prefabricated Housing

In America, traditional federal assistance is often geared towards providing individual housing and primarily focuses on homeowners. Moreover, post-disaster temporary housing is often constructed in areas with large open spaces, resulting in designs like suburban housing—for example, the Katrina Cottage. Most temporary housings are either trailers or manufactured freestanding single-family homes sited individually or within a trailer-park-like context. Neither is ideal for a dense city like New York City, with minuscule land for redevelopment and where the displaced population greatly exceeds existing housing resources. Given its disproportionated percentage of the population being renters than homeowners, as well as only one existing commercial trailer site, the traditional stratagem to post-disaster modular housing would be nearly impossible to deploy successfully in NYC (NYC Emergency Management, 2018).

Compared to conventional projects, ensuring compliance with building codes may expand the scope of engineering work and increase initial expenses. There might be uncertainty regarding applying the building code to modular projects. This may discourage some owners from constructing modular (Wilson 2020). On the contrary, modular buildings are fabricated in conformance with the same building codes as traditional on-site construction (Bertram et al., 2019), with no additional provisions regarding the usage of modular construction. However, because the applications and approvals process for modular building differs from that of conventional construction, it might be a hurdle for inexperienced project teams. In addition, some states do not have governmental programs to regulate modular building and provide project teams with requirements for alternate applications and approvals processes for modular construction, despite many states currently having such programs (Wilson 2020).

According to Wilson (2020), even though the code requirements for modular projects are the same as those for conventional projects (based, in most jurisdictions, on the International Building Code), and even though there are no special provisions regarding modular construction methods, the ways in which the codes are applied and inspected are different for modular projects. This is because modular projects are built using prefabricated components assembled on-site.

Like their private-sector counterparts, public-sector enterprises can enjoy cost savings and productivity gains by adopting a modular approach for large-scale publicly funded projects with recurring aspects, such as hospitals, schools, and shelters. By combining these projects across multiple cities, regions, or states, government clients can make a greater impact. The development of standards by government clients might push many manufacturers to use modular construction, thereby affecting the
entire industry. Additionally, the public sector can encourage modular adoption by upgrading building codes, which is consistent with the goal of removing barriers to more affordable housing. Streamlining building standards can increase manufacturing efficiency in varied countries, and product designs and production procedures can be approved in factories instead of on individual job sites. This can lead to quicker and more effective approval processes, lowering the inspection burden on-site to merely assembly verification (Bertram et al. 2019).

Site selection is the first step of the iterative interim housing selection. Many regulatory and constructability factors weigh the selection of an appropriate site. Some key considerations include a complete site assessment- areas that would become accessible within the first week after the storm are considered first; equipment such as trucks and cranes required to deliver and construct the units must be able to reach the site. As time passes and recovery efforts proceed, more areas will become available for site selection, which requires coordination with debris management/road clearance, food and supply distribution, and search and rescue operations (NYC Emergency Management 2018).

Since interim housing happens contemporaneously with permanent housing reconstruction, sometimes even in proximity, the use of land for interim housing is primarily weighed against other post-disaster needs and the community’s long-term recovery plan. Other constructability considerations include 1) whether or not the site unoccupied by buildings is under repair or being rebuilt; 2) within two years or the expected timeline of interim housing, whether there are plans to rebuild or redevelop the site permanently; and 3) whether or not the site is currently used for other recovery efforts (NYC Emergency Management 2018). For these reasons, intact buildings or under repair are automatically excluded from potential sites. In contrast, sites with destroyed buildings or sustained damage so much that they are deemed for demolition would be listed as potential sites.

It is impossible to implement the design process without the permission of the site’s owner. Since it might be challenging to locate landowners: some might be displaced by the storm; land publicly owned—such as by the city, state, federal, or multi-state authority—is strongly preferred over privately-owned properties, such as those owned by individuals, developers, institutions, or not-for-profits. Furthermore, multiple lots are potentially more complex than a single lot because a single lot usually only has one owner, whereas multiple lots might have multiple owners (NYC Emergency Management 2018).

Flavelle (2022) writes that “the biggest problem we have in disaster recovery funding is the gap between sheltering and permanent housing,” and uncovers that most of FEMA’s departed mobile homes are sold rather than reused. According to agency data, the majority are sold for 10 to 15 percent of what it cost FEMA to furnish them, including hauling, installation, and the trailer itself. According to FEMA, installing and removing a mobile home on private property costs an average of $232,800. Transportation and maintenance costs amount to $30,900, while administrative expenses total $41,200. If a trailer is located in an RV park or other commercial location, the average cost increases to $252,600 (Flavelle,
Furthermore, FEMA claims that “its main role is to supply temporary relief, not to fund permanent repairs or buy new homes for disaster survivors” (Flavelle, 2022).

### Advantages of Modular Construction

To build larger buildings, modules are standalone, three-dimensional portions or partially completed pieces that may be stacked or linked side by side. Before being shipped, they are usually approximately 95% fully furnished with the necessary living quarters, storage areas, kitchen, and bathroom amenities. The primary benefit of modular construction is that it may be put to use right once it is connected to power and water sources (Knaack et al. 2012, p.48).

According to Yan et al. (2011), the benefits of modular construction as a post-disaster housing option are significant. They include streamlined logistics, reduced need for resources and construction workforce, high-quality control, and flexibility in design and customization. By relying on a single source of solutions, modular construction can simplify the post-disaster housing process and provide a foundation for recovery and rebuilding for affected communities. Although the availability of resources may not be addressed by modular building as an innovative technology, it can significantly lessen the strain of seeking resources. Modular construction may enhance the lives of impacted people and provide the groundwork for recovery and reconstruction in the wake of a disaster by offering rapid and effective housing alternatives (Gunawardena et al. 2014). Modular construction can comprehensively answer the problems associated with traditional building techniques for post-disaster home rehabilitation. Its benefits make it a widely sought-after option in disaster-stricken areas, even if there may still be obstacles to overcome in terms of resource and finance limits (Shahzad et al., 2022). The total financial savings are as high as 5.5% (Lawson et al., 2012).

A crucial element of success is including a small number of partners in the repair process. Modular construction reduces the need for a large construction workforce and equipment on site, which can be beneficial in post-disaster situations where resources may be limited. Because the home is already constructed by the time it arrives at the building site, modular construction, by nature, includes a minimal number of parties. As practically all of the construction components would be integrated into a single module before it left the production facility, the disaster relief effort would rely on a single contractor rather than several distinct contractors and subcontractors. Most of its construction is carried out as pre-organized mass manufacturing, which is streamlined and will be relatively unaffected by the circumstances such as bad weather. Before modular components are erected on site, most processes are already integrated. This aspect of modular construction will make the entire post-disaster housing process simpler. The fact that much of the knowledge in rebuilding is focused on one source of solutions is a significant benefit of employing modular buildings as a post-disaster housing option (Gunawardena et al., 2014).
Modular construction offers a high degree of flexibility in design and customization. Modules can be pre-engineered in order to provide residents with a better interior atmosphere to function in various climatic settings. This allows for the creation of unique and innovative housing solutions that can meet the specific needs of the affected community, such as incorporating features for people with disabilities or special needs. The modular design also allows for easy adaptation and expansion over time as the needs of the community change, making it a long-term and sustainable solution for post-disaster community recovery. Furthermore, a higher level of readiness and using already prototyped modules with well-established manufacturing logistics can speed up the delivery of finished goods (Gunawardena et al., 2014).

