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BUILDING BACK TOGETHER: EXPLORING LOCAL-DRIVEN RESILIENCE IN SUDAN'S POST-DISASTER HOUSING

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”أما السودان، فأنا أحمله بين جوانحي حيثما ذهبت وحيثما

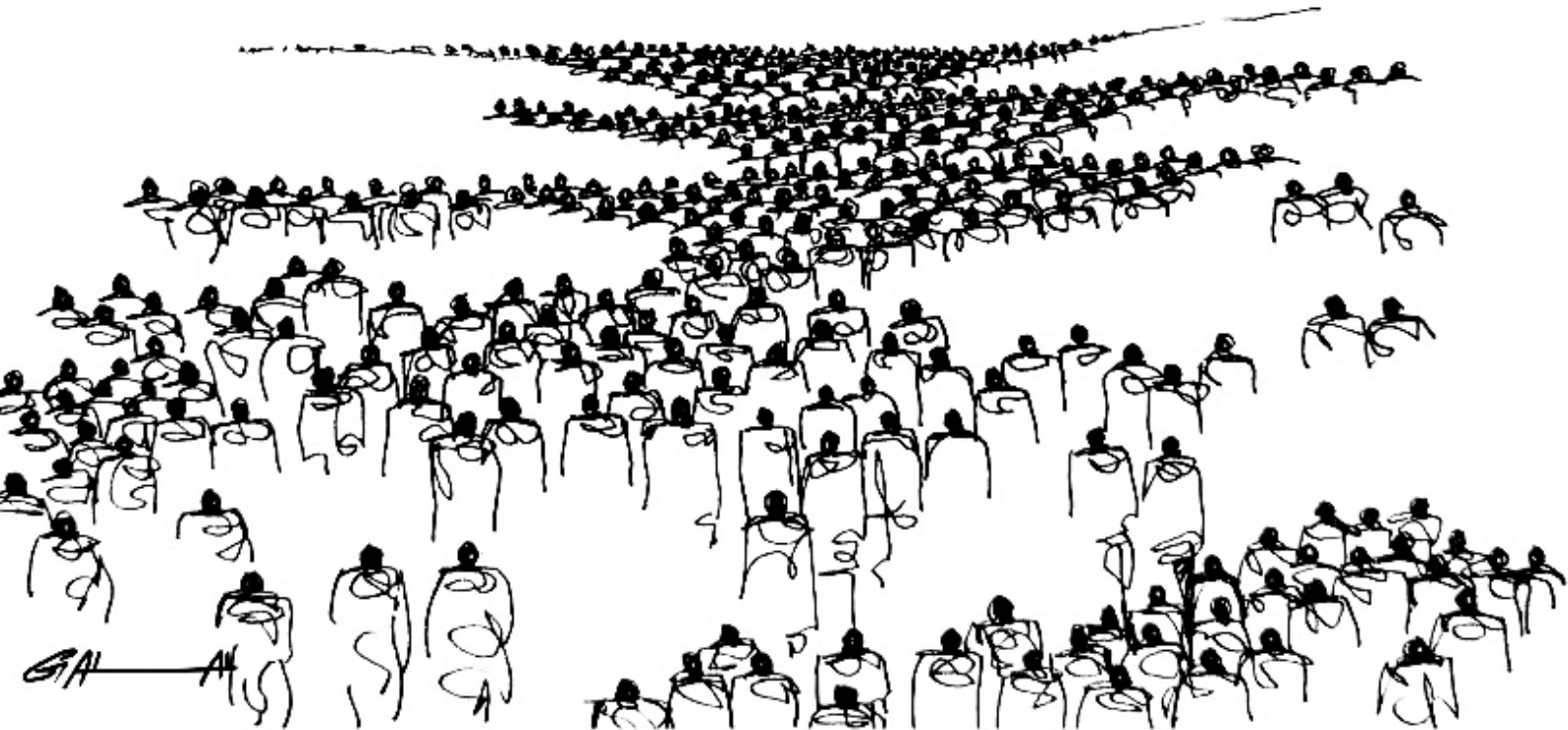
أذهب، هذا هو الوجع الأول، والوجع البدائي واللانهائي“

الطيب صالح

“AS FOR SUDAN, I CARRY IT WITHIN ME WHEREVER
I WENT AND WHEREVER I GO. THIS IS THE FIRST PAIN,
THE PRIMITIVE AND ENDLESS PAIN.”

El-Tayeb Salih

Artwork by Sudanese Artist
Galal Yousif



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DEDICATION

This research is a small contribution, as a sole academic, to every Sudanese person who's navigating life's uncertainties with resilience and hope. It is dedicated to the Sudanese people I know and those I don't, to those who have lost someone or lost their homes.

We as Sudanese people, we belong to Sudan and without it we are only scattered pieces waiting to be unified. To my beloved country, I long to see you safe and prosperous.

I would like to thank my sources of strength, my family I wouldn't have made it through this challenging experience without your boundless affection, unconditional love and support. Of course, to my beloved friend who stood with me through every hardship and supported my every decision Samar Elkamil, your belief in me has given me strength. To the dear friends and colleagues I made a long this journey, your insightful guidance and shared laughter had only made this journey more beautiful.

ABSTRACT

As we witness the horrors of the recent large-scale conflict that erupted in Sudan as of April 2023, which escalated into one of the most severe internal displacement crisis in the world. It becomes especially relevant to address the architectural challenges and strategies associated with humanitarian shelter response in Sudan emphasizing the dire needs for comprehensive and sustainable solutions. This thesis employs a mixed-methods approach through qualitative and quantitative analysis to contextualize the framework of architecture, the conflict and displacement dynamics in the country. The findings suggest that locally driven, resilient transitional shelters can potentially enrich the Sudanese community with the ability to withstand the war on a solid foundation for long-term recovery. Moreover, the research contribute to the broader field of humanitarian aid through comprehensive recommendations to improve the architectural shelter response in conflict-affected regions

KEYWORDS

Resilience, Internal displacement, IDPs, Core Shelter, Emergency Shelter, Post-Disaster, Housing, Conflict

Artwork by Sudanese Artist
Soma Siddig

Lost Artwork by Sudanese
Artist
Soma Siddig

TABLE OF CONTENTS

CHAPTER I INTRODUCTION

1.1 Introduction 11
1.2 Research Objective 12
1.3 Research Methodology 12
1.4 Research Structure 12
1.5 Research Limitation 13

CHAPTER II THEORETICAL BACKGROUND

2.1 Housing and Resilience in the Face of Disasters 14
2.2 Disaster Recovery Management Plan 15
2.3 Basic Guidelines for Emergency Shelter Design 20
2.4 Qualitative Aspects of Temporary Shelters 22

CHAPTER III CASE STUDIES

3.1 Philippines, Typhoon (2013-2017) 26
3.2 Chad, Sudan Conflict (2023) 33
3.3 Chile, Valparaiso Fire (2014-2016) 39
3.4 Somalia, Draught/Conflict (2011-2013) 45
3.5 Iran, Iraqi Conflict (1995) 51
3.6 Conclusion & Lessons Learned 57

CHAPTER IIII COUNTRY PROFILE (SUDAN)
4.1 General Description 59
4.2 Key Demographics, Cultural, Social & Economic Data 61
4.3 Natural Hazards 67
4.4 Displacement in Sudan 70
4.4.1 Natural Disasters and Forced Displacement 72
4.4.2 Armed Conflicts and Displacement in Sudan 72
4.4.2.1 Historical Overview 72
4.4.2.2 Sudan Conflict 2023 78
4.4.3 Displacement Effects on Rural and Urban Life 87
4.4.4 Addressing Displacement: Strategies for effective humanitarian shelter 88
4.5 Architecture and Construction Typology in Sudan 89
4.5.1 Housing Architecture Typology 90
4.5.2 Traditional Building Materials 94
4.5.3 Application of Building Materials & Technology for Housing 98

CHAPTER V DESIGN PROPOSAL

5.1 Contextualized Design aspects 101
5.2 Design Proposal 103
5.2.1 Concept 104
5.2.2 Architectural Layout 106
5.2.3 Construction Methodology 109
5.2.4 Wastewater Management System 111
5.3 Re-settlement 115

CHAPTER VI RESULTS AND CONCLUSION 117

BIBLIOGRAPHY 120

LIST OF FIGURES

Figure 2.1 Disaster Management cycle– lesswrong
Figure 2.2 Disaster relief in Nepal-habitat for humanity org
Figure 2.3 ARK Inflatables-Blogger.com
Figure 2.4 canopy as an example of emergency shelter - Author
Figure 2.5 tent as an example of temporary shelter - Author
Figure 2.6 container as an example of temporary housing - Author
Figure 2.7 single unit house as an example of transitional shelter - Author
Figure 2.8 example of progressive permanent houses - Author
Figure 2.9 The diagram illustrates the overlaps between some different shelter terminologies - Bashawri, Abdulrahman, Stephen Garrity, and Krisen Moodley. “An Overview of the Design of Disaster Relief Shelters.” Procedia Economics and Finance 18, (2013)
Figure 2.10 Temporary Shelter in Nepal-ArchDaily
Figure 2.11 Earthquake Shelters-world architecture
Figure 2.12 Bamboo Shelters - Worldpress.com
Figure 2.13 Bam Earthquake Region 1000 Emergency Accommodation Units -Dorce

Figure 3.1 image of the disaster shelter in Cebu, Philippines -shelter for the victims of the typhoon by Danilo RAVINA
Figure 3.2 image of the disater shelter in Philippines - disaster ready org
Figure 3.3 location of the disaster shelter - Author
Figure 3.4 shows transitional shelter adopted in the Philippines - Author
Figure 3.5 Bent Construction Method - Author
Figure 3.6 shelter construction technique - Philippines - Author
Figure 3.7 image of the disaster shelter in Ouaddaï, Chad - BetterShelter
Figure 3.8 image of the disaster shelter in Chad - UNHCR
Figure 3.9 location of the disaster shelter, Chad - Author
Figure 3.10 shows emergency shelter adopted in Chad - Author
Figure 3.11 shows a shelter unit - Author
Figure 3.12 shows the structural design - Author
Figure 1.1 shelter construction technique - Chad - Author
Figure 3.14 IKEA Foundation shelter unit
Figure 3.15 Shelter unit Kit -wall street journal
Figure 3.16 image of the disaster shelter in Valparaiso, Chile - ArchDaily
Figure 3.17 image of the disaster shelter in Chile - ArchDaily
Figure 3.18 location of the disaster shelter, Chile - Author
Figure 3.19 shows core shelter adopted in Chile - Author
Figure 3.20 shelter construction technique - Chile - Author

Figure 3.21 shelter unite, Chile - Author
Figure 3.22 image of the disaster shelter in Garowe, Puntland, Somalia - Somalia study of drought and conflicts 2011-2013
Figure 3.23 image of the disaster shelter in Somalia - Somalia study of drought and conflicts 2011-2013
Figure 3.24 location of the disaster shelter, Somalia - Author
Figure 3.25 shows core shelter adopted in Somalia -Author
Figure 3.26 shelter construction technique - Somalia - Author
Figure 3.26 shelter unite, Somalia - Author
Figure 3.27 image of the disaster shelter in Ahwaz, Khuzestan, Iran-Contemporary architecture of Iran
Figure 3.28 image of the disaster shelter in Iran - CalEarth.org
Figure 3.29 location of the disaster shelter, Iran - Author
Figure 3.30 shelter construction technique, Iran - Author
Figure 3.31 shelter unit, Iran - Author
Figure 3.32 Table of comparison between the different Case-Studies - Author

Figure 4.1 Pyramids of Merowe, Sudan – Encyclopedia Britannica, Inc
Figure 4.2 Sudan geolocation – Encyclopedia Britannica, Inc
Figure 4.3 Sudan climatic map - OCHA ReliefWeb
Figure 4.4 urbanization level in the city of Kassala, Sudan - Alamy
Figure 4.5 street artwork by Galal Yousif - africanarguments.org
Figure 4.6 rural roads in sudan - Photo by Aya Sinada
Figure 4.7 Sudanese woman cooking food outdoors in the house – SkynewsArabia
Figure 4.8 Sudanese woman preparing produce to dry - photo by Aya Sinada
Figure 4.9 Sudanese men gathered for community festive – DW
Figure 4.10 celebration of “Sitti Mariam” the noble sufi ladies of the Khatmiyyah in Sinkat town in East Sudan - Photo by Zofa_Photography
Figure 4.11 islamic prayer during the month of Ramadan - Ali Alshalali Tumbler
Figure 4.12 Sudan flood in Tutti Island, Khartoum 2023 – CNN
Figure 4.13 average annual natural hazard occurrence for 1980-2020 - Worldbank
Figure 4.14 Key natural hazard statics for 1980-2020 - Worldbank
Figure 4.15 Flooding of the Nile in september 23rd 2016 and september 2nd 2020 in state of Khartoum – NASA Earth Observatory
Figure 4.16 Draught in Sudan - CNN
Figure 4.17 displacement in Sudan - UNHCR
Figure 4.18 destroyed houses after the war in Khartoum - Le Monde
Figure 4.19 recent photo of the displaced people escaping the battles in Sennar - Sudan Tribune
Figure 4.20 displacement due to the war in south Sudan - CNN

