Post-Catastrophe Modular Shelter: Temporary Housing Design for Displaced People in Gaza

Asala M. Abdelnabi, Hala S. Nasereddin, Bader M. Alatawneh

***Abstract*— The escalation of natural and man-made catastrophes highlights the urgent need for efficient post-catastrophe housing strategies, especially in light of the extensive damage caused by the Israeli attacks against Gaza since October 7, 2023, which displaced more than 1.7 million individuals. This research proposes an innovative, modular temporary shelter design for displaced populations, particularly residents of the Al-Zahraa Towers in the Gaza Strip. The design addresses key requirements such as rapid assembly, cost-efficiency, environmental responsibility, and community cohesion. The research integrates site-specific analysis, climate adaptation, and community-focused design to address urgent housing needs. Using recyclable materials and participatory construction methods, the proposed shelters feature modular 3×3×3-meter units that support rapid deployment, environmental performance, and future expansion. The master plan emphasizes social cohesion, accessibility, and self-sufficiency through productive gardens, communal spaces, and flexible layouts. This adaptable design framework aims to enhance resilience, dignity, and recovery in post-catastrophe contexts.**

Keywords: post-catastrophe Architecture, recovery plans, temporary shelter, socio-environmental resilience, modular construction, climate adaptation, economic, recyclable material, Gaza Strip.

I. INTRODUCTION

Each year, millions are displaced by natural and human-made disasters. In 2023, global displacement reached 110 million, with projections nearing 130.8 million by 2024 [1]. Conflict-affected regions such as Syria, Ukraine, Afghanistan, and most recently, Gaza, contribute significantly to this crisis. In Gaza alone, approximately 1.7 million people have been left homeless, many relying on temporary shelters provided by UNRWA and other public facilities [1].

Post-disaster shelter response typically unfolds in three phases: immediate emergency relief (1–2 weeks), temporary shelter (up to two years), and permanent housing (long-term reconstruction). Each stage requires adaptable, sustainable, and socially responsive architectural solutions, yet many current practices fall short.

Figure 1. Al Zahraa towers , (Source: BBC News)

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This research focuses on designing modular, rapidly deployable, and climate-responsive temporary shelters in temperate Zone B regions, using Al-Zahraa in Gaza as a case study. It specifically addresses the needs of 448 residents displaced by the bombing of Al-Zahraa Towers on October 19, 2023 [2].

The study proposes human-centered design strategies that meet urgent needs while supporting long-term recovery, social cohesion, and environmental resilience.

II. RESEARCH SIGNIFICANCE

Temporary shelters currently used in post-catastrophe contexts often fail to adequately address the multifaceted challenges facing displaced populations. These shelters frequently exhibit poor environmental performance, limited durability, inadequate social integration, and insufficient adaptability to changing needs. Thus, displaced communities face ongoing threats, environmental vulnerability, compromised physical and psychological health, and fragmented social cohesion. There is an urgent need for innovative approaches to post-catastrophe architecture that prioritize sustainable design, adaptability, and community well-being, fostering long-term resilience.

III. PROBLEM STATEMENT & RESEARCH QUESTION

In recent years, catastrophic events have increased significantly, with their impacts worsened by climate change, social instability, and political conflicts. For instance, satellite analyses by Corey Scher (CUNY Graduate Center) and Jamon Van Den Hoek (Oregon State University) revealed that over 160,000 buildings in Gaza were severely damaged since October 2023, displacing more than 75% of the local population. Displaced communities often rely on temporary shelters such as tents and caravans, which tend to become semi-permanent but frequently fail to meet essential human needs. Key challenges include compromised safety, limited privacy, insecurity, poor environmental conditions, social fragmentation, unemployment, malnutrition, and declining mental and physical health.

Notably, while individuals with private land or independent homes often return once conflicts subside, residents of apartment buildings, like those from Al-Zahraa Towers, commonly remain in temporary aid shelters for extended periods, awaiting reconstruction. These prolonged

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stays in inadequate shelters underscore the urgent need for transitional housing solutions that promote self-sufficiency, dignity, and resilience.

Therefore, this research aims to develop sustainable and innovative shelter designs to enhance living conditions and facilitate rapid, effective recovery.

The primary research question guiding this study is:

"How can temporary shelters be designed to effectively meet the urgent needs of displaced people, while addressing cultural context, environmental challenges, construction speed, and long-term usability?"

IV. Aims and Objectives

This study aims to improve living conditions for displaced populations by designing innovative and sustainable temporary shelters. Its key objectives are:

- Assess social, environmental, and health needs of displaced communities.
- Analyze site-specific climate and cultural conditions.
- Develop cost-effective, adaptable modular shelter units.
- Integrate renewable energy and efficient resource use.
- Foster community cohesion through inclusive design and participatory building.
- Create flexible plans incorporating communal spaces and productive gardens.
- Provide scalable solutions for post-disaster housing in resource-limited settings.
- Designing shelters that reduce environmental impact and manage energy, water, and waste efficiently.