Modular building has several environmental advantages. One advantage of using modular systems is that they help reduce emissions of greenhouse gases (GHG) by 30 percent right on the job site (Modular Building Institute, 2021). When construction time is cut down, there is less need to use energy, fewer trips made by workers, and suppliers and subcontractors make fewer journeys to the construction sites (due to material delivery in bulk to the factory plants). Less waste is another of its most important benefits, resulting in more exact purchase, planning, and cutting of materials. In reality, modular buildings generated 75% less wood and drywall waste per project than site-built homes (1,380 lbs. for modular vs 5,500 lbs. for conventional) (Modular Building Institute, 2021). This is because monitoring, reusing, recycling, and disposing of trash in a modular production setting is simpler. In addition, towards the end of the life cycle of modular structures, modules can be disassembled, moved, or reconditioned for use in other projects rather than discarded. In spite of the fact that modular constructions create less waste, 10–15% more materials are required to provide the requisite structural strength (Kamali & Hewage, 2016). Whereas conventional building techniques cause disruptions to the activities of the construction site by means of on-site construction time, noise, dust, congestion, and trash, modular construction is superior since it causes far less disruption to the project site (Kamali & Hewage, 2016).

As previously mentioned (Lawson et al., 2012), it has been discovered that using prefabricated modular structures significantly reduces construction waste, mainly by reducing waste material (Modular Building Institute, 2021). Site wastage is reduced by up to 70%, demonstrating the environmentally friendly nature of modular construction and its commitment to energy-efficient solutions. As a result, there is an improvement in energy efficiency, reduced costs, and a shorter building schedule (Gunawardena et al., 2014; Shahzad et al., 2022). Rogan et al. (2000) compared the costs and benefits of modular construction to traditional construction methods for a typical four-story residential structure in London, in addition to the mentioned advantages of modular construction. Even though the upfront expenses for modular construction were just 2% more, it has been demonstrated that over the course of the building's existence, it offers several benefits over conventional construction techniques. The findings demonstrated that modular construction has advantages for both the builder and the customer, with a predicted turnover of 39% higher and an internal rate of return (IRR) of 43% greater (Rogan et al., 2000).
In addition, modular buildings can be energy-efficient by streamlining the building process and reducing the need for large amounts of resources, which can help reduce long-term energy costs and provide a more sustainable solution. Another advantage of modular construction in disaster-stricken areas is its ability to quickly transport and assemble in the affected area. This allows for quick deployments of temporary or permanent housing solutions, which is especially important in remote or hard-to-reach areas.

Modular structures have been demonstrated to be more ecologically friendly, offering energy-efficient solutions and time-efficient. By using mass production facilities, many homes can be built and installed quickly, reducing the amount of time required for the impacted communities to resume their everyday lives. The time savings offered by modular construction can also mitigate the potential impact of rising labor and material costs and currency rate swings, thereby reducing the project's overall cost. The findings of Lawson et al. (2012) further reinforced the time-saving benefits of modular construction. By reducing the expected on-site time for construction by 50% and improving productivity by 80%, modular construction offers a more efficient solution than traditional site-intensive building approaches. The time efficiency of modular construction, combined with its environmental and cost-saving benefits, makes it an attractive option for post-disaster housing reconstruction efforts. Moreover, by avoiding labor and material cost changes over time and currency rate swings, the project's funding will see even higher savings (Gunawardena et al., 2014). Other considerations, such as a reduction in on-site overhead, the avoidance of adverse weather, the uniformity of design, a high level of energy efficiency, and increased installation efficiency, might also contribute to cost savings (Ramaji & Memari, 2015).

The modular design also allows for easy customization to meet the specific needs of the affected community, such as incorporating features for people with disabilities or special needs (Gunawardena et al., 2014). Furthermore, modular construction reduces on-site reportable accidents by 80% (Bayliss & Bergin, 2020; Lawson et al., 2012). A higher degree of education and expertise is necessary to work in a prefabrication factory as opposed to traditional on-site building, which is a key socioeconomic benefit of modular prefabrication. By closely supervising and training factory employees, construction-related accidents can be reduced, making these jobs safer. Individuals who previously would not have considered a career in construction may become more interested in the industry as a result of safer, cleaner, and more accessible employment opportunities. This may allow for a more varied workforce in future factory-based construction occupations (Bayliss & Bergin, 2020).

According to Rogan et al. (2000), the lead time for delivering modular homes may be pronouncedly shortened if the constituent components have previously been planned, produced, and prototyped. Industry standards state that if the components have already been prototyped, the lead time might be as little as six to eight weeks. The precise lead time, however, may change based on elements such as the production plant's location and how close it is to the disaster-affected area. Additionally, the production of prefabricated modular homes takes place away from the building site in a controlled environment, reducing the time needed for construction. After being built, the dwellings may be moved and put together
in the disaster-affected region, significantly reducing the time needed to offer long-term housing alternatives for individuals impacted. Individual processes can be scheduled to occur unimpededly and geographically apart from one another in specialized factories thanks to prefabrication. There are no unfavorable weather conditions within the factories. The layout of the floor area can be optimized for the production process and the usage of specialized technology, such as automated systems and assembly lines. The ability to closely monitor and achieve higher-quality standards during each production stage is another benefit of prefabrication in the factory (Knaack et al., 2012, p.92).

Furthermore, techniques like Building Integration Modeling (BIM) may be utilized to quickly gather and route all such design requirements from a disaster-affected community to the designers. BIM can facilitate the coordination of prefabricated, modular, and on-site transportation schedules. The optimal size for transporting modular or prefabricated components is contingent on a number of factors, including government size limitations, project location, availability of staging locations, optimal crane size, and final building proportions and massing (BC Housing et al., 2014). Indeed, BIM can play a crucial role in improving the efficiency and effectiveness of post-disaster housing reconstruction efforts. BIM creates virtual models of building structures, which can be used to analyze and optimize building design, construction processes, and facility management. BIM can streamline communication and collaboration between various stakeholders, such as designers, contractors, and community representatives, and ensure that all requirements and expectations are clearly understood and met. In the context of post-disaster housing reconstruction, it can quickly gather data and feedback from the affected community and incorporate it into the design process, ensuring the new housing solutions meet the community's specific needs and preferences while designed to be both functional and livable. BIM can also help to identify potential challenges and risks early in the design process and allow for effective risk management and mitigation strategies to be put in place. Modular construction is a fantastic method to guarantee that the impacted people's livelihoods are restored to their contentment and that their fundamental human rights to permanent housing are met as soon as feasible (Gunawardena et al., 2014).