Figure 4.21 burnt villages in Darfur - CNN
Figure 4.22 war torn Khartoum, Sudan - Jordan Times
Figure 4.23 Illustration of a brief timeline of the war in Sudan since independence - Art work by lizar_tistry
Figure 4.24 spread of famine and food insecurity - The guardian
Figure 4.25 mother carrying her children and some belongings as they flee the war - UNHCR
Figure 4.26 women carrying her belongings and fleeing to safety - InfoMigrants
Figure 4.27 map of the number of displaced people due to the Sudan war 2023 as of June 2024 - UNHCR
Figure 4.28 Refugee camp in Ethiopia - News24
Figure 4.29 makeshift shelter by the displaced people - Bonblast Twitter
Figure 4.30 displaced Sudanese people sheltering in a schoolbuilding - Middle East Monitor
Figure 4.31 displaced Sudanese people sheltering in the peripheries of towns - The independent Uganda
Figure 4.32 Sudanese people displacement- UNHCR
Figure 4.33 Sudanese people displacement- UNHCR
Figure 4.34 before and after images of the destruction in Khartoum, Omdurman - Photo by Abushama
Figure 4.35 before and after images of the destruction in Khartoum, Omdurman - Photo by Abushama
Figure 4.36 map of the ethnic groups in Sudan - NIH
Figure 4.37 Tukul in south Sudan - wikipedia
Figure 4.38 House in Dongola (North Sudan) - Orange Dragon Foundation
Figure 4.39 House in Khartoum capital (Central Sudan) - Sudanfax
Figure 4.40 men sitting housh space in Sudanese houses - Photot by Khalid Alarbi
Figure 4.41 tent in empty plot in the city - Author
Figure 4.42 mud gottiya - Author
Figure 4.43 straw gottiya - Author
Figure 4.44 straw mat dwelling - Author
Figure 4.45 apartment building - Author
Figure 4.46 single story house - Author
Figure 4.47 Villa in Khartoum - Author
Figure 4.48 Concrete construction - Mkc Image
Figure 4.49 Mud construction - Flicker
Figure 4.50 Brick construction - four square
Figure 4.51 Thatch/straw construction - Medium.com
Figure 4.52 Fired brick - Pressenza
Figure 4.53 Rammed Earth- Archi soup
Figure 4.54 Compressed Earth Blocks- Yenuli Constructions

Figure 4.55 Ferrocement Vaulted roof- ArchDaily
Figure 4.56 Baladi Flat Roof - (Elkhalifa, 2011)
Figure 4.57 Shagig Roof - (Elkhalifa, 2011)
Figure 4.58 Precast Concrete Roof - (Elkhalifa, 2011)
Figure 4.59 Truss Roof - (Elkhalifa, 2011)
Figure 4.60 Semicircular vaults - (Elkhalifa, 2011)
Figure 4.61 Jack-Arch Roof - (Elkhalifa, 2011)
Figure 4.62 Dome Roof - (Elkhalifa, 2011)

Figure 5.1 image of the shelter option adopted by the displaced people - Photo by ispionline.it
Figure 5.2 image of local construction material in Sudan - Photo by globalgiving.org
Figure 5.3 image highlights the aftermath of the conflict with the destruction of infrastructure - Photo by joyphillips.blogspot.com
Figure 5.4 image shows the breakout of the war in the capital Khartoum - photo by Alsharq al-awsat
Figure 5.5 concept diagram of the design proposal - Author
Figure 5.6 diagram of future expansion of the project - Author
Figure 5.7 Ground Floor plan - scale 1:100 - Author
Figure 5.8 enlarged plans of the living area showing the different space configurations - Author
Figure 5.9 cross section showing the construction detail of the main living unit - Author
Figure 5.10 process of making the compressed earth blocks - Author
Figure 5.11 types of compressed stabalized earth blocks
Figure 5.12 cross section through the toilet to show the drainge system - Author
Figure 5.13 axonametry of the shelter unit - Author
Figure 5.14 axonametry of the settlement - Author
Figure 5.15 Variations of the design in different phases of the project - Author
Figure 5.16 Variations of the design in different phases of the project - Author

LIST OF TABLES

Table 3.1 Table of comparison between the different Case-Studies - Author
Table 4.1 South Sudanese displacement numbaers– UNHCR
Table 4.2 Darfur displacement numbers – UNHCR

CHAPTER I INTRODUCTION

Humanitarian shelter response is a critical field of study within humanitarian aid and development, as shelters provide more than physical protection, they also ensure dignity, stability and a concrete foundation for rebuilding lives. The geopolitical landscape of the modern world is characterized by long-standing conflicts and natural disasters that have long existed, inflecting unforeseen circumstances on millions of people that have been continually displaced, seeking safety and refuge.

Sudan epitomizes the challenges and complexities of humanitarian shelter response. The country has been plagued by protracted conflicts and violence. The country's political scene has been increasingly unstable ever since the ousting of president Omer al-Bashir in 2019, further complicating the humanitarian efforts. The relentless conflicts have led to massive displacement to millions of people, many of whom continue to live in camps or temporary shelters. Currently, the displacement crisis in Sudan represents the largest internal displacement crisis in the world with over 11 million people internally displaced (OCHA, 2024). The humanitarian shelter response undertaken by the displaced population has ranged around the country. While a significant number continue to struggle to secure adequate shelter, many others are compelled to settle for substandard shelter solutions.

Since the break of the war in April 2023, the country has been faced with an unprecedented scale of violence and dire humanitarian conditions. The provision of adequate shelter remains a significant challenge due to factors such as limited resources, restricted access to conflict zones, and environmental hazards like floods. As the war is expanding there persist a need to address the broader aspect of the humanitarian crisis and the best approach for humanitarian shelter response.

A multifaceted architectural research bring into perspective the architectural challenges inherent in the humanitarian shelter crisis by integrating contextual understanding, innovative design and community integration based on sustainability principles. This systematic approach, extends humanitarian shelter response beyond providing immediate needs, but also contribute to long-standing resilience and recovery efforts in crisis affected regions

1.1 Research Objective:

The research aims at establishing an analytical multidisciplinary framework to consider the humanitarian response in the aftermath of the ongoing Sudan war 2023. In light of the significant displacement crisis and the precedent poor shelter conditions, the research attempts to critically asses the political, cultural and architectural aspects of the internally displaced population in an evolving conflict dynamics. Ultimately, building on local economic notions to reinforce humanitarian recovery of the internally displaced population. By examining the case of Sudan, this research contributes to the broader field of humanitarian aid and development, offering insights that can be applied to other conflict-affected regions in Africa and beyond.

1.2 Research Methodology:

This research uses both an integrated qualitative and quantitative analyses of the recent conflict in Sudan and examining the current situation of the country and its people to clearly propose a transitional shelter design grounded in these insights. That is based on the analysis of multiple case studies ending in a cross-case conclusion drawn from each project. Grounded on the dynamic factors and historical attributes of Sudan, both as a country and as people, this study contextualizes Sudan within international humanitarian response standards, including those established by the UNDP and the SPHERE Standards.

1.3 Research Structure:

The research is divided into six chapters, each of which serves a particular objective within the research's framework. The opening chapter serves as an introduction, outlining the research aim, topic and the inherent limitations to provide a foundational understanding. Chapter two examines the tools and guidelines required for effective humanitarian emergency shelter response, to establish a theoretical framework for further exploration. Following that, chapter Three, an architectural study of five different case studies is conducted, examining various approaches and solutions relevant to the research objective. In Chapter Four, attempts to contextualize the study area by delving into the various background elements required for a thorough understanding. Chapter Five presents the culmination of insight gained, proposing a design based on analyses and observations presented in the previous chapters. Finally, Chapter Six summarizes the research's findings and conclusions, providing valuable insights and recommendations based on the extensive investigation conducted throughout the study. By means of this structured approach, the research follows a systematic path from beginning to end, enriching scholarly discourse on humanitarian shelter response in the specified context.

1.4 Research limitation:

To begin with, the research relies on secondary sources such as reports by international organizations and national governmental publications, however, availability of particularly national data and documents has been significantly restricted due to the current warfare that has severely impacted many databases. As a result, some information may be outdated and therefore it may lack to capture the most recent situation in Sudan. Secondly, because the study aims to combine the findings of different disciplines including humanitarian, architecture, and social science, the multidisciplinary approach might be underdeveloped in certain fields to some extent. Possibly, a more in-depth investigation into one specific dimension may result in a more detailed comprehension. Additionally, limited engagement with the local and affected stakeholders, including local organization and internally displaced population due to disrupted internet communication channels in Sudan. Involvement of these stakeholders could enhance the relevance and acceptance of the proposed solutions. More importantly, the nature of the ongoing conflict presented various and unexpected changes during the period of the research being conducted. The spread of the conflict and pattern of displacement has been constantly evolving making it more difficult to form a comprehensive understanding of the evolving situation and the long-term effectiveness of the proposed project. Continuous monitoring and adaptation of the proposed design will be necessary to ensure its ongoing relevance and effectiveness. Acknowledgment of these limitation presents a great opportunity to encourage further future research to address these gaps, therefore contributing to more robust and comprehensive knowledge.

CHAPTER II THEORETICAL BACKGROUND

2.1. Housing and resilience in the face of disasters

To others, a house is merely the walls and roofs that provide protection for one's life. However, for the people living within them, a house transcends its physical existence. It shapes their daily lives and continually grows within them, encompassing many of their most esteemed memories, relationships, and powerful experiences. A house is an essential need in many aspects of people's lives and the starting point of their everyday experiences. It is the manifestation of the personal connection individuals have to our tangible world. Most importantly, having a place of shelter is essential for an adequate, safe, and dignified life.
Primarily, houses provide secure and safe enclosure to carry on daily activities. Additionally, they integrate with the surrounding built environment that fosters social interactions, supports community networks, and enhances the overall quality of life. Well-planned architectural elements and urban design can promote sustainability, accessibility, resilience and cultural continuity, thereby creating harmonious living spaces that contribute to the social and economic vitality of society.

Resilience to Disasters:

The term resilience was introduced into the English language in the early 17th century from the Latin verb resilire, meaning to rebound or recoil. However, there is little evidence of its use until Thomas Tredgold and subsequently Holling presented the term in material science and in relation to ecology and the environment. Decades later, the term resilience evolved to encompass various interpretations to its meaning by policy makers, practitioners and academics. Douglas and Wildavsky (1982) defined resilience as "The capacity to use change to better cope with the unknown: it is learning to bounce back". Surly, resilience is complex and open to a variety of interpretations, but in a post-disaster context, resilience displays the ability to withstand adversity and the human natural instinct for survival. Communities that are better prepared for abnormal events tend to demonstrate greater resilience. And to ground those concepts of resilience experts involved in the planning, design, and management of the post-disaster response must understand the various hazard threats to buildings, spaces, and places, as well as how these structures will perform in the event of a disruptive incident, while encouraging communities' growth. (Amaratunga and Haigh 2011)

Disasters, whether natural or man-made, are catastrophic events that profoundly impact the lives of people. While these events have a communal negative impact, affecting the population as a whole, they are also experienced by individuals both on a collective and personal level. The repercussions of such disasters significantly disrupt the lives of individuals, leading to substantial personal and communal losses. The significance of the adversity of disasters are fatalities and population displacement. Initially, the impact of a disaster is marked by its

unpredictability and further exacerbated by its catastrophic aftermath. Although disasters are generally difficult to predict, man-made disasters and conflicts are often more severe due to their unexpected nature and the challenges in anticipating their occurrence.

Armed conflicts represent the most prevalent category of man-made tragedies globally. These conflicts are evident in various forms, including civil wars, regional clashes, and invasions. Among these, civil conflict inflicts the most severe damage on economic activities, social capital, and institutional frameworks. Civilian life invariably bears the brunt of these conflicts, with non-combatants often becoming the principal victims. Moreover, conflicts are often political in nature when groups within a society aim to achieve their objectives through legal and established societal norms. In some instances, groups resort to violence to advance their interests. Armed conflicts are the most common type of conflict worldwide, and the cause of it is usually very complex. Displacement is one of the major adversity of armed conflict, displaced people lose their assets, livelihood and accumulated wealth. (Amaratunga and Haigh 2011)

2.2. Disaster recovery management plan:

Recovering from a disaster is a challenging process that requires immediate and strategic actions. In the aftermath of a disaster, the first priorities are locating victims, providing essential medical care, and ensuring access to water, food, and shelter for survivors. The broader aim of recovery is to restore basic services and facilities, including economic stability and infrastructure. Implementing a recovery plan based on fundamental principles can reduce the risk of future events, decrease the vulnerability of the impacted population, and promote the concept of "building back better," ensuring the sustainability of recovery efforts

Figure 2.1 Disestar Mangement cycle– lesswrong

Disaster management consists of five main phases: prevention, preparation, response, mitigation and recovery. The recovery phase is considered the least developed and the least well understood. Nevertheless, this phase is crucial for connecting people with expertise, knowledge and resources. There's no specific point in time at which the response phase changes into recovery, but rather a transition between the two, as the state of emergency after the disaster is being brought under control, the recovery phase begins. The recovery phase goes through various stages, starting from the immediate aftermath of a disaster, during the relief phase itself and continues until full recovery is achieved.

Early recovery takes place during a transition period that represents a vital bridge between emergency relief and long-

term development. Medium-term intervention aims at rebuilding shelter, infrastructure and livelihood. While, long-term intervention is related to building government capacities and reducing future risks. (UNDP 2022)

Shelter development is an important aspect in humanitarian recovery, the role of an architect is through good integration of architectural design within the framework of disaster alleviation.