The research addresses the urgent need for effective temporary housing by proposing adaptable, sustainable, and community-focused solutions that support both immediate recovery and long-term resilience.

V. Literature review

Recent scholarly work emphasizes the need for post-disaster shelter designs that go beyond emergency response and address long-term resilience. Modularity and flexibility are key attributes in this context. Modular construction facilitates rapid deployment and phased assembly, making it suitable for unpredictable post-disaster environments [3], [4]. While shipping containers have been repurposed for emergency housing due to their availability and speed of deployment, their poor thermal performance in hot climates, such as Gaza, underscores the need for context-sensitive adaptations [5].

Sustainability is increasingly regarded as a central pillar in post-catastrophe shelter design. Studies highlight the importance of integrating green infrastructure to manage local microclimates and support physical and mental health [6], [7]. In Gaza specifically, overlooking cultural norms in shelter design has led to social fragmentation and community dissatisfaction [8]. However, user-driven adaptations in refugee camps such as Zaatari have shown the benefits of allowing residents to modify their shelters to fit social and cultural needs, thus fostering a stronger sense of community [9], [10].

Challenges in existing shelter systems include substandard construction, lack of cultural relevance, short-term planning, and poor adaptability. Research stresses the necessity of pre-disaster planning and "second-life" strategies that allow shelters to evolve from temporary to more permanent structures [4], [11]. These insights align with international humanitarian guidelines such as The Sphere Handbook, which promotes long-term sustainability and dignity in shelter provision [12]. Another recurring recommendation is the use of local and recycled materials. This approach not only reduces costs and environmental impact but also enhances cultural relevance and community participation [13]. The LEGO architecture model, which employs interlocking modular units for fast, tool-free assembly, presents a promising strategy for scalable and customizable post-disaster housing [14].

VI. Methodology

This research adopts a comprehensive, multi-scalar methodology to develop socially responsive temporary shelters for displaced communities in Gaza after the October 2023 war. Addressing both the physical and social dimensions of post-catastrophe recovery, the methodology combines site-specific analysis, contextual design, and community engagement. The process begins with a top-down spatial analysis, starting from the Gaza Strip, narrowing to the Gaza Governorate, and focusing on Al-Zahra City. This stage examines environmental, historical, and socio-political conditions, ensuring contextual relevance. The social impacts of displacement, such as disrupted community ties and psychological trauma, are central to the design process. These insights guide shelter planning that promotes not just safety and function, but also social cohesion and psychological healing. The methodology proceeds through:

- Scenario development for shelter siting,
- Modular unit design based on daily life patterns,
- Community-scale planning for shared spaces, and
- Sustainability integration, environmental, structural, and social.
  Participatory construction techniques are employed to foster community ownership and resilience.

Ultimately, this scalable, adaptable framework seeks to rebuild both habitats and human connections, supporting long-term recovery in resource-constrained settings.

A. Site Conditions

To achieve a responsive temporary shelter design, it is important to study the environmental, historical, socioeconomic, and post-conflict conditions of the site. This research employs a top-down analytical framework, beginning at the macro scale of the Gaza Strip, narrowing to the Gaza Governorate, and focusing specifically on Al-Zahra City. This methodology facilitates making more informed and effective architectural interventions.

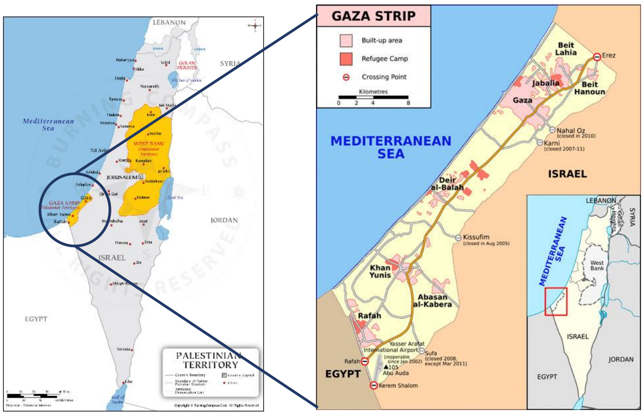
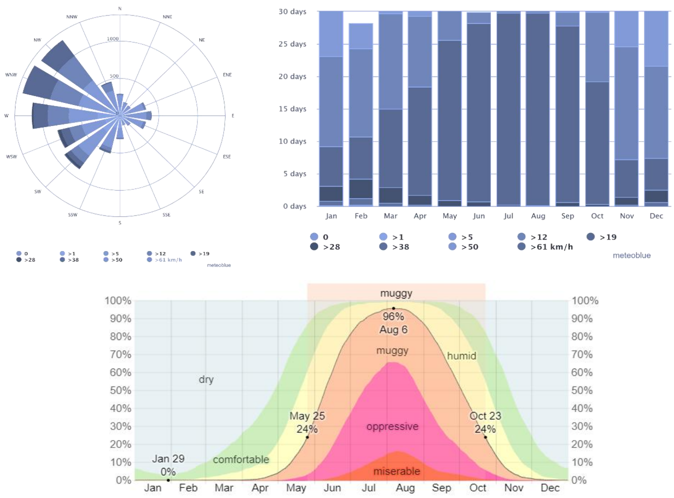