On average, multi-family residential projects take 385 days to complete from approval to occupancy (Modular Building Institute, 2021).

**Disadvantages of Modular Construction**

Because the prefab home is a factory product and needs much more than a brilliant design to sell, the architect needs a business partner to construct the product. Limitation of prefab includes: The design must be able to be divided into prefabricated parts appropriate for industrial manufacturing if a portion of a building is to be prefabricated. Modules must be specified in terms of their weight, size, and surface resiliency to facilitate their handling and transportation during installation (Wilson, 2020).
The general public has a negative perception of modular construction, which has been proven in a number of studies (Cooke & Friedman, 2001; Kamali & Hewage, 2016; Wilson, 2020). It is a crucial factor that slows down the expansion of off-site construction practices worldwide. It is a frequent misconception especially in the United States that mobile homes (also known as manufactured houses) are identical to modular and prefabricated homes, despite the fact that there are significant differences between the three types of structures. Between 1954 and 1968, 25 percent of all single-family dwellings in the United States were manufactured mobile homes constructed as a module on a chassis (Boafo et al., 2016). It is possible that a lack of awareness on the side of end users (customers) on the benefits and numerous opportunities afforded by off-site building techniques might have an effect on market demand, and as a result, stiffened the growth of these techniques. Among architects, Knaack et al. (2012) discovered that prefabrication’s negative reputation is because it provokes a fear that notions such as intelligent/critical thinking, innovative architecture, and the profession of architecture are all becoming defunct.

Research (Schoenborn, 2012) discovered that the effect of off-site construction on project costs is not entirely evident due to the numerous factors involved. Among the unknown variables is the absence of access to secret project financial information and the utilization of current equipment. According to Schoenborn (2012), if the cost sources of modular construction are not well handled, modular structures can be more expensive than conventional buildings. For instance, cost reductions attributable to time savings (i.e., "time is money") might be countered by transportation or extra technical expenses in modular construction.

The modular design approach is very different from the typical design approach. Significant pre-project planning and engineering are necessary to ensure the success of prefabrication, pre-assembly, and modularization. These three processes are sometimes referred to as "pre" processes. In addition to the difficulty of the design of the modules themselves, additional considerations are required when combining diverse components within a module and when modules are lifted, transported to the final project site, and assembled to form the building. These additional considerations are on top of the complexity of the modules’ design. A higher level of accuracy must be achieved before the component may be manufactured or assembled. Because of the complexity of the interconnections between the modules, complex systems require more technical design. If the scope of a project is not clearly specified before construction begins, it will be difficult to make revisions once construction has begun (Kamali & Hewage, 2016).

Effective coordination is absolutely necessary for the many stages of a modular building project, such as the pre-project planning, procurement, supply chain scheduling, installation, construction, and delivery stages. The construction and installation phases both demand careful attention. Communication needs to take place often among all parties engaged in the project, including the owners, engineers, designers, suppliers, and contractors, so that all of the required information, such as decisions, designs, transportation requirements, and timetables, can be accessed timely (Kamali & Hewage, 2016).
According to experts, sharing technical skills with those involved in disaster relief operations might impede or slow down the process. Various resources would need to be called upon at different times by different contractors in site-intensive constructions (Yan et al., 2011). The knowledge gap (Abdul Nabi & El-Adaway, 2022) in a significant home rebuilding operation is exacerbated because many disaster relief initiatives involve non-technical parties, such as locals and catastrophe victims. As a result, many of these individuals could lack the required building technical knowledge (Gunawardena et al., 2014). On the other hand, prefabrication encourages a cumulative development of technical knowledge such as connections, details, and technical standards because the profession steadily involves more areas of responsibility. The pace of delivering housing solutions is significantly influenced by the institutions and appointed officials' knowledge of the relevant technology. The better quality requirements that can be guaranteed since the modules are built in a setting with strict quality control, like a manufacturing facility, will improve customer satisfaction (Knaack et al., 2012).

Another determinant is regulation. Installing all necessary machinery at a modular manufacturing plant necessitates a sizable initial investment for the company to begin production. Standards for quality certification and warranties are crucial elements that can enlighten and inspire client confidence. In addition to simplifying the provision of financing, development financiers and mortgage lenders require specific certifications and warranties in order to approve loans. As economies of scale are achieved and insolvency risk is mitigated, funding will become easier. Governments might encourage offshore manufacturing by including offshore manufacturing objectives in public initiatives (Bertram et al., 2019).

Ramaji and Memari (2015) revealed several transportation restraints. Regarding the commercial feasibility of modular systems, the relevance of transportation and logistics cannot be overstated. It is recommended that the modular project team investigate the region's module transportation limits before moving forward with any design phases. In addition to becoming familiar with the fundamental transportation rules, it is essential to investigate the specific requirements for traffic control allowances (such as staging areas, etc.) posed by highly populated areas. Because of the high costs involved and the complex planning required, transporting fully finished homes or modules to remote locations is often not viable (Lawson et al., 2014). In most cases, the greatest distance a cargo may travel is a limitation placed on modular production. The shipping laws of each nation may impose dimension restrictions on the module, creating an extra barrier to passage. The means of transport and the route it takes can sometimes impose restrictions on the modules' dimensions, weight, and size. In addition, delays might be brought on by the requirement of licenses for larger components or by delays brought on by customs at international crossings. While some research suggests that it can be beneficial to have modular or pre-fabricated units in storage, other research suggests there are also risks to storage. Even if disaster-ready modular modules are in storage, it can be difficult to transport them over vast distances or highways that have been damaged. Furthermore, transferring units individually to the location may take too long if many households are displaced (BC Housing et al., 2014).
Literature (Ramaji & Memari, 2015) indicates that when the number of stories in a modular project (e.g., multi-family vs. single-family structures) increases, the time savings diminish significantly because the project becomes more sophisticated, necessitating additional engineering, communication, and job site labor. Despite the fact that the project is a high-rise building, modular buildings are nevertheless completed faster than traditional ones. Shahzad et al. (2022) discovered that poor manufacturing capacity is identified as an obstacle that hinders the implementation of modular offsite building. This problem could be amplified in case of emergency and disaster. In addition, the state of the regional economy is a factor that is considered when choosing whether or not modular building services will be introduced into a particular location. Modern building practices may not be economically viable in places where labor is readily available at a low cost. Similarly, one of the limitations is the scarcity of competent and experienced experts, such as engineers and designers with sufficient expertise working with modular systems. Another considerable challenge is presented in the form of trying to locate off-site construction specialists, suppliers, and contractors instantly (Kamali & Hewage, 2016). Another downside of the prefabricated alternative is the investment expenses for industrial buildings and equipment, which must be considered (Knaack et al., 2012, p.92).