Figure 2.2 Disaster relief in Nepal - habitat for humanity org

Emergency shelter response:

Temporary dwellings can be defined as structures to inhabit people living in communities which have been affected by a disaster (commonly referred to as disaster survivors). Post-disaster dwellings constitute a crucial centrepiece in sustaining human survival following catastrophic events. The significance of temporary shelters lies in their provision of essential opportunities for the affected populations to secure a renewed chance at life. Beyond their function as mere “products,” post-disaster shelters serve as cultural artefacts imbued with diverse implications and interpretations unique to their respective communities. The importance of temporary shelters becomes paramount following a disaster when survivors are unable to reside in their former homes or secure new permanent housing.

The design of temporary shelters is integral to disaster alleviation efforts; an optimal design facilitates an efficient transition for displaced individuals, thereby enhancing the overall recovery process. Although that post-disaster shelters are executed after the strike of a disaster, the shelter design is predominantly linked with “preparation” or pre-disaster phase of the disaster management plan. (Abulnour 2014)

Figure 2.3 ARK Inflatables - Blogger.com

Categories of shelter/housing:

Generally, Disaster shelters are commonly used until the displaced population are re-housed in their original dwelling or new permanent accommodation. The types of shelter presented below are considered as an approach rather than a phase of the recovery, most post-disaster shelters are built, upgraded and maintained by the affected population themselves, and this self-management should be supported. Shelters are divided into seven main categories: (Garrity, Moodley and Bashawri 2014)

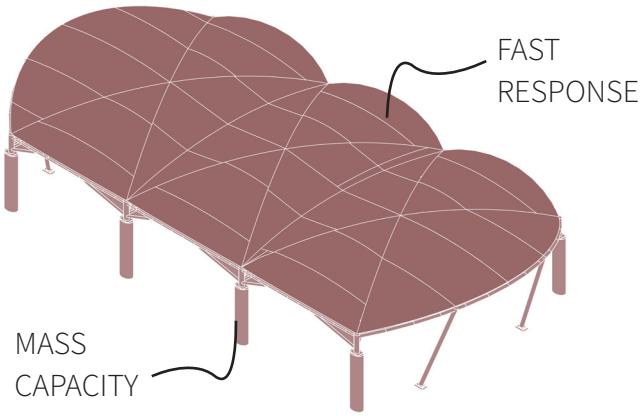


Figure 2.4 canopy as an example of emergency shelter - Author

Emergency Shelters; this type of shelter is used for short periods for immediate life-saving support and is usually the most basic shelter support. Emergency shelter are commonly does not allow for long periods of stay as it doesn't necessarily support food preparation activities and prolonged medical services.

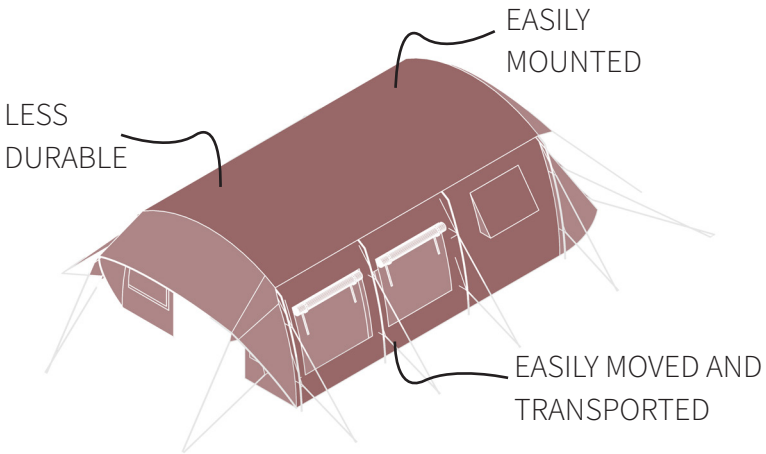


Figure 2.5 tent as an example of temporary shelter - Author

Temporary Shelters; this type of shelter is meant for short-term use. The duration of stay is limited and therefore prioritizes speed and limits costs. An example of temporary shelters are simple tents or public mass shelter used for a few weeks following a disaster.

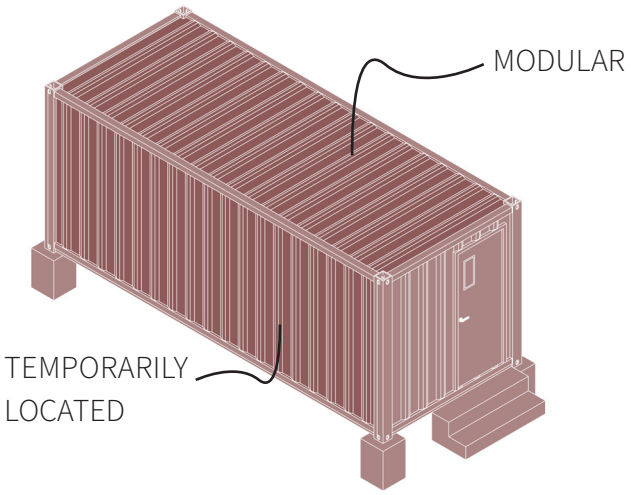


Figure 2.6 container as an example of temporary housing - Author

Temporary Housing; This type of shelter are often distributed for long-term periods such as six months to three years. An example of temporary houses are rental houses or prefabricated units that allow for people to return to their daily lives. Additionally, they are usually located in temporary lands.

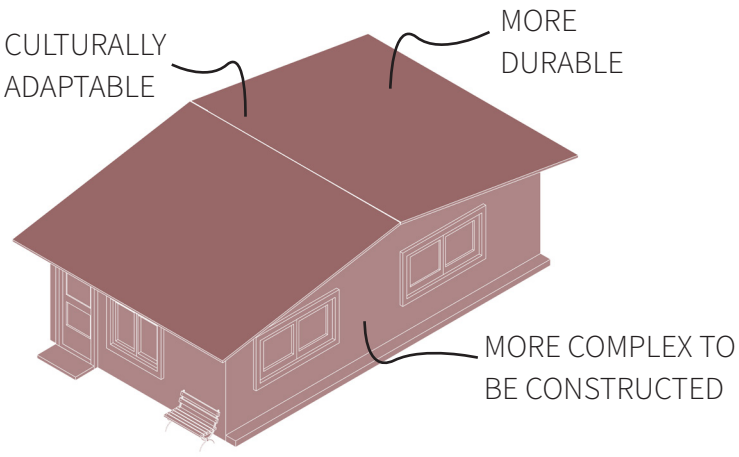
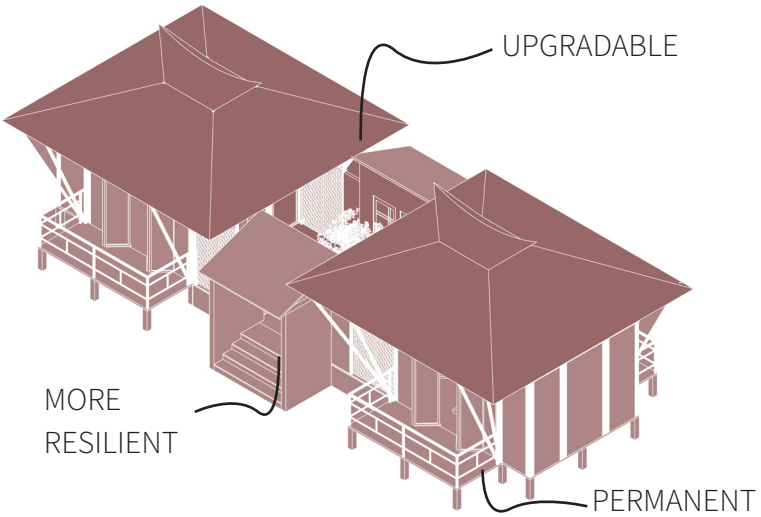


Figure 2.7 single unit house as an example of transitional shelter - Author

Transitional Shelters; this type of shelters is usually developed for long-term periods from months to years. They are developed by the displaced individual within proper and resourceful transitional management. They are relocated from temporary sites to a permanent location, upgraded into part of a permanent house that support long-term recovery.



Progressive Shelters; this type of shelters is designed and built to be more permanent and upgradable in the future through alterable structural components.

Figure 2.8 example of progressive permanent houses - Author

Core Shelter/One-Room Shelters; this type of shelter is designed and built with the intent of being permanent housing in the future, including foundation, plumbing and various utilities. They consist of one or more rooms that meets the housing living standards and facilitate improvement, but they are not intended to be a full permanent house.

Permanent Housing; This type of shelter can be upgraded from transitional shelter, a progressive shelter, a core shelter, or even a new house. These houses should be resistant and resilient to future disasters

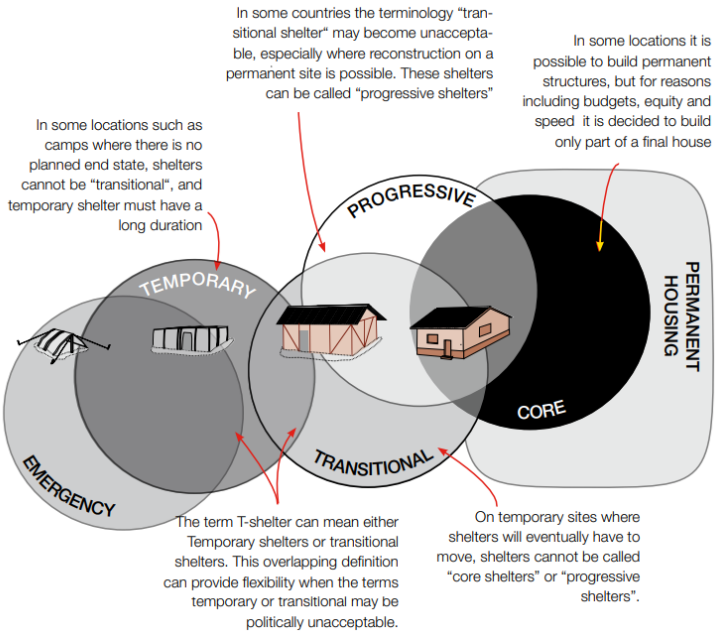


Figure 2.9 The diagram illustrate the overlaps between some different shelter terminologies - Bashawri, Abdulrahman, Stephen Garrity, and Krisen Moodley. "An Overview of the Design of Disaster Relief Shelters." Procedia Economics and Finance 18, (2013)

The type of shelter to be used following a disaster depends on many criteria including the severity and type of the disaster, the length of the period as well as the number of displaced populations. Several environmental, economic, technical and sociocultural circumstances also influence the appropriate shelter type. Moreover, the need for one or more of these shelters does not follow a certain rule that is applicable to each type of disaster. They are categorization to simplify the necessary approach to cover shelter needs and survivors conditions which can be implemented differently.

2.3. Basic guidelines for Temporary Shelter design:

Firstly, one of the most critical aspects to be considered in the design of any type of post-disaster shelter is the involvement of relevant stakeholders. This includes, but is not limited to, the affected displaced population, governmental bodies, civil society organizations including NGOs, and professional experts. Secondly, efficiency of coordination strategies between all disciplines reduces financial losses and time wasting. The design of the shelter must be efficiently integrated within the overall post-disaster management plan, as it cannot function independently without consideration of the other essential elements such as food, security, hygiene, and health. Thirdly, taking into consideration the uniqueness of each disaster situation, each disaster influence the design and construction of temporary shelter by several factors, including the type of disaster, the country's status, local conditions and cultural values. All this factors raise questions about how does the management plan allocate resources and balance the need for speed with ensuring the quality of the design and construction.

Each disaster recovery plan is inherently case-sensitive and necessitates a comprehensive analysis of the broader disaster context. This analysis includes the specific circumstances of the disaster, the conditions of the affected population, and the characteristics of the location. Consequently, similar disasters can lead to different recovery management approaches and distinct architectural designs for temporary shelters. (Abulnour 2014)

For instance, the two shelter designs presented below are responses to common natural disasters, (earthquakes), yet they exhibit strikingly different architectural solutions. Figure (2.10) illustrates the shelter response to the survivors of the 2015 earthquake in Nepal, while Figure (2.11) depicts the shelter response for the survivors of the 2017 earthquake in Iran.
Although both designs serve the purpose of providing shelter, there are significant differences in the choice of building materials and construction techniques. These differences are influenced by the contextual conditions, including the availability of local materials, transportation means, and other local factors. Additionally, the earthquake itself had different impact on the number of affected population and the intensity of the impact.

Figure 2.10 Temporary Shelter in Nepal - ArchDaily

Figure 2.11 Earthquake Shelters Iran - world architecture

Standards for temporary shelter response:

Although standards to be applied to the shelter design depends on the context, valuable international standards and guidelines were used to better shape the architectural proposal including “National Post-Disaster Recovery Planning and Coordination UNDP Guidance note”. The Global Shelter Cluster (GSC) database which was a key tool for case studies analysis. And most importantly, the SPHERE handbook, developed under the sphere project (2011), was the most extensive document providing minimum housing in post-disaster context. The handbook addresses key issues regarding the right to adequate housing determined by the United Nations. (Nappi and Souza 2015).
In this research, the sphere handbook has been essential to comply with the standards for minimum covered space area where people have access to sufficiently covered living

space that provides adequate thermal comfort, protection, privacy, security and health. In addition, the handbook highlights essential strategic planning for sheltering strategies designed to meet the needs of the population affected by the disaster. These guidelines are composed in coherence with the core design aspects to define the best performance of shelter which takes into account sociocultural, environmental and economic factors.