Figure 2 Palestine and Gaza Strip Maps , (Source: Burning Compass)

1) Environmental

Gaza has a hot semi-arid climate (Köppen: BSh) with Mediterranean features, marked by mild, rainy winters and dry, hot summers. Rainfall is limited to the period between November and March, averaging about 395 mm annually. August is the hottest month with average highs of 31.7°C, while January is the coolest at around 18.3°C. Humidity peaks in summer, and the region experiences strong sunlight



Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	28.0 (82.4)	29.0 (84.2)	32.0 (89.6)	35.0 (95.0)	40.0 (104.0)	38.0 (100.4)	36.0 (96.8)	39.0 (102.2)	36.0 (96.8)	38.0 (100.4)	32.0 (89.6)	31.0 (87.8)	40.0 (104.0)
Average high °C (°F)	17.96 (64.33)	19.08 (66.34)	20.79 (69.42)	23.18 (73.72)	26.46 (79.63)	28.26 (82.87)	29.88 (85.78)	30.58 (87.04)	29.7 (85.46)	27.94 (82.29)	24.43 (75.97)	20.16 (68.29)	24.87 (76.77)
Daily mean °C (°F)	16.13 (61.03)	17.1 (62.78)	18.8 (65.84)	21.21 (70.18)	24.68 (76.42)	26.89 (80.4)	28.57 (83.43)	29.21 (84.58)	28.3 (82.94)	26.28 (79.3)	22.77 (72.99)	18.43 (65.17)	23.2 (73.76)
Average low °C (°F)	13.31 (55.96)	13.72 (56.7)	14.91 (58.84)	16.95 (62.51)	20.7 (69.26)	23.28 (73.9)	25.02 (77.04)	25.79 (78.42)	25.36 (77.65)	23.35 (74.03)	19.75 (67.55)	15.63 (60.13)	19.81 (67.66)
Record low °C (°F)	6.0 (42.8)	6.0 (42.8)	8.0 (46.4)	12.0 (53.6)	14.0 (57.2)	18.0 (64.4)	21.0 (69.8)	21.0 (69.8)	22.0 (71.6)	19.0 (66.2)	13.0 (55.4)	8.0 (46.4)	6.0 (42.8)
Average precipitation mm (inches)	137.69 (5.42)	98.93 (3.89)	56.75 (2.23)	28.93 (1.14)	14.95 (0.59)	2.15 (0.08)	0.25 (0.01)	0.82 (0.03)	2.85 (0.11)	21.22 (0.84)	62.73 (2.47)	115.36 (4.54)	45.22 (1.78)
Average precipitation days (≥ 1.0 mm)	12.09	9.45	7.0	4.45	2.82	0.36	0.0	0.27	0.64	4.27	8.18	11.09	5.05
Average relative humidity (%)	62.18	61.48	61.93	61.21	59.93	65.31	69.06	69.29	66.68	61.1	55.71	57.75	62.64
Mean monthly sunshine hours	7.91	8.12	10.36	12.86	13.73	14.07	13.96	13.17	11.78	11.36	8.58	8.08	11.17

Figure 3 Weather Data for Gaza, Source: www.meteoblue.com

year-round with moderate northwesterly winds.

2) Historical and Socio-economic Background

Even before the October 2023 conflict, Gaza faced major challenges in public services due to prolonged conflict, blockade, and overpopulation. Electricity, clean water, and sanitation were unreliable, with over 95% of the water supply unfit for consumption. High unemployment, poverty, and a declining fishing industry persisted despite a well-educated population. In the face of these hardships, Gaza's residents have shown remarkable resilience. Community life continued through vibrant markets, local sports, and cultural gatherings that reflect both strength and hope.