Kamali and Hewage (2016) concluded that a few different research projects have focused on the various positive aspects and potential drawbacks of adopting cutting-edge construction methods like modular building over the past several years. Despite this, most existing research uses qualitative, rather than quantitative, language to discuss the benefits and drawbacks of modular building. For instance, no transparent and trustworthy cost evaluations, such as life cycle cost analyses, demonstrate that modular constructions are superior to traditional buildings that are identical in every other way (from an economic point of view). In addition to that, the price should be brought up specifically. When comparing the various construction methods, using "cost" as a monetary measurement cannot be utilized as a reliable decision-making criterion because there are many different construction procedures. As was shown earlier in this investigation, the modular building has a number of extra advantages that can lead to indirect cost savings (also known as added value). Some of these advantages include increased work speed, productivity, and safety (Modular Building Institute, 2021). In contrast, the "economy of scale of production" is a significant factor to consider when selecting a construction approach, which is why the modular building is such a popular option. It is possible that using a traditional construction technique rather than a modular plan will result in lower overall construction costs for irregular builds or modules that are not repeated. Currently, there are limited studies on the environmental impacts of the modular construction technique. One of the reasons why there are fewer studies could be that modular construction is relatively new compared to traditional approaches. As a result, there is insufficient knowledge and data based on actual projects backed by modular building manufacturers/developers to conduct various assessments (Kamali & Hewage, 2016).
Therefore, a disaster management organization should have standard designs for various module types to accommodate various post-disaster circumstances. The planning and lead-in periods will be significantly reduced since certain module types will be pre-designed and pre-engineered. However, this shows that the parties participating in disaster relief activities would profit significantly from the modular construction if they can plan and be ready, ideally before a tragedy occurs. Given the enormous number of homes that are frequently needed after a natural catastrophe, suppliers will need to be able to provide a significant number of modules quickly. However, because economies of scale will favor modular construction more than traditional methods, it will still be best able to meet this high demand (Rogan et al., 2000).

Standard designs can also help ease modular structures' transportation, installation, and maintenance. The modular components can be easily transported to disaster-stricken areas and quickly assembled on-site, reducing the time and effort required for construction. Additionally, standardization makes it easier for maintenance crews to access and repair the structures if needed, leading to a longer lifespan for the modular structures. The many benefits of modular construction, including time efficiency, resource efficiency, and cost savings, have made it a highly desirable solution for post-disaster housing reconstruction. Techniques such as BIM have further improved the effectiveness of modular construction by streamlining the design and construction process. When disaster management organizations have standard designs for various module types, the lead-in time for construction can be reduced to as little as six to eight weeks, allowing impacted communities to return to their livelihoods sooner. However, modular construction still needs to be widely adopted in the United States, and there is a need for more education and awareness to promote its benefits and encourage its use in disaster-stricken areas (Knaack et al., 2012, p.37).

Knaack et al. (2012) mentioned that despite its potential benefits, prefabrication has faced several challenges in its design and implementation, including a lack of standardization, quality control issues, limited design options, and a lack of widespread understanding and acceptance among stakeholders, such as clients and contractors. The book highlights that there are often logistical challenges in the transportation and on-site assembly of prefabricated components, resulting in increased costs and longer construction schedules. However, the book points out that despite these challenges, the use of prefabrication has grown in recent years as construction professionals continue to search for more efficient, sustainable, and cost-effective methods of building. The future of prefabrication is brilliant because of technological advancements and improved cooperation between architects, engineers, and contractors. It might become more prominent in the building sector in the upcoming years (Knaack et al., 2012).
Post-Disaster Housing Solutions and the Katrina Cottage

Traditional post-disaster housing solutions, such as travel trailers and manufactured homes, are based on the statutory supposition that temporary housing assistance will not be required for more than 18 months (El-Anwar 2013). Direct housing assistance is offered for up to 18 months from the date of the disaster designation for survivors who qualify. The 18-month eligibility period is decided solely by the date of the disaster designation, not the date of the applicant's move-in. The 18-month timeframe is established by statute. The selected state may request an extension of FEMA's direct housing mission based on its needs. If the affected state requests and FEMA approves an extension to the original 18-month program term, FEMA may extend the site's closure date with the landowner's consent due to extraordinary circumstances (FEMA 2023). Often, an extension would be granted. Survivors residing in group sites are exempt from paying rent for the first 18 months following the disaster designation. If the program is prolonged beyond the first 18-month period, FEMA is compelled by law to begin charging rent. The rent is based on the Fair Market Rate established by Housing and Urban Development (HUD) for the local area (FEMA 2022).

FEMA works with low-income survivors whenever possible to reduce their rent (FEMA 2023). For instance, according to a FEMA press release (2022), individuals residing in the affected area who can provide legitimate proof of their income after the disaster and meet the Very Low-Income Limit set by HUD will be eligible for the significantly reduced rent of $50 per month. For households whose combined earnings exceed the Very Low-Income Limit but still want to request a lower rental rate, they must provide documentation of their post-disaster income and current housing expenses, such as mortgages, to evaluate their financial capability to pay rent and determine the appropriate rent amount. However, given the unaffordability of housing markets, it is extremely challenging for displaced families to find affordable permanent housing solutions to vacate FEMA's temporary housing after the planned 18 months. The widespread destruction accompanying large-scale natural disasters challenge the effectiveness of typical temporary housing methods in meeting the victims' housing demands.

In the Gulf Coast region of the United States, Hurricane Katrina (August 2005) obliterated the housing stock and displaced more than 330,000 families. This housing problem was aggravated by Hurricanes Rita in September 2005 and Wilma in October 2005. According to a 2009 FEMA report, after Katrina, temporary housing was used for as long as 44 months (El-Anwar 2013). FEMA's resistance to change and strict definition of “temporary” led Congress to strip FEMA's housing authority in May 2006. By December of that year, millions were invested in the Katrina Cottage, a small, hurricane-resistant home that could be placed in the yard of a damaged structure while the owner repaired their home (Evans-Cowley & Kitchen 2011). Katrina Cottage is extremely affordable, with its construction cost averaging $42,000 in 2008.

The 380-square-foot Katrina cottage was constructed to withstand winds of at least 150 miles per hour. These cottages can be installed in the yard of a damaged residence to serve as temporary housing.
while the owner rebuilds. The cottage has garnered widespread media notice in North America. The cost of a cottage is equivalent to that of a FEMA trailer, with the added benefit that the structure can remain on-site as a guest room, studio, or granny flat and withstand most hurricanes. This possible permanence is precisely why FEMA first refused to identify the cottage as "temporary" housing, despite its superior durability (Evans-Cowley & Kitchen 2011; Levine et al., 2007).