2.4. Qualitative aspect of Post-disaster Shelter Design:

In the aftermath of a disaster, the urgency and humanitarian fragility necessitate a design and construction process that prioritizes speed, durability, and appropriateness. To design shelters that are both sustainable and appropriate for a variety of contexts and situations, the following key factors must be considered.

Figure 2.12 Bamboo Shelters - Worldpress.com

Technical Factor:

The material used for construction should apply to aspects of availability, speed of construction and coherence with the surrounding environment. It must provide good quality, cost-effectiveness, appropriateness and local knowledge of the material.

The bamboo shelter in figure (2.12) uses bamboo as a construction material, it is considered to be very versatile, extremely resistant to compression and bending, and it is widely available in most parts of the world. Bamboo is ideal for temporary facilities, because it can be used as a structural element,

Figure 2.13 Bam Earthquake Region 1000 Emergency Accommodation Units -Dorce

for walls and roofing, it also uses various assembly techniques that increases its rigidity and resistance to mechanical forces.

Bamboo's sustainability, strength, cost-effectiveness, and versatility makes it an excellent choice for emergency shelter design and construction. Its rapid growth and renewability also contribute to environmental conservation, while its physical properties provide safe, durable, and comfortable living conditions in emergency situations.

Economic Factors:

Money is extremely important in disaster response and recovery efforts. It is a crucial factor in determining design and shelter costs. Disaster response shelter options include plastic sheeting, tents, prefabricated units, and temporary buildings. Some argue that upgrading shelters is more cost-effective than transitioning from emergency response to temporary shelter to permanent reconstruction.

In the same example shown in figure (2.12), the design of the shelter utilizes inexpensive, locally available materials like bamboo and tarpaulin that also cuts down of transportation costs. It is quickly

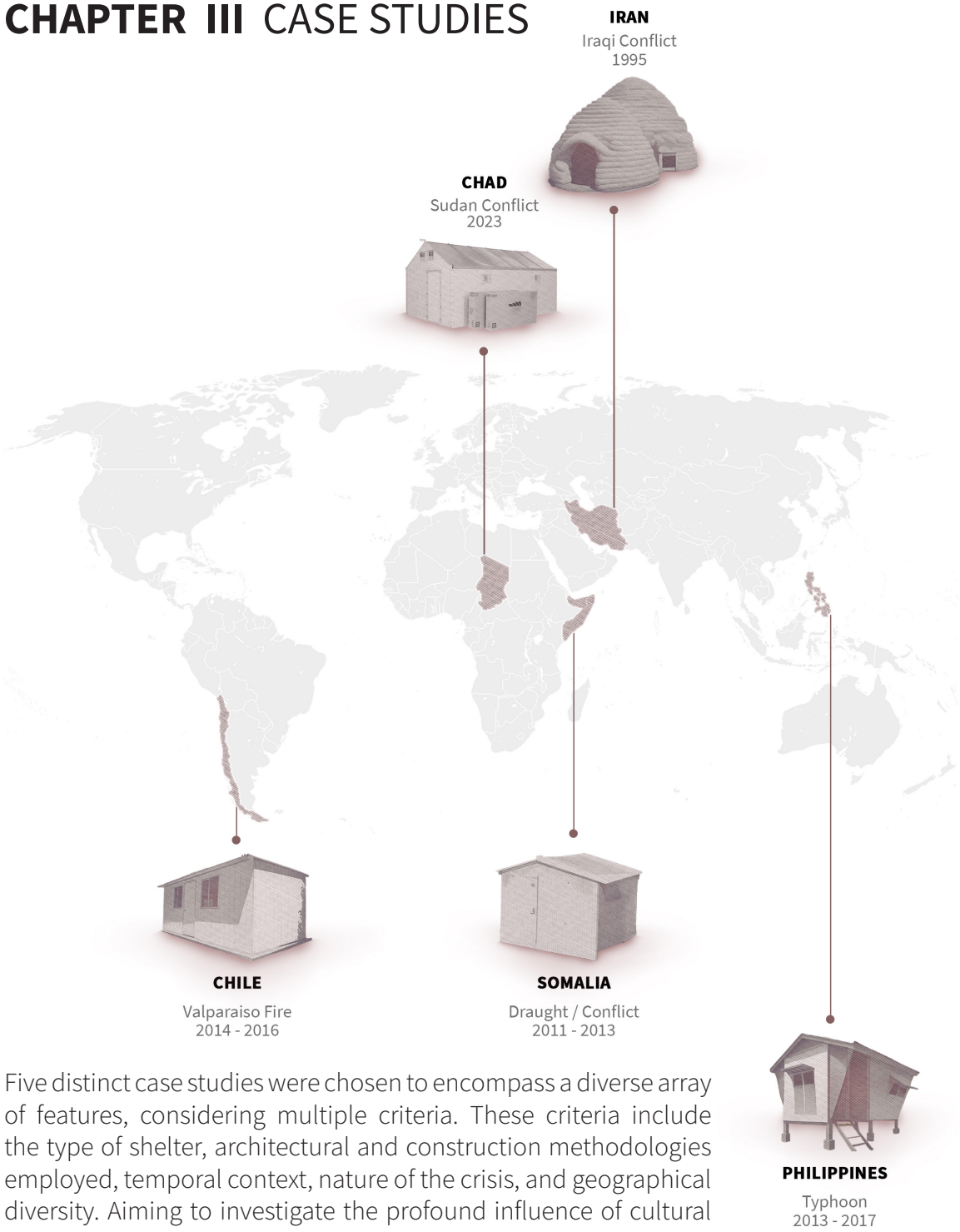
assembled which reduces the time needed for construction and consequently increases the number of units to be constructed. The bamboo's versatility allows it to be used in various parts of the design which eliminates the need for other industrial materials to be use.
In such critical situation the design of temporary shelters should take into account the economic factors that can support safe transition and recovery. These decision are based on the type of shelter to be used (emergency, transitional, core shelter …), the lifetime of the shelter and how it can support displaced people to provide adequate livelihood in long-term displacement scenarios.

Socio-cultural factors:
Post-disaster shelter design have significant impact on individual regions, countries and populations. As a result, they must be adapted to local communities and their lifestyle. Cultural requirements such as traditional values, religion, family size and local architecture styles vary greatly and could ultimately influence the lives of the affected population.

For example, in figure (2.13), prefabricated containers/shelters are often mass-produced with standard designs that does not account for cultural needs and preferences of the different communities. While they offer quick and efficient solution for emergency housing, they usually lack cultural integration and respect to cultural differences.
The longer the period planned for housing the more persistent it becomes to factor in the cultural appropriateness of the design. Communication with the involved individuals becomes necessary to develop a culturally relevant design that acknowledges traditional lifestyle with consideration of building practices.

To summarize, the strategic decisions outlined in previous points work in coordination together; for example, the choice of a using less durable material may work in conjunction with the type of temporary shelter to be built. In cases of immediate shelter relief, less durable options such as tents may provide the quickest solution for the displaced population until they are relocated to a more permanent shelter. On the contrary, more durable shelter design and construction may provide a better long-term solution, but they typically require more time and planning efforts to build and thus cannot be used as an immediate solutions. An assessment of the affected population's circumstances and the type of post-disaster shelter requirements can aid in the development of a more practical humanitarian shelter solution.

CHAPTER III CASE STUDIES



Five distinct case studies were chosen to encompass a diverse array of features, considering multiple criteria. These criteria include the type of shelter, architectural and construction methodologies employed, temporal context, nature of the crisis, and geographical diversity. Aiming to investigate the profound influence of cultural and social aspects on shelter design by examining these case studies from various parts of the world. Each case study is analysed separately following fixed criteria to identify distinctive patterns and themes. The cross-case study was used to draw on a consistent conclusion for a more focused comparison.

3.1. PHILIPPINES, TYPHOON

Figure 3.1 image of the disaster shelter in Cebu, Philippines -shelter for the victims of the typhoon by Danilo RAVINA

LOCATION: Cebu, Philippines
CRISIS: Typhoon Haiyan (Yolanda)
YEAR: 2013 – 2017
SHELTER SIZE: 18-24 M²
PEOPLE AFFECTED: 16,078,181

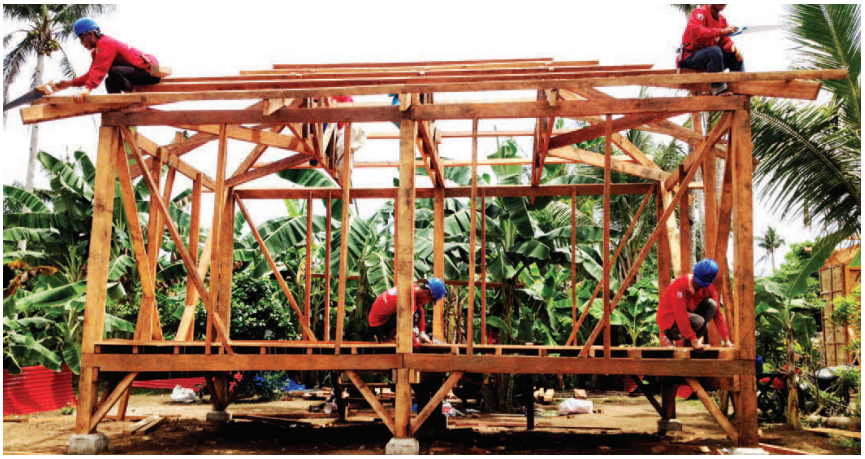


Figure 3.2 image of the disaster shelter in Philippines - disaster ready org

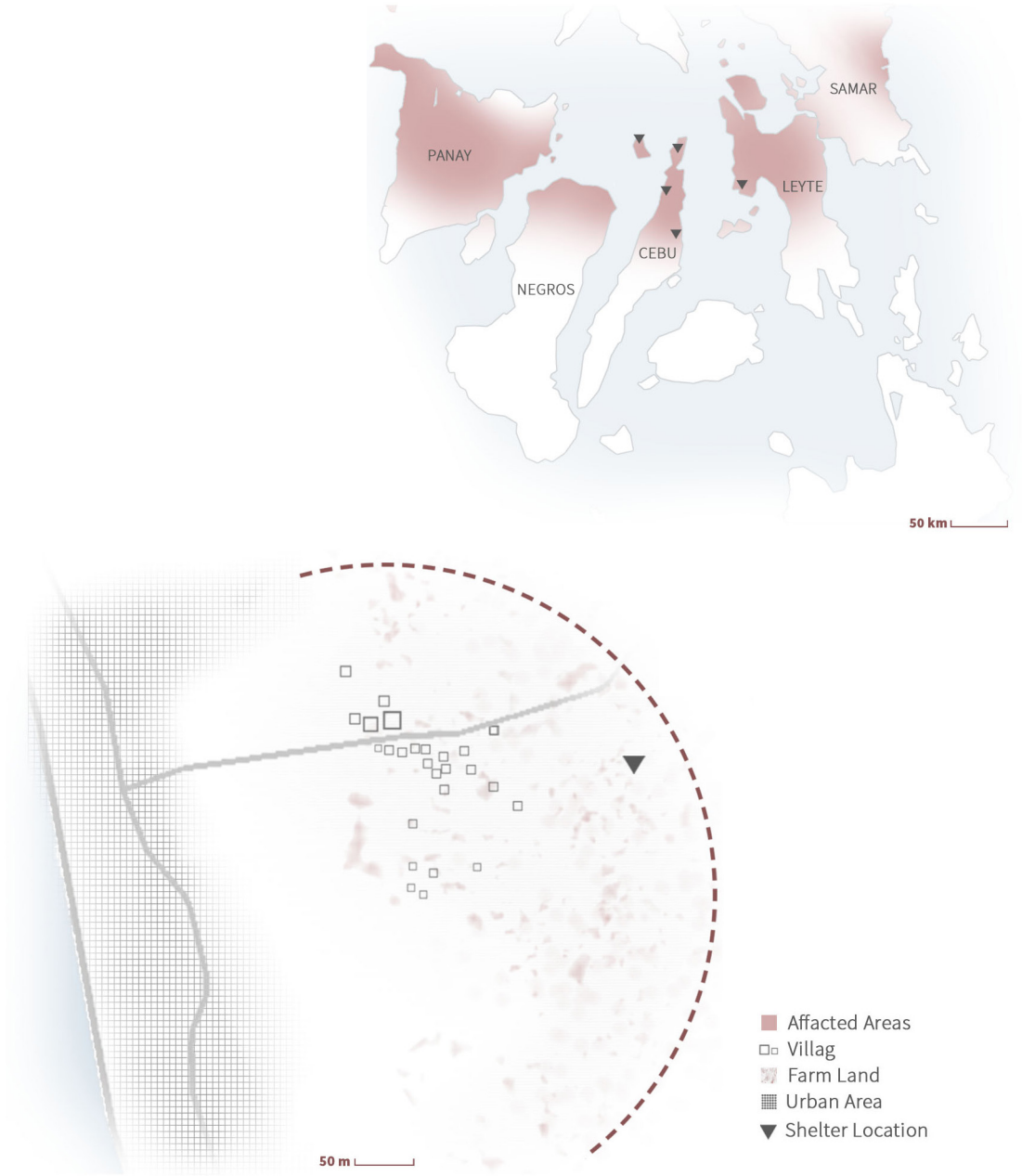


Figure 3.3 location of the disaster shelter - Author

Typhoon Haiyan (Yolanda) stands as one of the most extensive typhoons ever recorded to hit land, marking the deadliest occurrence in the history of the Philippines. Haiyan inflicted widespread damage from the eastern provinces of Leyte and Samar to the western region of Palawan. The 100km corridor in its path saw more than 1.1 million houses suffering damage, with over 50% of them being completely obliterated. Additionally, outside this corridor, an extra 300,000 houses faced damage. (ShelterCluster 2017)