Figure 4 Gaza's Infrastructure
(Source: different references, Authors' edits)

Figure 5 Gaza's Historical Brief Collage
(Source: different references, Authors' edits)

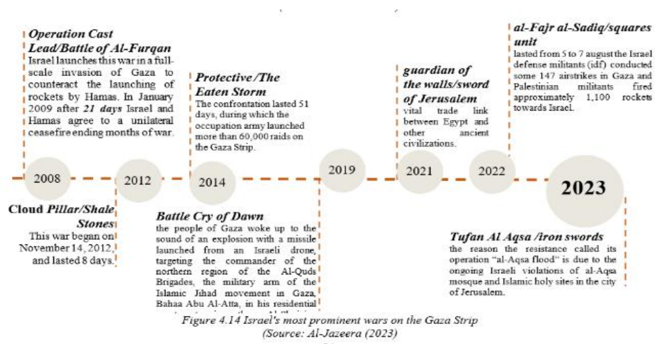


Figure 6 Israel's most prominent wars on the Gaza Strip

The recent conflict left much of Gaza's infrastructure inoperative, with damaged roads and widespread debris. Beyond physical destruction, the crisis also strained social ties and deepened psychological distress among the displaced population.

Historically, Gaza has endured repeated cycles of war and recovery as shown in figure (6). Yet, each time, it rises again. This research aspires to contribute meaningfully to that ongoing recovery by proposing shelter solutions that support a stronger, more resilient future.

Figure 7 Gaza Daily life
(Source: different references, Authors' edits)

B. Site selection and initial proposed sheltering scenarios

The target group for this temporary housing project includes residents displaced from multi-story buildings. Al-Zahraa neighborhood in Gaza was selected as a representative case study, supported by environmental, street, and building analysis maps shown in figure (9). While the design can adapt to other contexts, Al-Zahraa provides a specific context for detailed exploration. As displayed in figure (8), three initial scenarios for post-catastrophe shelter planning were evaluated, guided by key criteria:

1. proximity to demolished towers
2. adjacency to agricultural land
3. low agricultural value

The third scenario, involving multiple housing complexes on vacant land, was selected for detailed development and will be detailed in the following sections.

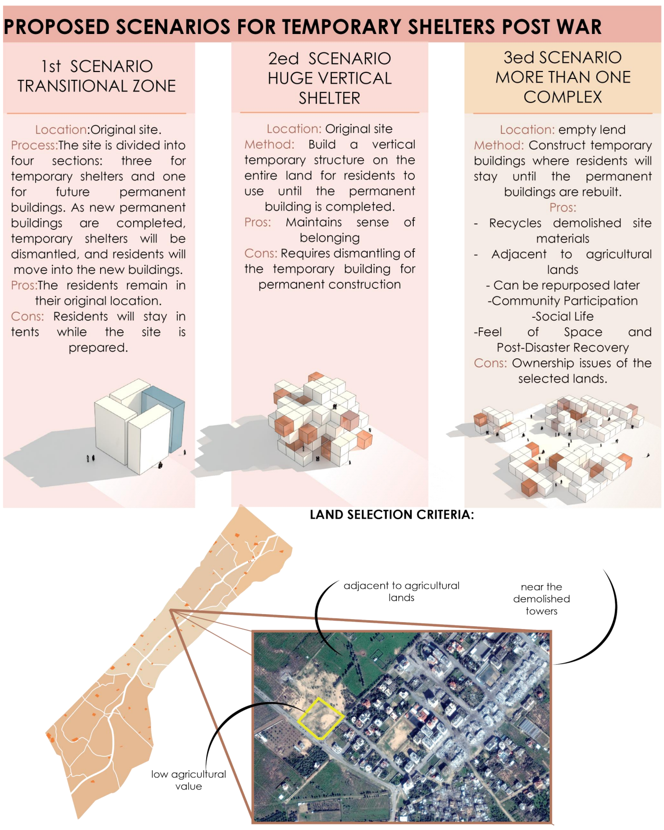


Figure 8 Proposed Scenarios

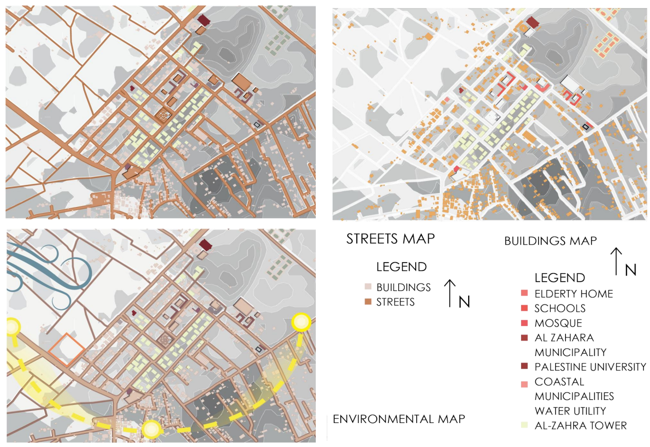


Figure 9 Site Analysis Maps

C. From Modular Unit Design to a Community:

After identifying the most suitable scenario for temporary shelter design, the research focused on the daily needs of the target users: an average Palestinian family of 5.6 individuals. To support a dignified living experience, the shelter needed to provide all essential household functions, including a living area, kitchen, master bedroom, bathroom, and an additional bedroom.