Although the cottage was successful in its pilot program in Mississippi, especially among the low-income population. Others had concerns, such as the potential for introducing Katrina Cottages to cause plummeting property values and rising crime rates (Rodríguez et al. 2018). Another key challenge of the cottages is that they would not be ready until two years after the storm. It also took a long time to get a cottage permitted. By then, all but the poorest residents had already identified other permanent housing solutions. Local government also argues that these poorest residents would not rebuild or that the cottages permanently brought low-income people back into their communities (Evans-Cowley & Kitchen 2011).

Method and Data Sources

This thesis adopts semi-structured, face-to-face interviews via Zoom. After each interview, the participant would be asked whether he/she could refer me to other pertinent sources as a snowball sampling technique.

Face-to-face interviews have a high potential for asking a range of topics and utilizing sophisticated questionnaires, but this potential cannot be achieved without well-tested questionnaires and a highly skilled interviewer to handle field logistics. It is the most flexible form of the data collection method. An interview conducted via Zoom is better than telephone interviews or mail surveys because of the possibilities of visual communication. In a face-to-face context, both verbal and nonverbal communication is feasible, allowing for optimal communication. Planned or somewhat structured interview schedules with open questions may be utilized as the interviewer offers questions, follows up with more inquiries, bridges silences, and records responses. However, this can be costly and time-consuming, so researchers should carefully examine whether this level of potential is essential to answering their study issue (Alasuutari et al., 2008).

Face-to-face interviews have a great potential for coverage and sampling but may be prohibitively expensive for large and sparsely populated nations, necessitating the use of cluster sampling or telephone surveys for geographically scattered populations (Alasuutari et al., 2008). As interviews are conducted via Zoom, there is no additional cost for travel or callbacks to non-respondents.
The primary benefit of face-to-face interviews, the presence of an interviewer, is also a detriment, as it may influence respondents' responses, particularly to sensitive issues. In general, the skill and competence of the interviewer might add to overall survey inaccuracy (Alasuutari et al., 2008).

The semi-structured interview provides a method for researchers to pay attention to lived experience and pursue questions based on existing theory by presenting a variety of options. It is sufficiently structured to discuss certain subjects relating to the phenomenon under investigation while giving room for participants to give new interpretations of the phenomenon under investigation (Galletta, 2013).

The semi-structured interview has a great degree of flexibility, and the arrangement of questions can be arranged to provide substantial and frequently multidimensional data streams. As a hybrid method, the semi-structured interview can be segmented, with questions ranging from completely open-ended to more conceptually oriented as the interview goes. Early-collected grounded data provide the context for studying participants' knowledge of the phenomena under investigation. The semi-structured interview's attention to lived experience while still addressing theoretically driven factors of interest is a crucial advantage (Galletta, 2013).

The semi-structured interview provides an excellent opportunity to address the complexities of the study topic: modular construction in a post-disaster setting. It permits the participant to interact with increasingly formal interview portions. It can be conducted in a single sitting or over several, and it provides for a great deal of reciprocity between the researcher and the participant. This reciprocity, or give and take, allows the researcher to examine a participant's comments for clarification, meaning construction, and critical reflection. It is possible to accomplish much during a semi-structured interview if you thoroughly prepare the questions (Galletta, 2013).

The procedure for semi-structured interviews is supposed to be cumulative and iterative, much like qualitative research in general. It facilitates structural continuity. The subsequent phases of the interview are determined by the participant's narrative and its progression. The questions you design should gradually lead the participant to a comprehensive examination of the variables of interest. The manner in which participants are guided through the protocol is another important feature of qualitative research. The semi-structured interview is crucial in facilitating the development of a narrative and incorporating theory-based inquiries. Thus, this strategy is ideally suited to assist in managing the depth and complexity of your data (Galletta, 2013).

Analysis

The Shock Doctrine

The Shock Doctrine (Klein, 2007) is rooted in the perverse experiments of psychologist Ewen Cameron, who aimed to reprogram his patients' behavior by erasing their memories and sense of time.
using electroshock therapy. This disturbing practice was quickly funded by the CIA and used to develop new torture methods that were later employed in Guantanamo Bay and other clandestine locations.

Today, the Shock Doctrine has undergone a rebranding, masquerading as economic shock therapy and disguised as scientific practice to erase culture, history, and memories in favor of a prepackaged way of thinking. By inducing shock on individuals, societies, and economies, the doctrine seeks to exploit the weakened resistance of those who have experienced it to replace what has been destroyed with something new.

However, the cost of this upheaval is staggering. Those who oppose the Shock Doctrine frequently face severe repression, such as imprisonment, torture, and murder. It is no wonder that so many individuals resist becoming indigent and powerless when the price of resistance is so high. Ultimately, the Shock Doctrine only serves the interests of a few powerful individuals while destroying the lives of the masses, creating what Naomi Klein calls "disaster apartheid."

A strategy that capitalizes on the disorientation and trauma caused by crises, such as natural disasters or political upheavals, the Shock Doctrine imposes unpopular economic policies that would otherwise be rejected by the public. This strategy is often associated with the economist Milton Friedman and the "Chicago School" of economics, which advocates for free-market policies and privatization.

In the aftermath of natural disasters such as Hurricanes Katrina and Sandy, the Shock Doctrine has frequently been used to implement privatization and serve corporate interests. Private actors, such as corporations and philanthropic organizations, have played a significant role in disaster relief, sometimes at the expense of local communities.

Following Hurricane Katrina in 2005, many New Orleans residents were left destitute and without essential services, such as healthcare and education. The federal government responded by allowing the privatization of public services, including the public school system in New Orleans. This initiative, driven by private actors and corporate interests, resulted in the closure of public schools and the expansion of charter schools, which were less accountable to their local communities.

Likewise, private actors and philanthropic organizations played a significant role in the recovery process after Hurricane Sandy in 2012. Critics argued that this approach led to a focus on short-term solutions and a lack of long-term planning, as private actors often prioritized their own interests over those of affected communities. Additionally, concerns were raised about the lack of transparency and accountability in the post-disaster response, as private actors frequently had substantial control over the distribution of aid and resources.

The use of the Shock Doctrine and the involvement of private actors in the post-disaster recovery process raise critical questions about the government's role, corporations' responsibilities, and the need for greater community involvement and accountability in response to natural disasters.
Curbing Disaster Capitalism via Government Responsibility

Neoliberalism, which champions free-market principles and minimal government intervention, has facilitated disaster capitalism by placing a disproportionate reliance on private actors for disaster response and recovery while scaling back government intervention.