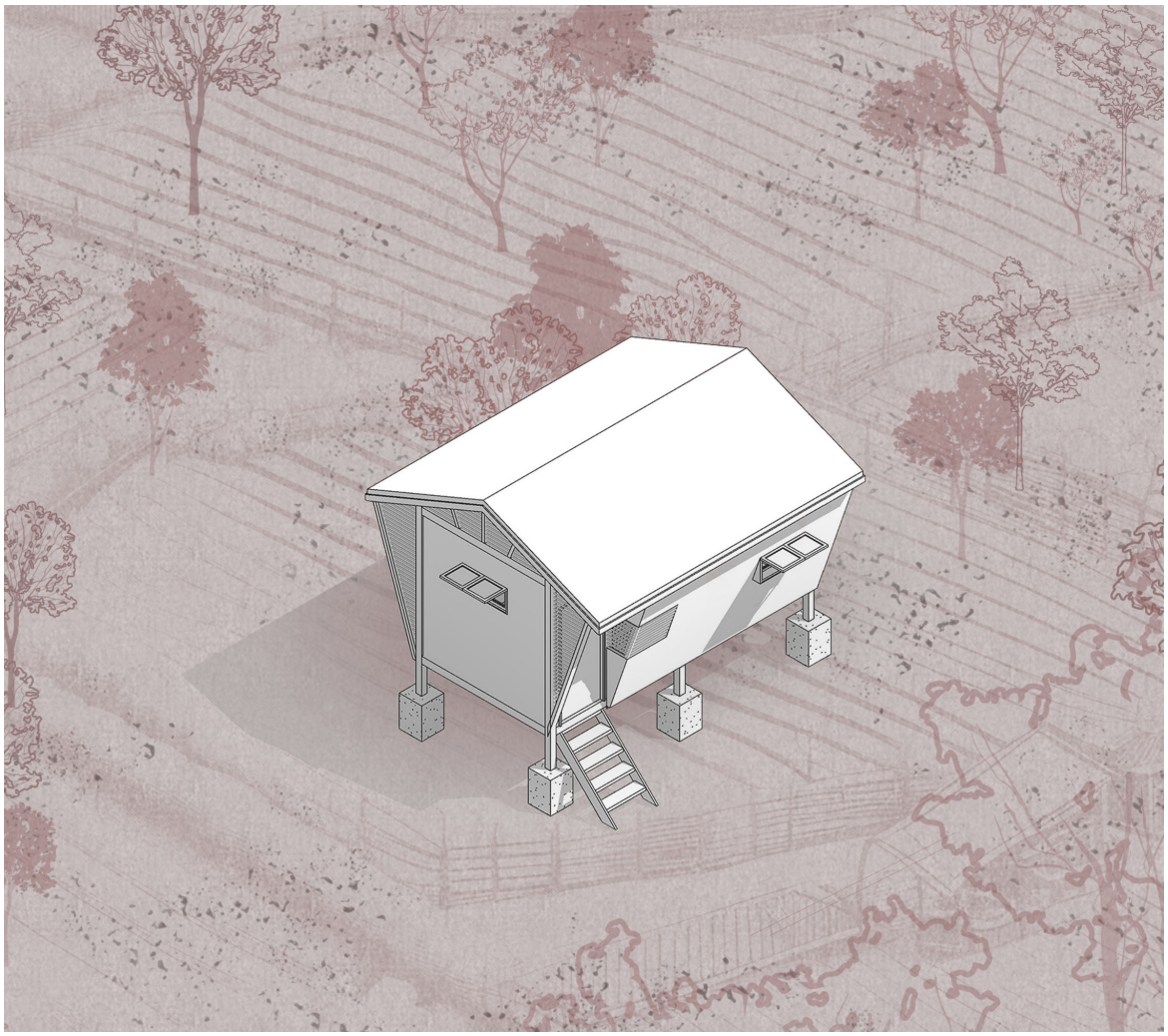


Figure 3.4 shows transitional shelter adopted in the Philippines - Author

The typhoon resulted in the displacement of over four million people, prompting many to seek initial shelter in emergency evacuation centres and larger public facilities. Some chose to evacuate to safer areas like Manila and Cebu. In the subsequent months, a considerable number of individuals found themselves residing in small tent cities, government-managed bunkhouses (emergency barracks), or with host families. Despite these efforts, the majority continued to live on-site, constructing makeshift shelters for themselves.

Design Methodology:

The shelter design drew inspiration from the initial model employed during the response to Typhoon Bopha in 2012, and consultations were conducted with local communities in both urban and rural areas. The technical and design advisor working closely with the engineering staff, created a design model that focuses on material availability and accessibility in local area backed with improved understanding of local construction techniques.

The conceptualized design was a climate-resilient transitional shelter named "I-Siguro Da-an," derived from the Cebuano vernacular term meaning 'To Secure First.' The primary characteristics of this shelter include:

- Portability for easy relocation
- Adaptability for enhancements
- Use of locally sourced and recyclable materials

Materials:

In the Visayas region, coco lumber is easily accessible and serves as the primary construction material for the local community due to its abundance and cost-effectiveness. However, obtaining 4"x4" posts proves challenging, leading to the decision to use basic dimensions of 2"x4" and 2"x6" at lengths of 8' and 10'. The construction of these wooden houses aims for swift availability and relies on local resources and industries. Amakan panels (is a type of traditional woven split-bamboo mats used as walls, paneling, or wall cladding. Wikipedia) were used locally for many years. In addition, the design of the unit encouraged circular architecture with the use of on-site salvaged materials for some parts of the building.

Disaster Risk Reduction Technique (DRR):

Due to the recurrent incidence of natural disasters within the country, the design has embraced the implementation of Disaster Risk Reduction (DRR) techniques. These strategies are specifically tailored to emphasize the significance of fortification and the integration of disaster-resilient construction practices. Their primary objective is to mitigate potential damages that might arise in future calamities.

These techniques underscore the pivotal role of building resilient shelters. While emergency housing is crucial for immediate shelter needs following a crisis, the focus remains on ensuring the longevity of these solutions. Thus, the design approach places vital importance on incorporating an optimal blend of disaster-resilient construction methods and the utilization of abundant and durable building materials. This technique aims to create sustainable housing solutions that endure beyond the immediate aftermath of a disaster fostering long-term resilience against future disasters. (Ravina and Shih 2017)

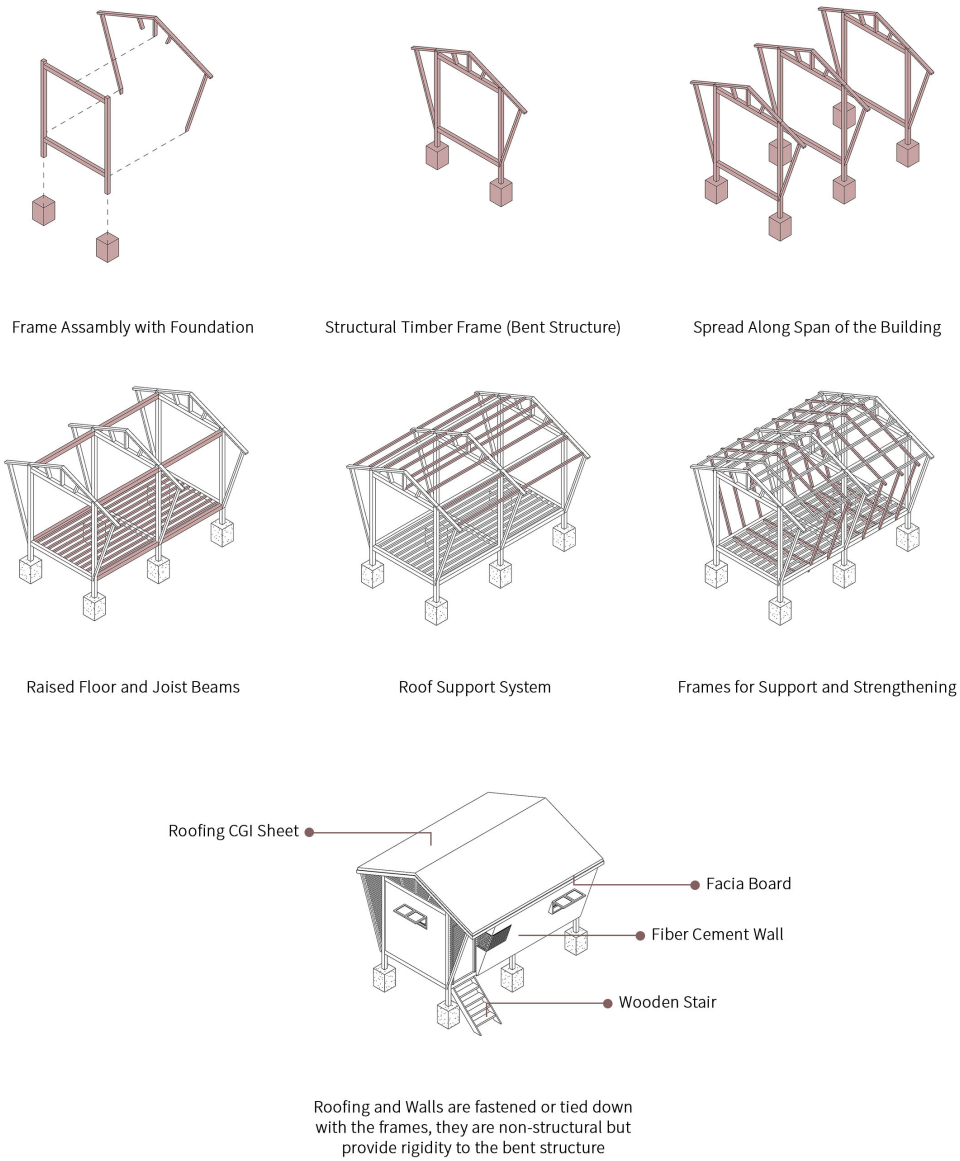


Figure 3.5 Bent Construction Method - Author

Bent Construction Method:

The shelter's design is rooted in the Bent method of construction, characterized by a series of structural frames that serve as foundational elements to which the flooring system, roofing system, as well as the interior and exterior walls are secured. The walls, the envelope are non-structural and primarily contribute to providing stability to the frames. The bents can either be prefabricated or assembled on-site. Additionally, diagonal braces are incorporated on all sides to enhance protection. The slanted walls design provides strength but also optimizes interior space for sleeping and various household activities for the family. (Ravina and Shih 2017)

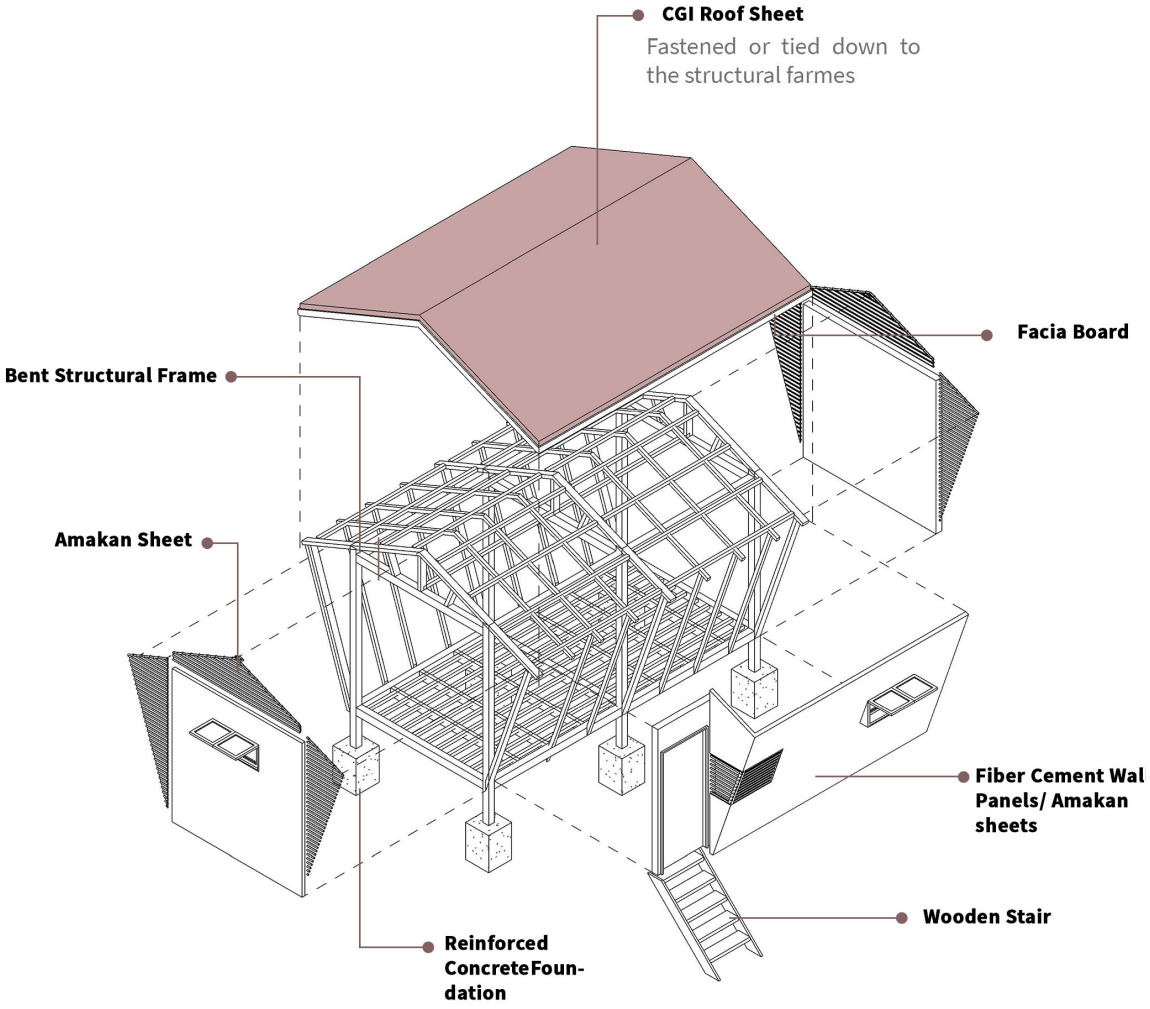


Figure 3.6 shelter construction technique - Philippines - Author

Family Size: 6 People
Size: 18 - 24 M²
Material: Concrete, Coconut wood frame, Amakan and Bamboo Splits
Duration of Construction: 3 -5 Days
Number of Units Built: 500 Units
Cost per unit: 1904 USD
Space per Person: 3.6 M²

Architectural Features:

1. Architecture Layout:

The floor plan is divided into two sections:

- The living module
- The sleeping module

The kitchen and bathroom are situated separately outside, constructed with a reinforced concrete frame and slab.