Through functional analysis, we found that the kitchen and bathroom could be combined into a shared "wet zone," as both require water supply but limited floor space. As a result, each functional space could operate efficiently within a volume of 9 cubic meters.

This led to the proposal of a modular unit based on a 3×3×3-meter cube, which was found to be the most efficient and flexible shape for organizing residential functions. The final design comprises five shelter layouts, each formed from four interconnected cubic modules (fig.10). These modules are assigned different functions based on privacy requirements and solar orientation, ensuring that the design aligns with the cultural and environmental needs of Gazan families.

Additionally, an important observation from field research revealed that, over time, families tend to expand their shelters informally and randomly. These unplanned extensions often cause problems such as blocking sunlight and disrupting site organization. To address this, the design includes a predefined extension framework: each unit is built with a structural beam to support future expansion. This approach allows residents to add walls and floors safely and within guided limits, reducing random construction and preserving the quality of the shelter

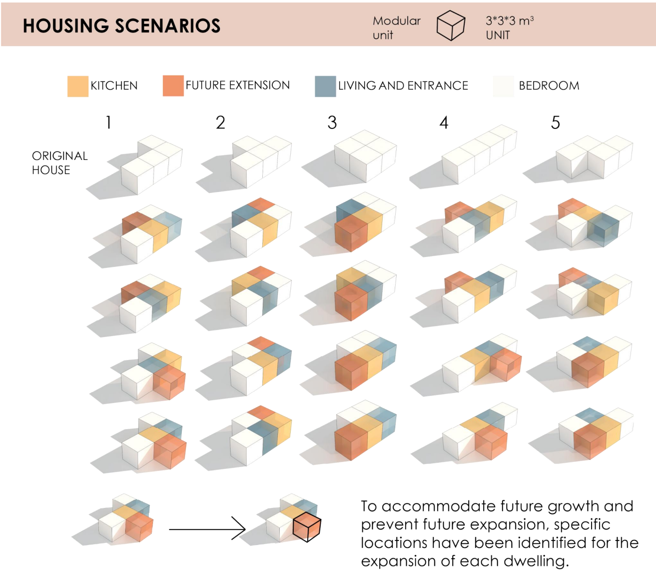


Figure 10 Housing Scenarios

environment.

After studying each housing unit individually, the designs were combined into a two-story configuration. forming six residential complexes. The overall massing and layout were carefully planned to align with the sun path and prevailing wind directions, optimizing natural lighting and ventilation throughout the complex as demonstrated in the study model (fig.11). Architectural elements such as openings, courtyards, and building orientation were strategically integrated to enhance environmental performance.

At the same time, the functional layout was clearly defined, with interior spaces organized according to their use, level of privacy, and access needs. This integration of environmental strategies with functional planning ensures the design meets both climatic and daily living requirements, creating a shelter that is both efficient and responsive to the local context.

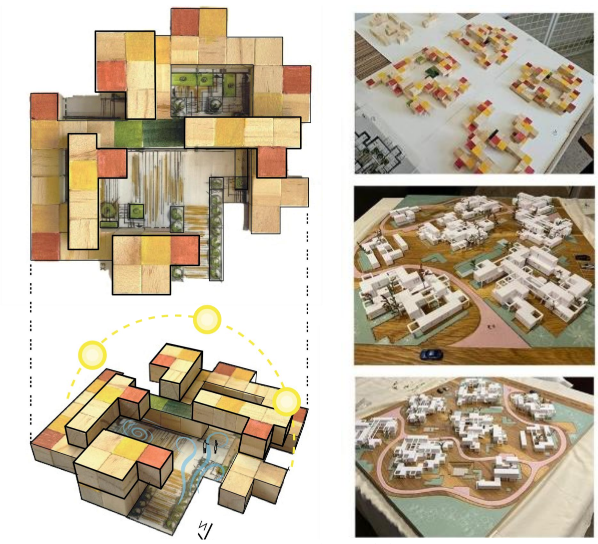


Figure 11 Study Model

D. Integrated Design Approach: Modularity, Participation, and Sustainability

The design adopts a modular construction system using 3×3×3-meter cubic core units, developed to serve as the fundamental building block for temporary shelters. Each unit is constructed using recycled materials sourced from the original demolished site, including concrete debris reshaped into interlocking bricks and salvaged steel for structural framing. The foundation, walls, and floor are detailed in a simplified construction system that facilitates community participation. Residents can actively contribute to the building process, promoting a sense of ownership and reducing reliance on external labor.