In the aftermath of natural disasters such as Hurricane Katrina and Superstorm Sandy, private contractors, non-profit organizations, and philanthropies have been heavily involved in recovery efforts. However, their involvement can result in a number of obstacles, including inflated costs, inefficiency, and exploitation of marginalized communities. Moreover, neoliberal economic policies are frequently implemented in disaster-prone regions, such as coastal areas, without adequate analysis of potential risks and repercussions, resulting in an increase in the frequency and severity of natural disasters, which in turn creates more opportunities for disaster capitalism to flourish.

To mitigate the negative effects of disaster capitalism, a significant transition away from neoliberal economic policies and toward a more comprehensive approach to disaster management with a focus on community resilience and equitable rehabilitation is required. Otherwise, communities prone to natural disasters will continue to be exploited and left vulnerable to further mistreatment.

Government involvement and accountability in disaster preparation, response, and recovery could substantially reduce the impact of catastrophe capitalism. First, by increasing government involvement, aid and resources could be distributed more equitably and efficiently, thereby reducing reliance on private contractors and non-profits that prioritize profit over community needs. In addition, increased government regulation could reduce instances of catastrophe capitalism-related exploitation and corruption. By investing in infrastructure such as flood barriers and early warning systems, the government could also assist in preventing or mitigating the effects of natural disasters. Following natural disasters, this would reduce the opportunities for private corporations to exploit vulnerable populations.

Lastly, a stronger government response could facilitate a fair and equitable recovery process by ensuring that the most vulnerable populations receive priority in allocating resources and aid and by not abandoning them during the reconstruction process. Prioritizing community resilience and recovery over corporate profit and interests would result in a more equitable and sustainable recovery.
To sum up, increased government responsibility would reduce reliance on private actors, increase the efficiency and effectiveness of aid distribution, prevent disasters, and prioritize equitable recovery, resulting in a substantial decrease in calamity capitalism.

<table>
<thead>
<tr>
<th>Bias</th>
<th>Impact on Beliefs</th>
<th>Manifestation</th>
<th>Remedy</th>
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<tbody>
<tr>
<td><strong>Myopia:</strong> a tendency to plan over short future horizons</td>
<td>Focus on short-term horizons in evaluating flood loss mitigation options</td>
<td>Failure to invest in cost-effective measures due to high upfront costs</td>
<td>Couple long-term loans with insurance premium reductions to spread the upfront cost over time.</td>
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<tr>
<td><strong>Amnesia:</strong> a tendency to base decisions on recent experiences</td>
<td>Fading memory of past floods and resulting damage</td>
<td>Failure to renew annual flood insurance policy</td>
<td>Automatically renew multiyear policies with constant annual premiums.</td>
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<tr>
<td><strong>Optimism:</strong> a tendency to underestimate the likelihood of personal harm</td>
<td>Underestimation of the probability of a flood</td>
<td>Tendency to see flood insurance and mitigation as overly expensive relative to benefits</td>
<td>Stretch time horizon so individual perceives the probability of a disaster to be closer to the scientific estimate.</td>
</tr>
<tr>
<td><strong>Inertia:</strong> a tendency to choose the status quo</td>
<td>A preference for the status quo in protective investments; for floods, doing nothing</td>
<td>Reluctance to purchase insurance or invest in loss-reduction measures (e.g., storm shutters); procrastination in decision making</td>
<td>Make protection the default; make insurance a condition for obtaining a mortgage, or part of a bundled policy the resident can opt out of.</td>
</tr>
<tr>
<td><strong>Simplification:</strong> a tendency to pay attention to only a few relevant factors</td>
<td>Limited consideration of information available about flood risk</td>
<td>Ignorance of the flood risk of a location; lack of knowledge of possible remedies</td>
<td>Implement communication programs that make it easier for residents to understand their flood risk, providing examples of the consequences of a flood.</td>
</tr>
<tr>
<td><strong>Herding:</strong> a tendency to make decisions by basing choices on the observed actions of others</td>
<td>Tendency to base insurance decision on whether friends and neighbors have flood policies</td>
<td>Low rates of take-up at the community level</td>
<td>Implement communication programs that emphasize social norms of safety; offer seals of approval that enhance the social status of protective investments.</td>
</tr>
</tbody>
</table>

Figure 8: Behavioral Risk Audit Matrix.

A problem-solution matrix that provides planners with an explanation of the biases that can lead to distorted perceptions of risk, how misperceptions may be manifested in preparedness errors, and possible remedies.
Addressing Disaster Denial in Urban Planning Amidst the Ostrich Paradox

In the realm of disaster management, the Ostrich Paradox has become a significant and conspicuous phenomenon. This cognitive shortcut highlights the cognitive biases and systemic shortcomings that have left us unprepared for disasters, leading to a reluctance to invest in disaster preparedness measures such as flood barriers, early warning systems, and affordable housing.

The Ostrich Paradox can have particularly dire consequences in disaster-prone regions. Hurricane Katrina, for instance, demonstrated the lack of readiness for a calamity of such a magnitude in the United States. The sluggish and inadequate response to the crisis, as well as its disproportionate impact on low-income communities, highlights the pressing need for enhanced government accountability in disaster planning, response, and recovery.

Cognitive biases like optimism bias and normalcy bias contribute to unreadiness by making people less realistic about the possibility of undesirable events and more confident in their own capacity to deal with emergencies. When it comes to disaster planning, the Ostrich Paradox can put people in harm's way. The inability to fully prepare can lead to devastating consequences, including physical harm and even death. To mitigate this, significant investment in modular and inexpensive housing is crucial. Such housing systems can shield vulnerable populations from natural disasters, but their high cost usually demands government aid.

Countries like Germany and the Netherlands take disaster preparedness and mitigation more seriously, and their governments play an integral role in ensuring that everyone can afford to live there and that essential infrastructure is in place. This results in less demand for resources during disaster response and recovery. Heightened government responsibility is vital to circumvent the worst ramifications of the Ostrich Paradox. This duty includes comprehensive catastrophe planning and preparation, effective disaster response, and impartial recovery efforts. Early warning systems and low-cost housing alternatives should be given priority by the government to create more disaster-resilient communities.

In conclusion, the Ostrich Paradox poses a significant obstacle during disaster management, requiring recognition of cognitive biases and active measures to mitigate their impact. Germany and the Netherlands have demonstrated that expanded government responsibilities can serve as a model for effective disaster management, which includes comprehensive planning and preparation, effective disaster response, and impartial recovery efforts.