2. Envelope:

- Walls are made with breathable materials, enhancing thermal comfort and allowing views from inside to outside, along with natural ventilation.
- The elevated floor is composed of fiber cement boards or bamboo strips, facilitating cross ventilation and improved thermal comfort.
- Lockable windows enhance ventilation, while roof fascia boards and short overhangs minimize negative forces during a typhoon.
- The roof consists of GI Corrugated sheets on coco purlins, reinforced with traditional umbrella nails for added stability during strong typhoons.

3. Slanted Walls:

A distinctive feature is the slanted walls on the longer sides of the house, providing several advantages:

- Reducing wind resistance and deflecting airflow (pending further wind analysis studies).
- Shading the house from 9:00 AM to 3:00 PM, preventing overheating and eliminating the 'Monroe' effect caused by wind updraft.
- Creating a perception of wider interior spaces.
- In the event of a disaster, the walls fall outward, minimizing harm to occupants.
- Internally, the slanted walls allow for expanded volumetric space, enabling the attachment of shelves without encroaching on the established floor footprint in the Living Module. In the Sleeping Module, bunk beds can be accommodated at the sides, allowing for elevated sleeping arrangements

Project Highlight:

- The simplicity of the design not only ensures that workers can receive appropriate training and adhere to efficient construction practices but also significantly reduces training time.
- The shelter, in addition to its simplicity, must maintain affordability without compromising the structural integrity of the project, all while being culturally sensitive to the needs and preferences of the community.
- Demonstrating the utmost significance, the active inclusion of the affected community emerges as a pivotal factor for the success of the shelter, fostering a sense of community engagement and ownership in the project.

3.2. CHAD, SUDAN CONFLICT

Figure 3.7 image of the disaster shelter in Ouaddaï, Chad - BetterShelter

LOCATION: Ouaddaï, Chad
CRISIS: Sudan Conflict
YEAR: 2023
SHELTER SIZE: 17 M²
PEOPLE AFFECTED: 2.5 million

Figure 3.8 image of the disaster shelter in Chad - UNHCR

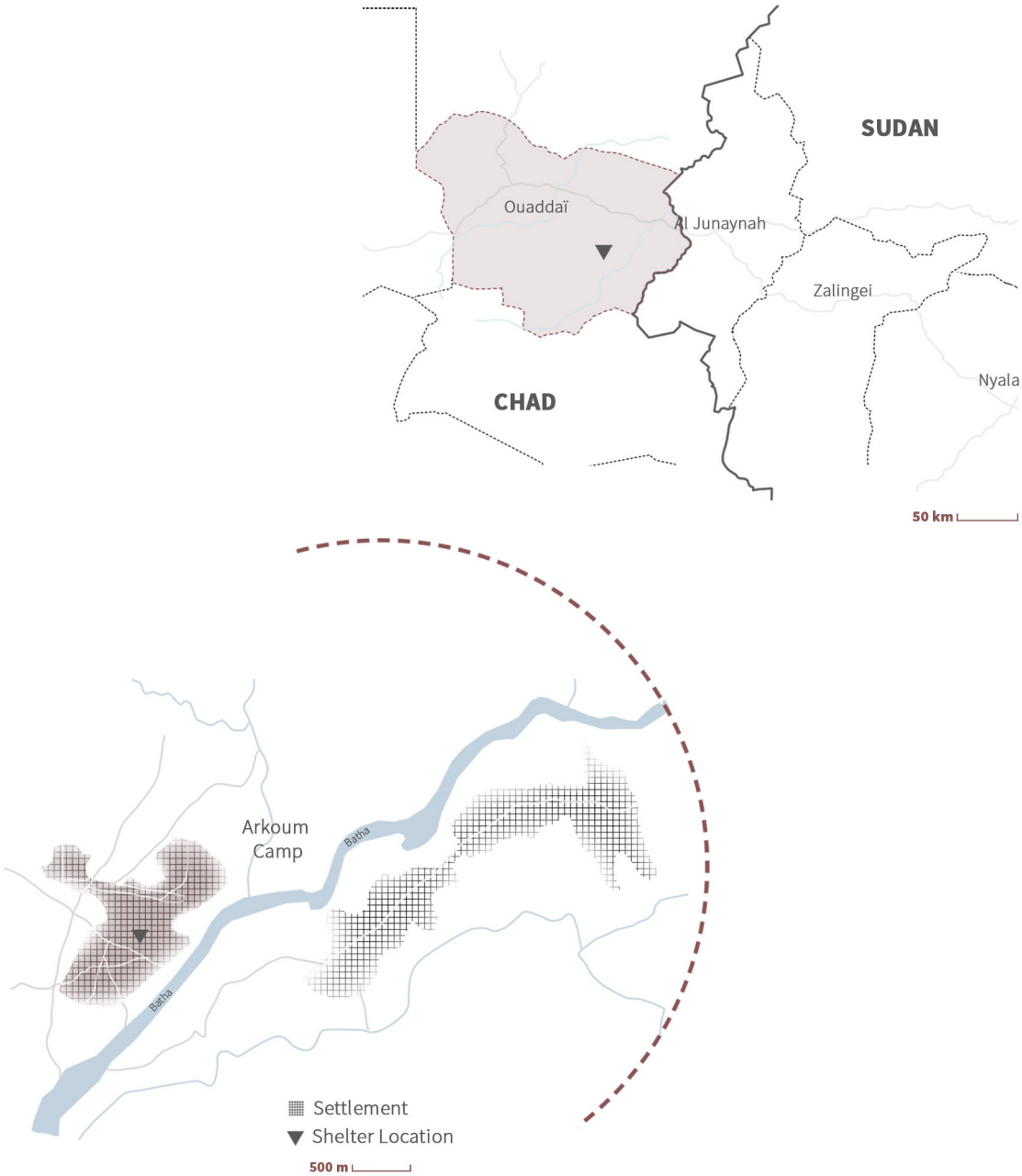


Figure 3.9 location of the disaster shelter, Chad - Author

The ongoing conflict in Sudan between the Sudanese Armed Forces (SAF) and the Rapid Support Forces (RSF) that erupted in April 15th 2023, has resulted in the displacement of nearly 6 million individuals, within Sudan and neighbouring countries. Chad received displaced people mostly from Darfur who were accommodated in spontaneous sites and managed camps across the eastern provinces in Chad. (UNHCR 2023)

Figure 3.10 shows emergency shelter adopted in Chad - Author

With the coordination between the Government of Chad and UNHCR, humanitarian aid has been delivering emergency since the initial weeks of conflict. Shelter assistance extended to unplanned sites and camps that emerged along the border area. The response included the improvement of existing infrastructure and newly created sites in eastern provinces. The IKEA foundation along with Bettershelter (An independent non-profit organization), provided financial support for the construction of 3,000 shelters in aid for the increasing displaced population. The shelter unites were placed in existing Arkoum Camp in the province of Ouaddaï, The 17 m2 unit provided shelter for a household of 5 people that consist of internal spaces for living, leisure and sleeping. The camp is already planned to provide multiple WASH facilities (the collective term for Water, Sanitation and Hygiene) they are interdependent and help keep refugees healthy. Without toilets, water sources for drinking and cooking can become contaminated which can be shared between several families. (IKEA 2023) (Bettershelter 2023)

Shelter Unit:

Better shelter in collaboration with IKEA foundation designed a modular shelter unit that can be easily assembled like a kit. The kit is delivered in a method that resembles IKEA's "Do it yourself" Concept The shelter unit is a temporary dwelling designed with emphasis on factors such as transport, volume, weight, cost, safety, as well as health and comfort. It can be assembled on-site without the need for additional tools and equipment and no special expertise. The shelter unit is packed as pieces in a flat-pack to simplify means of shipping and transportation. (IKEA 2023).

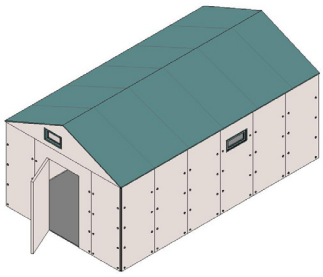


Figure 3.11 shows a shelter unit - Author

Relief Housing Unit (RHU); a resistant shelter that arrives with all parts in a flat-pack and is easy to assemble for immediate safety and dignity in emergency response.

- **All in a box:** Residents can move into a dignified shelter from start.
- **Modular:** Multi-sectoral use in different contexts and climates. Can be upgraded overtime to prolong lifespan.
- **Dignified, safe, temporary:** it offers disaster affected families a higher level of safety, protection and dignity.

Design Methodology:

The concept was to create a straightforward, modular galvanized steel frame that could be easily assembled and the then enveloped with prefabricated panels that are both waterproof and fire-resistant. The panels are made of polyolefin with UV protection to mitigate the harsh sunlight deterioration. All used materials provide strength to withstand severe weather conditions and lightness for convenient shipping and transportation. Finally, the roof is equipped with solar PV panels, capable of storing energy to provide lighting and charging stations during the night, the relief unit can be assembled as:

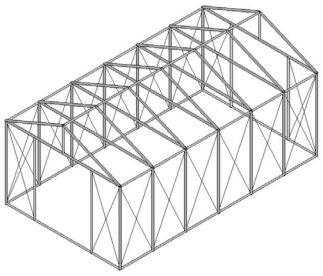


Figure 3.12 shows the structural design - Author

RHU structure; a robust shelter frame that lets residents make incremental upgrades with local material and use it throughout the duration of displacement.

- **Incremental approach:** the steel framework can be clad with tarpaulin and upgraded with local material over time.
- **User led process:** Residents can apply their expertise and building traditions, fostering independence
- **Localized:** Culturally and climatically adaptable, it may be combined with various materials and techniques in different responses and contexts.

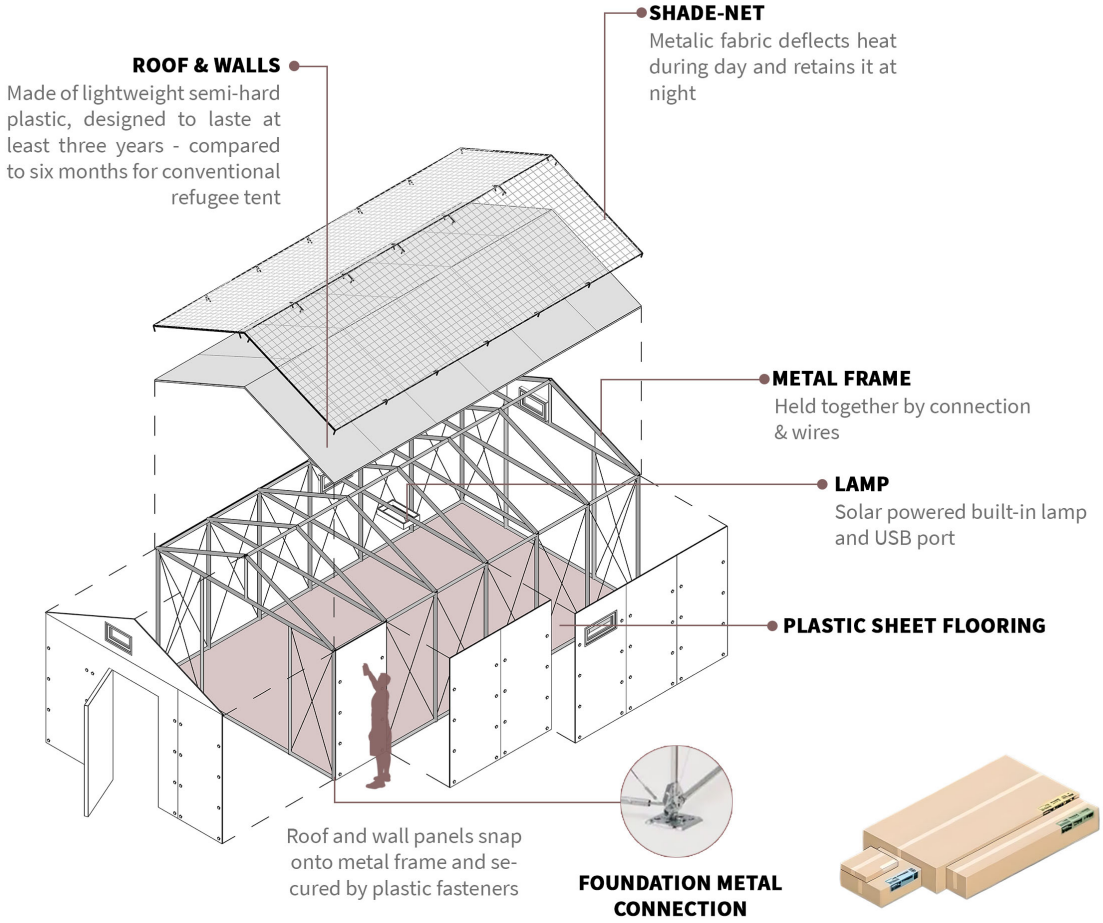


Figure 1.1 shelter construction technique - Chad - Author

Family Size: 5 People
Size: 17 M^2
Material: Galvanized steel frame, Polyolefin foam panels
Duration of Construction: 5 Hours - 1 Day
Number of Units Built: 50 Units
Cost per unit: 1150 USD
Space per Person: 3.5 M^2
Shelter Life Span: 3-10 Years
Construction Team: 4 People