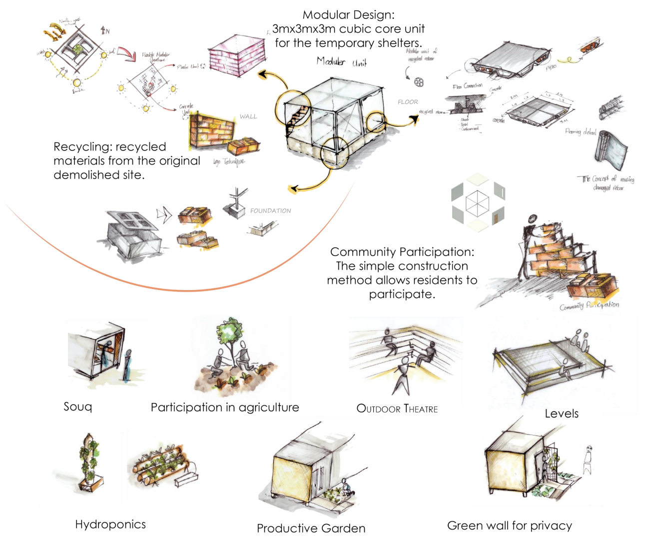


Figure 12 Conceptual Sketches

In addition to basic shelter functionality, the design incorporates a variety of productive and social elements to enrich daily life. These include productive gardens, hydroponic systems, and agricultural plots that reconnect residents with the land and promote food sustainability. Social interaction is encouraged through the inclusion of souqs (markets), outdoor theaters, and shared open spaces, while green walls and stackable modules offer privacy and flexibility for future expansion. The overall approach supports environmental resilience, functional diversity, and a strong sense of community identity within the post-catastrophe context.

E. Structural solutions and construction steps

The proposed conceptual design adopts a modular construction system based on 3×3×3-meter core units, using materials recycled by residents from buildings destroyed in the conflict. Each structural unit is formed using a simple steel frame, created by gathering and tying reclaimed iron bars to form hollow structural sections. These frames are reinforced with galvanized metal sheets to ensure durability and stability, supporting both walls and floors. The walls are made from recycled concrete, processed into brick-like units that interlock using a straightforward assembly method This system simplifies construction, supports flexible layouts, and reduces both material waste and building costs. The use of lightweight, manageable components makes it suitable for quick assembly and easy expansion.

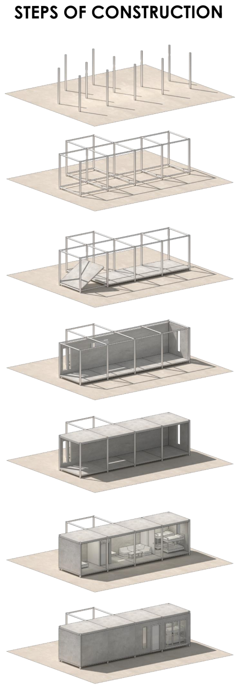


Figure 13 Steps of Construction

In the construction details, all housing units are elevated above ground level. This design prevents water intrusion, improves thermal performance, and allows for air openings beneath the structure that enhance natural ventilation. Floor-level openings help draw cool air from below, promoting passive airflow and reducing indoor temperatures. Ramps are also included to ensure accessibility for disabled individuals and those affected by the war, making the shelters usable for all residents. As shown in Figure (14), the wall profile is designed with rubber seals and overlapping joints to prevent water infiltration, ensuring durability in wet conditions. The floor panels are also shaped to fit securely on the steel structure, allowing for easy alignment and stable construction. The 3×3-meter floor panels connect at the corners using columns. The panels are shaped at the corners to allow more than one

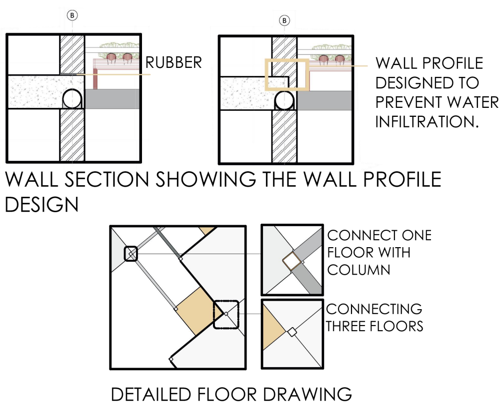


Figure 14 Structural Details

floor to join at a single point, making construction easier and faster (see figure (14)). One column can support a single floor or link up to three floors together, creating a stable and flexible system that allows for future changes or expansion. Figure (13) outlines the full construction sequence—from column foundations and steel framing to panel installation and interior completion. The method is simple and intuitive, allowing residents to build their own shelters without specialized labor. Recycled concrete blocks are shaped for interlocking assembly,