Adoption of Prefabricated Housing in NYC

In NYC, flooding is a much bigger risk than terrorism (T. Pawlowski, personal communication, January 7, 2021). It becomes an even bigger risk when states become too dependent on federal funding.
NYC has its unique risk. The Sandy experience is distinguished from previous major disasters by two key characteristics. First, the region affected by Sandy was densely urbanized, with particularly vulnerable coastal areas. This resulted in distinctive challenges for the recovery effort, such as the identification of temporary and permanent housing options for those affected. Furthermore, this also highlighted the shortcomings of federal disaster recovery programs when applied to densely populated urban regions. Despite these challenges, the Sandy storm impacted one of the world's most prominent metropolitan areas, which boasts unparalleled access to financial resources, professional expertise, and political influence. The interplay between these factors - the region's unique vulnerabilities and exceptional recovery capacity - presents an opportunity to glean important lessons about disaster response and recovery, particularly within densely populated urban areas (Finn, 2020).

High housing and renting costs, and a low supply of housing, exposed a blind spot in federal policy in disaster relief. Most federal recovery programs are based on the needs of owner-occupied, detached single-family homes, while 70% of the buildings affected by Sandy flooding were larger than 4 units. Housing reimbursement limits led to rushed repair programs. Even ownership is not uniform - of the over 1 million homes in NY owned, 43% are cooperatives or condos (Finn, 2020). As a result, in New York City specifically, temporary housing shortages were considerably more severe (C. Barton, personal communication, March 6, 2023). The city's 2014 Housing and Vacancy Study revealed a citywide rental vacancy rate of only 3.45%, whereas its 2011 survey indicated even fewer vacancies (3.12%). These figures are significantly lower than the national average vacancy rate in 2010, which was 11.4%. The majority of residents live in apartments and have little to no additional space to temporarily shelter displaced friends or family members. Furthermore, the city has few locations for temporary housing such as FEMA trailers or group homes. Although emergency shelters in New York City often occur in public schools, that is not a long-term option either. The combination of these elements makes it incredibly difficult, but absolutely necessary, to find inventive solutions to get inhabitants back into their homes as quickly as possible (Finn & Marshall, 2018).

The floodplain map of New York City, existing building codes, and other factors have impeded all forms of construction, not just modular and prefabricated housing. When the city's building codes were revised in response to the Flood Text, architects and contractors were concerned. All structures in flood-prone areas were required by the new regulations to be elevated above the base flood elevation, adding significant costs to construction projects. In addition, the city's zoning regulations and height restrictions limit the viability of constructing taller structures that could potentially house more people. Together with high land costs and limited availability, these factors make it challenging for any form of construction to flourish in New York City. While modular construction offers some benefits, such as decreased construction time and increased efficiency, it is difficult to implement on a large scale due to the city's regulations and restrictions.
Selling Adaptability or Sustainability? Start with the Deep Pockets.

Despite modular construction's growing prominence, in the United States it has not yet reached the same level of maturity as mass production. Even though windows, doors, and other building components are already modular and manufactured in factories, the overall construction process still requires a high level of customization and coordination. This results in longer lead periods and higher costs compared to conventional building practices.

Lack of standardization and a regulatory framework, which makes it difficult to achieve economies of scale, is one of the greatest obstacles confronting modular construction. In contrast to the automotive and consumer products industries, modular construction lacks industry-wide standards and protocols. This necessitates the custom design and engineering of each project, making it difficult to achieve the efficiencies and cost savings that come with mass production.

The limited adoption of modular construction by developers and contractors is another obstacle. Many still view modular construction as an unproven and untested technology, preferring to stay with conventional building techniques. This reluctance to implement modular construction hinders its expansion and makes it more challenging to achieve the required economies of scale.

The concept of selling sustainability and adaptability to those who can afford it is not a new phenomenon. When bikes, cars, TVs, radios, and other inventions were first introduced, they were often

Figure 9: Bijlmermeer, Netherlands 1975.
Source: Mass Support- Flexibility and Resident Agency in Housing

The honeycomb-like grid pattern of high-rise buildings separated by green spaces aimed to accommodate high-density living and provide affordable housing. Recent changes improved accessibility and community amenities, but the original design's legacy is an ongoing challenge.
only accessible to the wealthiest members of society. However, as the technology and manufacturing processes improved, these products eventually became more widely available to the masses. The same can be said for sustainability and adaptability in construction. By targeting the high-end market, developers can showcase the benefits of these features and demonstrate their value. As a result, they may be more willing to invest in sustainable and adaptable buildings. Eventually, as the technology and construction processes become more streamlined, these features will become more accessible to all. This can be seen in the Bijlmermeer project in the Netherlands, where modular and sustainable housing was initially targeted towards high-income residents, but has since become more widely available.

**Analysis from Interviews**

So far, I have interviewed Thad Pawlowski and Cynthia Barton. Thad is an adjunct professor at Columbia GSAPP and the managing director of the university's Center for Resilient Cities And Landscapes. Previously he worked at the OEM. Cynthia Barton is also a former employee of OEM and worked on the Urban Playbook design case study for modular constructions.

The two interviews revealed the following common themes:

1. Initially, modular housing was viewed as a potential solution to the housing crisis caused by Hurricane Sandy, but its implementation was hindered by zoning regulations and a lack of available space for new construction.
2. After the hurricane, the Rapid Repairs and Build it Back programs primarily served middle-class homeowners, leaving many low-income residents without access to adequate housing.
3. There were significant delays and obstacles in the recovery and reconstruction process, such as labor shortages, supply chain issues, and the need to update building codes and zoning regulations.
4. Changes to flood maps and building codes, which had a ripple effect on the entire program, contributed to the higher-than-anticipated cost of reconstruction.
5. There were criticisms of the government's response to Superstorm Sandy, including concerns about the sluggish distribution of federal relief aid and city officials' competence in recovery efforts.

In terms of analysis, Thad’s interviews shed light on the complex challenges involved in disaster recovery and rebuilding efforts. The difficulties associated with modular construction illustrate the limitations of this approach, particularly in areas where zoning regulations and space constraints make it difficult to build new housing. The focus on middle-class homeowners in the recovery efforts highlights the ways in which disasters can exacerbate existing inequalities, leaving low-income and marginalized communities without access to the resources they need to rebuild their lives.
The interview also suggests that there were significant institutional and organizational challenges involved in the recovery efforts, including a lack of coordination between different agencies and political leaders. Additionally, the challenges associated with updating building codes and zoning regulations demonstrate the need for a comprehensive approach to disaster recovery that takes into account the many factors that can impact the success of these efforts. This was cascaded by the transfer of the Bloomberg administration to the deBlasio administration. The differences in their approach to the recovery and rebuilding process were stark.

Sandy hit NYC in the 11th year of the Bloomberg administration: an extraordinarily competent and hubristic local government that almost operated like a city-state. The Bloomberg administration was very good at spending money and fearless about it. They knew how to do everything, and they could often do enormously complex things, like setting up the Rapid Repair program. When things got more political, spending money got harder. In comparison, the deBlasio administration is like “bozos”.