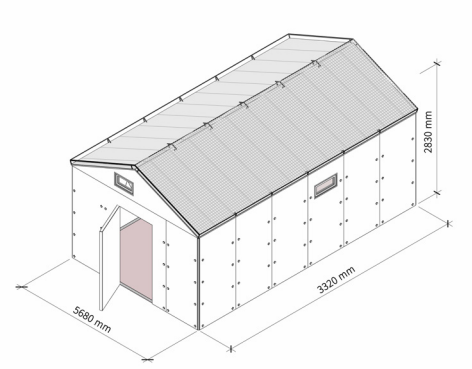


Figure 3.14 IKEA Foundation shelter unit - Author

Figure 3.15 Shelter unit Kit - wall street journal

Architectural Features:

- Doors; High resistant door and hinges with lock, which can be padlocked from both sides for added safety for women and children.
- Wall Panels; Polyolefin foam panels treated with fire retardant and UV protection
- Floor; Height adjustable, flood preventing tarpaulin made of woven high-density polyethylene fibers.
- Roof; Polyolefin foam panels treated with UV protection
- Windows; Intrusion prevention window with mosquito net and shade made of UV and heat resistant polymer plastic.
- Ventilation; UV and heat resistant polymer plastic
- Frame; Lightweight galvanized steel
- Foundation; Lightweight galvanized steel connection to foundation
- PV system: Providing 4 hours of light and mobile charging Customizable Fire resistant Lockable doors

Project Highlight:

- The unit does not only serves as a residential shelter but also functions as a versatile support system for communal and social purposes such as clinics, classrooms, and health facilities, etc.
- Its construction is swift and uncomplicated, allowing for easy assembly and disassembly.
- The straightforward design facilitates the potential for the structure to be built without the need for specialized expertise.
- The incorporation of lightweight materials ensures the unit's effortless transportation to various locations.
- The widespread of the use of the unit worldwide proves the efficiency in providing a temporary solution for emergencies
- The project is one of the most widely used solutions for emergency shelter around the world with one of the most recent applications

3.3. CHILE, VALPARAISO FIRE

Figure 3.16 image of the disaster shelter in Valparaiso, Chile - ArchDaily

LOCATION: Valparaiso, Chile
CRISIS: Forest Fire
YEAR: 2014 - 2016
SHELTER SIZE: 18 M²
PEOPLE AFFECTED: 12,500

Figure 3.17 image of the disaster shelter in Chile - ArchDaily

Figure 3.18 location of the disaster shelter, Chile - Author

Chile, situated along the Pacific Ring of Fire known for intense volcanic activity and earthquakes, faces a high risk of earthquakes, making it one of the most earthquake-prone countries globally. The Valparaíso fire in 2014 magnitude earned it the moniker “El Gran Incendio de Valparaíso.” It resulted in 15 casualties, affected 12,000 people, and destroyed more than 3,000 homes. The fire disproportionately affected the poorest areas characterized by informal construction, lacking urban planning, leading to high structural density, proximity to forests, and limited accessibility.

Figure 3.19 shows core shelter adopted in Chile - Author

Due to the vulnerable location of the city as it is continuously affected by natural disasters such as tsunamis and earthquakes, self-construction in Valparaiso has happened for generations and many people rely on self-construction of a basic housing construction from salvaged materials. Worried about losing their land and unwilling to resettle outside of the city, inhabitants immediately started reconstruction when the fire subsided after cleaning their land. The basic housing corresponds to a type of housing solution that has been proposed, according to its creators, as an evolution of the well-known “Mediagua”, capable of being built without substantially increasing costs and maintaining the concept of easy prefabrication and installation efficiency. The 19.3 m2 home is the most economical housing solution and is part of a series of housing models that have been increasing the technical and habitability standards. (ShelterCluster 2017)

Design Methodology:

Mediagua is a simple house design developed by the Chileans as a temporary shelter for the frequent crisis that the country has been going through for years now. They are designed to be temporary, but are frequently adapted by users while a more permanent solution is unavailable, which can take some years. (Wagemann and Moris 2018)
The design approach to the housing unit works in module that can be built in different sizes depending on the family size and the exterior panels can be made from cork or wooden panels depending on the geographical location in which said system will be installed. The structure is mostly made using wooden poles or stilts and zinc-aluminum panels. Most materials are cheap and easy to find, however Mediaguas are often built out of recycled material, self-built by the residents.

The Panel Construction Method:

The panel construction system employs panels as both the structural framework and the building envelope, supporting all the loads. It entails a more maneuverable, stackable and transportable panel modulation, it allows for improvements is assembly times. This results in a more adaptable, stackable, and transportable panel modulation, facilitating enhanced assembly and dismantling efficiency. Advantages of using the panel system includes:

- Efficient and flexible construction approach using prefabricated panels.
- Swift and uncomplicated assembly (requiring no specialized labor).
- Improved comfort and habitability, thanks to an insulated envelope and an average height of 2.3 meters.
- Utilization of certified materials.
- Expandability for future modifications and additions.

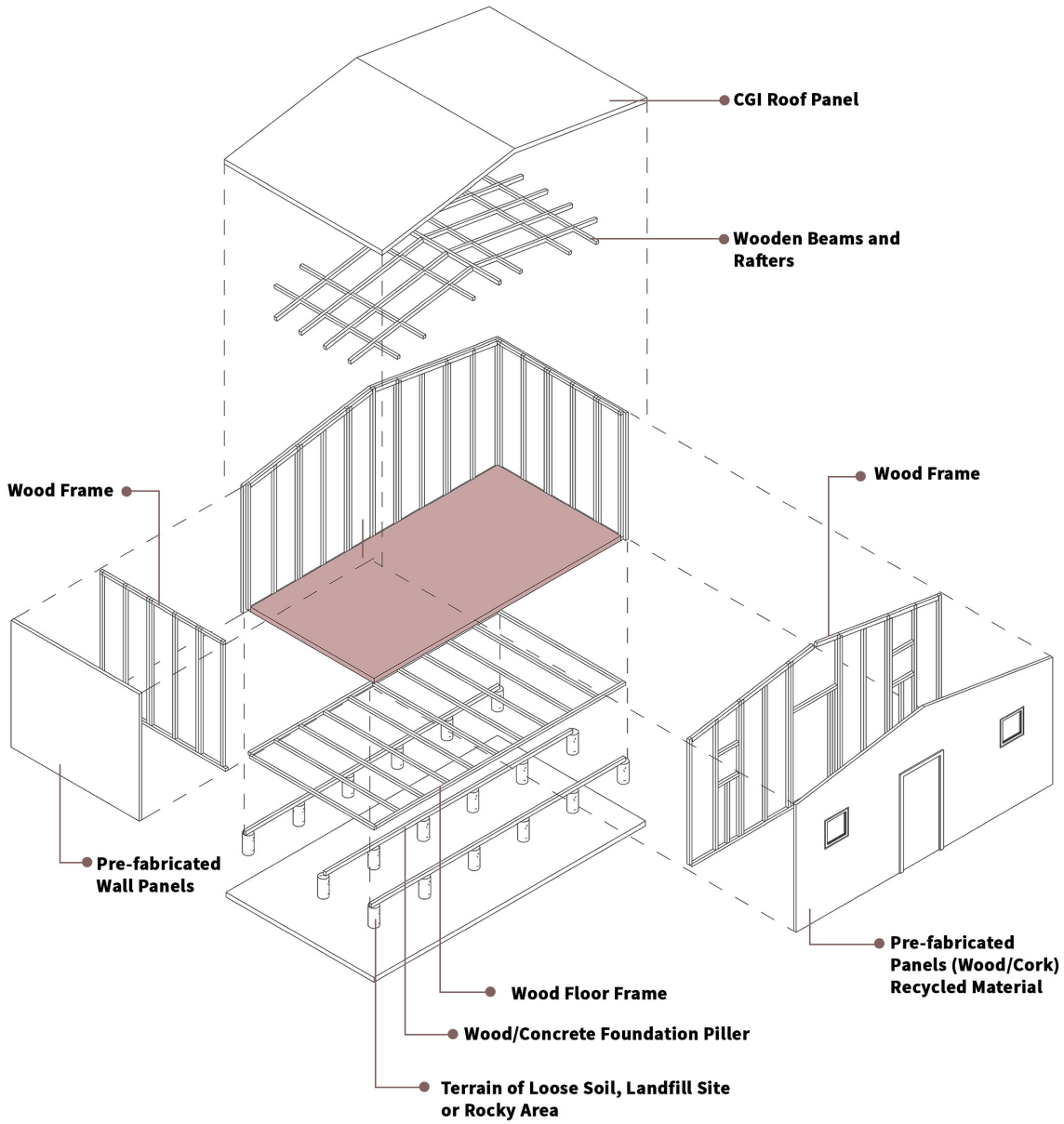


Figure 3.20 shelter construction technique - Chile - Author

Family Size: 3.4 People
Size: 18 M^2
Material: Wood panels and wood frames, wood/concrete foundation
Duration of Construction: 2 Days
Cost per unit: 1300 USD
Space per Person: 5.3 M^2
Construction Team: 6-8 People

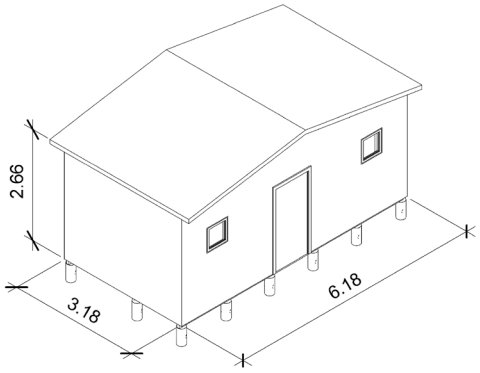


Figure 3.21 shelter unite, Chile - Author

Architectural Features:

- Floor Panels:

The floor panel consists of a 2 x 3" pine frame, 15 mm structural plywood, and 50 mm expanded polystyrene insulation. These panels can be supported by either a concrete pile structure or wood.

- Walls:

The walls feature a 2x2" pine structure, 50 mm expanded polystyrene insulation (for potential improvements). Internally, the panel is covered with a 9.5 mm OSB board, while externally, it is protected by a 9.5 mm R8 Smart Panel.

- Roof:

The roof is also panel-based, comprising a 1 x 4" pine structure, 80 mm expanded polystyrene insulation, asphalt felt, and internal coverage with a 9.5 mm OSB board. Externally, it is shielded with a 0.35mm grooved zinc sheet and maxseal (foam) to prevent air leaks. The panel is supported by perimeter walls and a structure involving 1x4" pine beams, 2x2" pine shorelines, and a 1x2" pine mooring slab.

- Windows and Doors:

Windows are sliding and aluminum-made, while the door, with a width of 90 cm, ensures universal access for individuals with disabilities or mobility challenges. Both windows and doors come pre-installed on the factory-built panel.

Project Highlight:

- Given the area's susceptibility to hazards, a significant portion of residents possessed pre-existing construction knowledge, with 80% of homes being self-constructed, a factor that greatly facilitated the project's execution.
- The preparation and planning aimed at enhancing disaster readiness are conducted with high efficiency, demonstrating a proactive stance in equipping the community for potential emergencies.