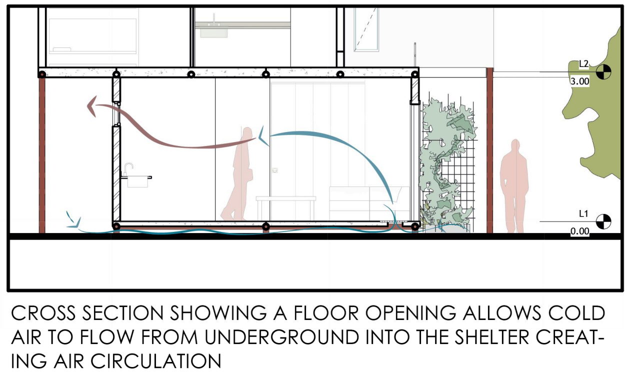


Figure 15 Detailed Cross Section

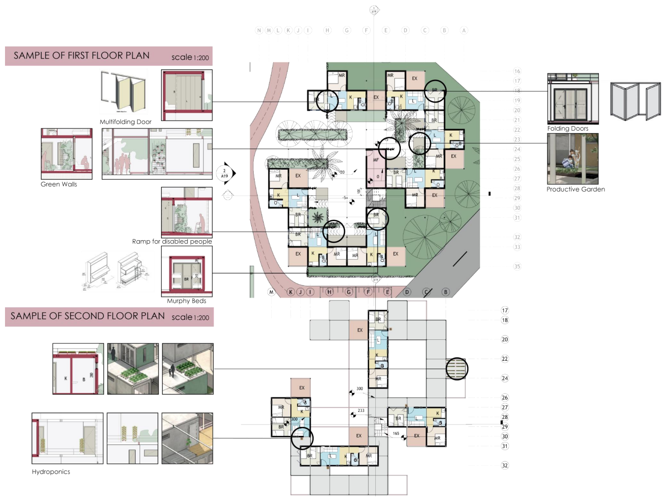


Figure 16 Architectural Plan and design features

supporting a replicable and adaptable system that can evolve with changing needs.

F. Plans and design features

The master plan features ground and first-floor units arranged around central courtyards and green zones, fostering natural lighting, ventilation, and opportunities for community interaction. Each housing unit includes essential living spaces—kitchen (K), bathroom (B), bedroom (BR), and master bedroom (MR)—carefully organized to maximize efficiency and comfort. Designated areas for future extensions (EX) allow families to expand within defined boundaries, controlling unplanned growth and preserving spatial coherence.

Interior layouts incorporate space-saving solutions such as Murphy beds and folding or multi-folding doors to improve circulation and adaptability based on residents' daily needs. Accessibility and universal design principles are embedded throughout, with integrated ramps and pathways ensuring full mobility for people with disabilities.

To enhance the living environment, green walls are introduced to improve privacy and encourage social interaction. Productive gardens and hydroponic systems are integrated into outdoor spaces, promoting self-sufficiency and providing residents with meaningful, sustainable activities. Additionally, multifunctional spaces (MF) are incorporated within the courtyards to support social relief, recreation, and flexible community use.

The elevations were designed with careful attention to privacy, responding to the functional needs of each unit. As shown in the section and northern elevation, two types of windows were used. Smaller, upper-level windows were placed in kitchens and bathrooms to allow light and ventilation while maintaining privacy. In contrast, vertical windows were strategically positioned in living and bedroom spaces to frame views and provide daylight without compromising the privacy of the interior.

Figure 17 Architectural Northern Elevation and Section

In summary, the design blends technical innovation with user-centered flexibility and environmental responsibility to deliver a scalable, resilient housing solution. The proposal prioritizes individual dignity, community well-being, and sustainable rebuilding, offering a practical, adaptable framework for post-disaster recovery in resource-constrained environments.

G. Master plan

The master plan presents a well-organized layout that balances functionality, accessibility, and social integration across six temporary housing clusters. The design follows a clear spatial hierarchy, moving from public zones, such as the central square, amphitheater, and agricultural areas, to more private residential spaces at the core of each complex. Semi-public and semi-private areas, including courtyards and shared gardens, act as transitional buffers, encouraging social interaction while preserving personal privacy. The arrangement promotes a strong sense of community without compromising individual comfort or autonomy.

The design consists of six temporary housing complexes, each arranged to provide immediate and adaptable living solutions. Every complex includes multiple housing units and two additional facilities reserved for future use, such as a market, clinic, or school. These services address essential community needs and support long-term functionality.

Figure 18 Master Plan

Each housing unit features a private entrance, a home garden, and green walls. These elements enhance personal privacy, improve air quality, and contribute to the visual quality of the complex. Hydroponic growing areas on the first floor enable residents to grow food without soil, supporting

Figure 19 3D shot

Figure 20 3D shot

healthier living and small-scale food production.