In Cynthia’s interview, she discusses various aspects of post-disaster housing and temporary housing solutions. She highlights the fundamental link between affordable housing and the disaster housing crisis, which she believes is mainly due to the lack of affordable and resilient housing stock. She notes that the key to successful post-disaster housing is to have it tied into the existing community and accessible to all.

Cynthia expresses reservations about the use of modular units that are built ahead of time before a disaster strikes. She cites issues related to storage and unpredictability about where they will be needed. She suggests a better approach is to have contracts with manufacturers to keep a certain minimum quantity of materials in stock and start producing them when needed. She also dispels the myth that people are willing to stay in temporary housing for an extended period of time. She cites the example of Onagawa Japan where temporary housing was built on a leased baseball field. It was successful because people knew it was temporary and had a clear timeline. Cynthia suggests that if temporary housing is needed, it should be built with a clear deadline and a reason for its existence.

Cynthia also discusses the myth that modular housing is always more expensive, and emphasizes that it can effectively transition to affordable housing. She suggests that modular housing should be considered as an affordable housing solution from the outset.

Finally, Cynthia emphasizes the need for a realistic timeline for post-disaster housing recovery, noting that a 10-year timeline is more accurate than a 5-year one. She suggests that although modular construction may not necessarily be cheaper, it is faster and more predictable, making it a more efficient solution.

Overall, the interviews highlight the importance of addressing the root causes of disaster vulnerability and building more resilient communities that are better prepared to withstand future disasters. This requires a coordinated and comprehensive approach that involves a range of stakeholders, including government agencies, non-profit organizations, and community members. The interviews also
underscore the importance of investing in disaster preparedness measures, such as having contracts with modular construction factories ahead of time, and ensuring that communities are better equipped to respond to future disasters. Both interviewees believe that adhering to a more realistic and feasible post-disaster reconstruction timeline would be instrumental in order to achieve a more equitable disaster aid distribution.

**Analysis from Deborah Gans’ Presentation**

Deborah Gans's presentation (Gans, 2023) for the panel called *Mass Support: Flexibility and Resident Agency in Housing* focuses on the type-based Build it Back modular project, a federal funding initiative initiated after Superstorm Sandy to construct hundreds of one- to four-family modular homes in the outer boroughs of New York City. Gans admits that the city turned to modular out of desperation several years into Build it Back. Gans was also a part of the original Build it Back. The 34 staple houses took seven years to complete and finished after the modular project which took eighteen months to wrap up.

It is worth noting that all Build it Back modular houses are coastal properties. While the project was required to concentrate on individual homes within their lock lines, Gans notes that the house-by-house approach prioritized flexibility and variety over efficiency and modular standardization. This piecemeal methodology for reconstruction was compelled by the federal funding initiative that was predicated upon homeowner flood insurance, which exclusively financed the restoration of individual houses within their distinct perimeters. Furthermore, by mandating these types can then be adapted to various lot conditions and families. The project initially started with seven types. When the city then took those types and manage every step of the homeowner engagement process. Homeowners were allowed to customize their house plans within the constraints of zoning and technology, resulting in approximately 20 distinct types and nearly 35 distinct builds for 100 houses.

Gans also discusses prefabrication, a housing concept that ranges from individual components such as windows and doors to custom-built homes. She notes that modules are the most comprehensive factory model at present and reduce on-site labor and work. In modern times, we have taken for granted customized mass production with digital technologies that offer vast choices of individualistic preferences. Although many of our consumed products are mass-produced and standardized, they still offer remarkable variations. However, it is important to note that these variations are not superficial, as they are backed by a certain level of standardization. For example, whether it is a customized Nike sneaker or a custom-built modular home, each product goes through a standardized checklist to ensure quality and consistency.

Gans investigates two crucial concerns regarding modular prefabrication: how superficial versus significant are *variety* and *adaptability*, and how can it be adapted to fit into the established collective
frameworks for low-level permanent infrastructure? Regarding *variety*, Gans asserts that the current manufacturing configuration fosters interminable and sometimes indiscernible heterogeneity. Regarding *flexibility*, Gans explains that most factories are, in essence, woodworking shops sheltered by a roof. The creativity lies in the assembly line, where walls are fashioned on tables, lifted, hoisted, aligned, and put into place to make every unit distinct. While this approach may not be cost-efficient, it is the modular industry's foundation. The variety and flexibility it offers allow clients to create products that meet their desires and needs. The modular industry thrives on this model, and one can see from the top that the products remain the same as the wood frame on a flatbed. It enables flexibility in the type and variety of products, allowing for every inch of a lot to be utilized, or the kitchen's location to be shifted, though some units are genuinely distinct from the others. The process is designed to keep the units individualized in order to achieve a shared typology of houses.

Then, Gans expounds upon the constraints of modular production by highlighting that modules must not exceed 14.5 feet and 30 feet in width and height, correspondingly, and that anything wider than 12 feet necessitates an escort. Furthermore, the creation of open spaces, which are typically linked with spatial versatility, via module joining is arduous owing to the instability of horizontal joining. Currently, the maximum height for modular disaster housing is three stories.

Gans concludes that, as demonstrated by the mass production of automobile models, industrial manufacturing relies heavily on adaptability. However, authentic flexibility is an innate property of the system. She accentuates the importance of modular prefabrication in the construction of American suburbs, as well as the necessity to consider how it can adapt and merge with larger collective frameworks.

**Conclusion**

After doing in-depth research on the topic, it has become abundantly clear that modular construction has a massive amount of untapped potential in terms of meeting the urgent demand for housing that is both affordable and resistant to natural disasters. Before this potential can be completely realized, however, there are a number of barriers that need to be addressed. These challenges include legislative and political restrictions, size limitations on modules, and difficulties in the creation of open areas. The housing sector might experience a revolution as a result of developments and advances in modular construction technology, which is not only economical but also friendly to the environment and efficient.

It is absolutely necessary to be aware of the potential restrictions that may be imposed by modular construction and to approach it with a critical mindset. It is necessary to conduct an in-depth analysis to determine whether modular building methods are appropriate for a certain setting or kind of structure. This analysis should take into account the distinctive demands and qualities of each community and
undertaking. It is essential to take a strategic and well-rounded strategy in order to assure the economic and environmental feasibility of modular building as a solution for housing needs.

One method that could help ease the housing crisis is to invest in technology that allows for the construction of modular homes. The building industry could become more widespread and standardized through the promotion and incentive of the use of modular construction, which would lead to reduced prices and speedier construction timeframes. An increase in financing for research and development of modular construction technology could result in advances in design, materials, and production methods. This would increase the possibility that this housing strategy could be implemented. The inherent benefits of modular construction, such as flexibility, quality control, and sustainability, can assist in fulfilling the urgent demand for housing that is both affordable and resistant to the effects of natural disasters.
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