A bike path made from recycled plastic runs through the site, linking plazas and key activity zones. The landscape design remains flexible, with green spaces carefully distributed to serve both recreational and productive functions. Three main public squares structure the site:

Amphitheater Area – Designed for events and performances, this open-air venue supports public meetings, cultural shows, and community gatherings.

Figure 21 Amphitheater Area

Social Agricultural Area – A shared farming zone where residents can grow vegetables and herbs, promoting local food cultivation and self-reliance.

Figure 22 Social Agricultural Area

Public Plaza – A landscaped, multifunctional square for everyday social interaction, outdoor activities, and relaxation.

Figure 23 Public Plaza

The overall layout prioritizes inclusivity, clear circulation, and the integration of communal and private spaces, strengthening social ties while respecting individual needs.

The visual identity and connectivity of the proposed temporary housing complex are achieved through a combination of colored units and a continuous structural frame system. Varying façade tones, applied in a controlled, muted palette, help define unit clusters, creating a clear identity for each zone while maintaining overall visual harmony. establishing a sense of place and helping residents visually identify their dwellings within the larger community. Structurally, the repeated steel frame system links the modular units across levels and courtyards, forming a lightweight grid that connects units horizontally and vertically. Reinforcing a clear, continuous architectural language throughout the site. Together, Color and structure work to define a clear visual language that improves spatial understanding and fosters a sense of belonging among residents.

Figure 24 3D shot

H. Design flexibility

The design demonstrates a high level of flexibility in both form and function, making it suitable for implementation across various sites. As shown in Figure (25), each housing complex is developed in two orientation scenarios to adapt to solar exposure and wind direction. The modular structure allows the complexes to be configured in multiple ways, accommodating irregular site conditions, varying land dimensions, and phased construction timelines. This adaptability ensures the system is not limited to a fixed land

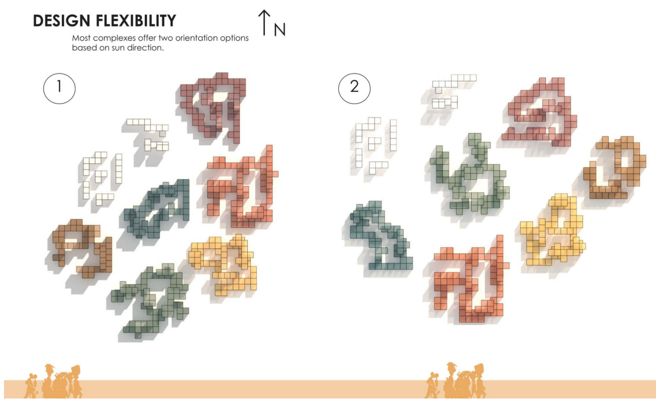


Figure 25 Design Flexibility

parcel or rigid master plan. Instead, it functions as a replicable and scalable solution that can be adjusted to suit specific topography, site conditions, or urban boundaries. The open layout also reserves space for flexible landscape components—such as public courtyards, green areas, and communal facilities—which can be integrated based on the needs and context of each location.

Additionally, the housing complex is designed for easy assembly and disassembly, using modular components that can be relocated or reconfigured as needed. This flexibility allows the structures to transition beyond their role as temporary shelters. Once no longer needed for emergency housing, the units can be repurposed for other functions such as community centers, social hubs, educational spaces, or market stalls—extending their lifespan and supporting long-term community development.

VII. CONCLUSION

This research presented a practical and adaptable design solution for post-catastrophe temporary shelters, focusing on the displaced residents of Al-Zahraa Towers in Gaza. The modular system—based on 3×3×3-meter recyclable units—responds to urgent needs such as rapid deployment, cultural sensitivity, environmental performance, and long-term usability.

The proposed shelter design goes beyond emergency housing. It integrates community spaces, green infrastructure, and user-driven expansion, enabling displaced people not only to survive but to rebuild dignity, cohesion, and self-sufficiency. Built from recycled materials and assembled through participatory methods, the system is cost-effective, scalable, and easy to replicate.

Importantly, this research presents a solution that can be applied to any land and adapted to various population sizes or displacement patterns. Its flexible modular approach also performs effectively in regions with similar temperate or semi-arid climates, making it a viable model for broader post-disaster recovery efforts across the Global South.

VIII. RECOMMENDATIONS

Based on the findings and design framework developed in this study, the following recommendations are proposed:

- Applying the same modular strategy in different social and cultural contexts, adapting layouts and materials to suit local traditions and community needs.
- Testing and implementing the design in varied climatic regions—especially other temperate or semi-arid zones—to assess performance and improve environmental adaptability.
- Collaborating with humanitarian agencies and local governments to scale the approach and integrate it into formal post-disaster response plans.
- Encouraging further research on how modular shelters can evolve into semi-permanent or permanent settlements without compromising dignity and sustainability.

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