3.4. SOMALIA, DRAUGHT/CONFLICT

Figure 3.22 image of the disaster shelter in Garowe, Puntland, Somalia - Somalia study of drought and conflects 2011-2013

LOCATION: Garowe, Puntland, Somalia
CRISIS: Draught/Conflict
YEAR: 2011 - 2013
SHELTER SIZE: 16 M²
PEOPLE AFFECTED: 1.4 Million

Figure 3.23 image of the disaster shelter in Somalia - Somalia study of drought and conflicts 2011-2013

Figure 3.24 location of the disaster shelter, Somalia - Author

The enduring humanitarian crisis in Somalia is characterized by persistent conflicts, climate-related adversities, outbreaks of communicable diseases, feeble social protection mechanisms, insecurity, and accessibility challenges. The situation is extremely grave, necessitating sustained and enhanced humanitarian assistance over an extended period. Across all 18 regions of Somalia, there are more than 2,000 internally displaced persons (IDP) settlements. Recent internal displacements in Somalia are primarily driven by conflict or the fear thereof, constituting 33% of all movements. Other significant factors include drought (22%), lack of livelihood opportunities (16%), and evictions (5%)

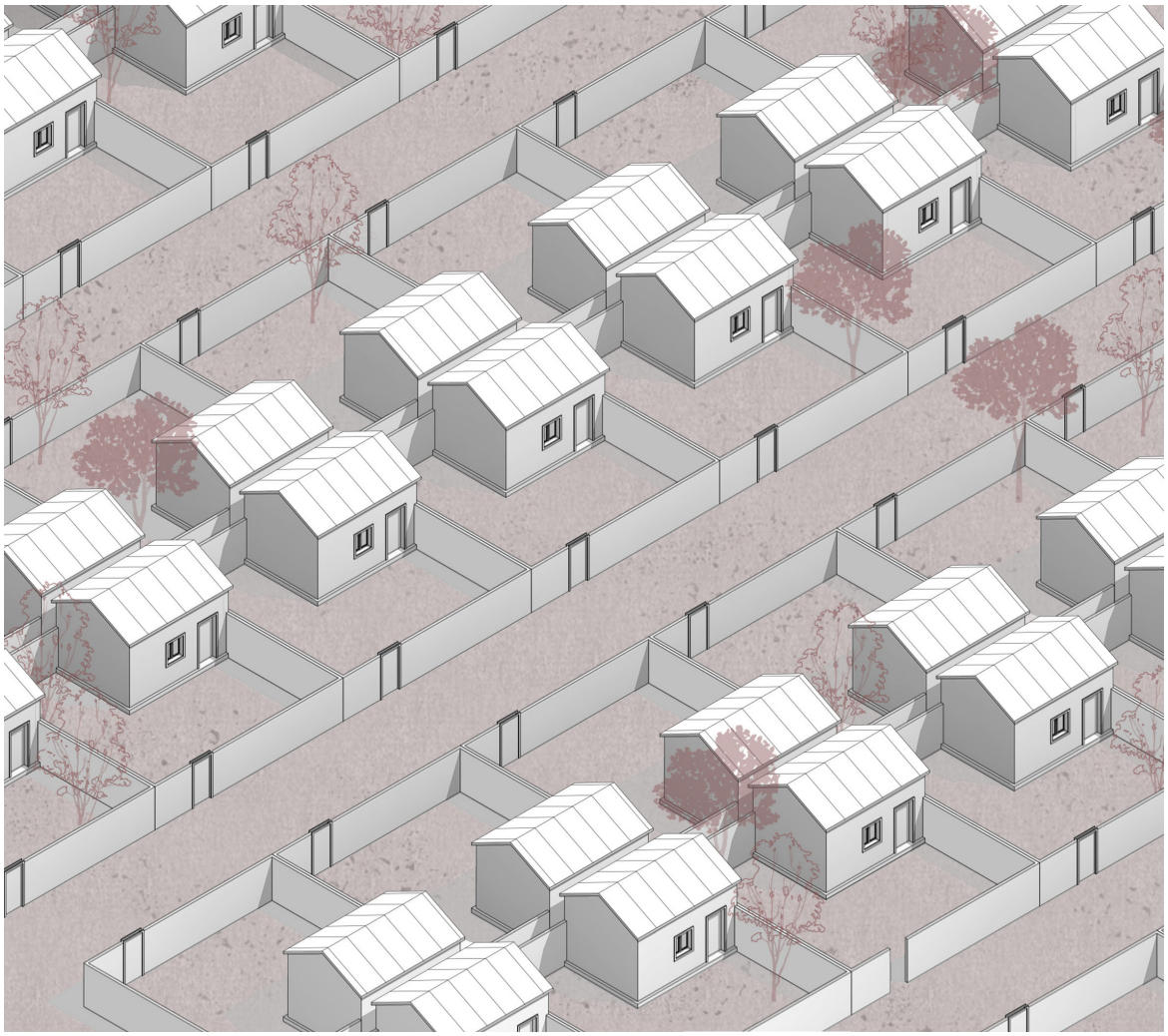


Figure 3.25 shows core shelter adopted in Somalia -Author

In terms of emergency response, the Cluster devised a basic kit designed for local procurement and storage at strategic locations in Somalia and Kenya through collaboration with Cluster partners. Transitional shelter assistance was directed towards established Internally Displaced Person (IDP) settlements in Puntland and Somaliland. Initiatives ranged from distributing shelter kits to constructing houses complete with corrugated iron roofing materials. The third pillar aimed to facilitate voluntary relocation or the return to original places of residence. Given the influx of returnees from Yemen and Kenya, the Cluster adopted an inclusive approach, promoting the integration of IDPs, returnees, and marginalized urban communities.

Design Methodology:

Overall, the shelter is designed crafted with high-quality, resilient materials. With proper maintenance, the shelter is anticipated to have a prolonged lifespan, ranging from 10 to 15 years. The use of new stone blocks, predominantly favoured by the local community, enhances its durability. Additionally, out of the 10x10 meters available on the plot, only 4 meters were utilized, leaving ample space for potential future family extensions, such as an additional room.

Before the construction begins, the community undergoes technical training to acquire the necessary skills for building their own units. This training is conducted under the guidance of construction workers. While the building may be deemed sturdy, it lacks a specific earthquake-resistant structure. The foundation, made of concrete, plays a crucial role in preventing collapse and offering protection from floods.

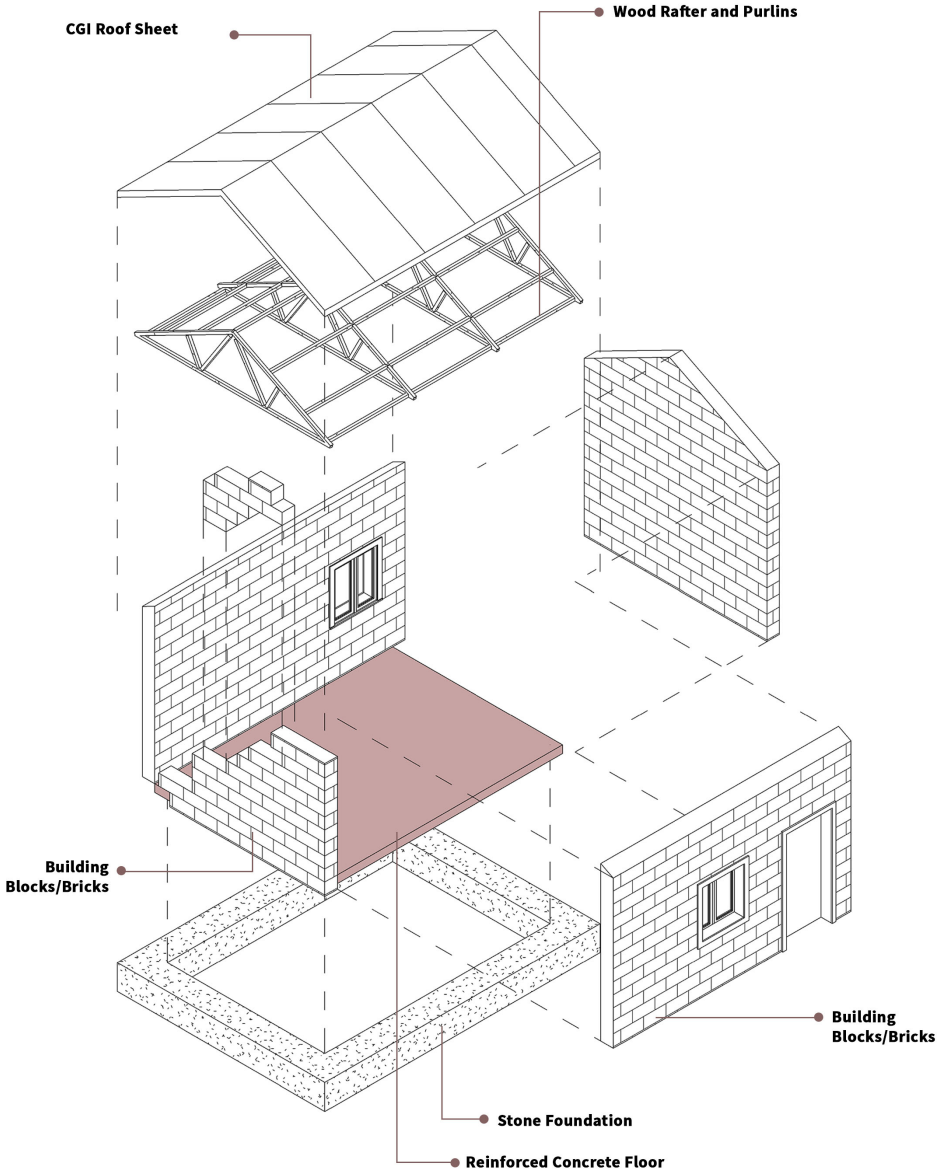


Figure 3.26 shelter construction technique - Somalia - Author

Family Size: 5.9 People
Size: 16 M^2
Material: Stone block, Timber, Wood
Duration of Construction: 10 Days
Number of Units Built: 1,200 Units
Cost per unit: 1693 USD
Space per Person: 2.7 M^2
Shelter Life Span: 10-15 Years
Construction Team: 3 People

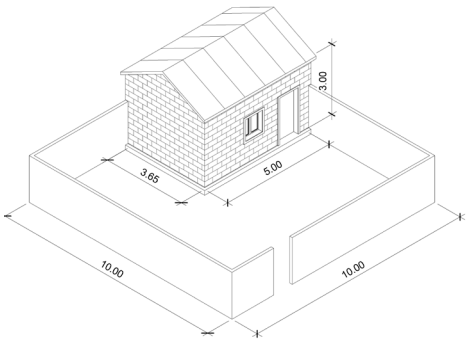


Figure 3.26 shelter unite, Somalia - Author

Architectural Features:

- The door is designed for easy access by individuals with disabilities, ensuring universal accessibility.
- The shelters feature lockable doors from the inside, and each unit includes a separate toilet for the household.
- The shelter boasts a purposeful rectangular layout, presenting a robust design that incorporates:
    - A Corrugated Galvanized Iron-sheet (CGI) roof
    - An interior floor space measuring approximately 4 by 4 meters.
    - Meticulously constructed exterior walls using stone blocks composed of materials like cement and mortar.
    - Two windows and a single door, assembled with timber and securely affixed with nails. Additionally, thoughtful provisions for ventilation have been strategically placed above both the door and windows, ensuring effective airflow within the structure.
- An additional small toilet facility, positioned within the plot's compound, the intentional allocation of space allows for potential future enhancements or expansions, offering the flexibility to upgrade or modify the structure as needed.

Project Highlight:

- This project addresses the intricate challenges of an enduring crisis, offering a fitting response that respects the cultural and social dynamics of the affected communities.
- The project highlights the appropriateness of the distinguished architectural style that responds to the particulate cultural living style of Somalia
- The project puts forward a more sustainable settlement approach to address the persistent displacement issue.
- The shelter is conceived as neither purely transitional nor entirely permanent, striking a balance between the two, acknowledging its durability while retaining adaptability for future changes.

3.5. IRAN, IRAQI CONFLICT

Figure 3.27 image of the disaster shelter in Ahwaz, Khuzestan, Iran-Contemporary architecture of Iran

LOCATION: Ahwaz, Khuzestan, Iran
CRISIS: Iraqi Conflict
YEAR: 1993
SHELTER SIZE: 14 M^2

Figure 3.28 image of the disaster shelter in Iran - CalEarth.org

Figure 3.29 location of the disaster shelter, Iran - Author

Iran hosts more than 500,000 Iraqi refugees, about 350,000 of whom were expelled from Iraq at the time of the Iraq-Iran War because of their suspected Iranian origin. Iran is host to one of the largest and most protected urban refugee situations in the world and has provided asylum for refugees for over four decades mainly from Afghanistan and Iraq. Due to the Government's progressive and inclusive policies, refugees have been given access to education, health, and livelihoods opportunities. It is estimated that 99% of refugees in Iran live in cities, towns and villages side by side with the Iranian host community, while 1% live in 20 settlements managed by UNHCR's. Many refugee camps has been dismantled ever since and specific data on the location of the sandbag shelter was not found. Some research indicates that the refugee camp was in the Khuzestan region close to the city of Ahwaz near the boarders with Iraq, but it is not confirmed.

Design Methodology:

Following thorough research into traditional earth building methods in Iran, and subsequent detailed prototyping, the sandbag or 'superadobe' system has been developed by Iranian architect Nader Khalili. This innovative concept enables individuals to construct their own shelters by filling sandbags with the local earth and then stacking them into dome forms, secured by barbed wire. These shelters exhibit robust structural strength, capable of withstanding earthquakes, fires, floods, and hurricanes.

The construction process is notably quick, easy, and cost-effective. By applying external plaster and incorporating any necessary additional spaces, these shelters can be transformed into permanent structures. The system embraces sustainability by relying on sun, shade, and gravity for energy. Moreover, it boasts adaptability in terms of size, material, and configuration, extending its utility to the construction of roads and other infrastructure. (López, González and Llauradó 2019)

The sandbag shelter system not only complies with the stringent requirements of UNHCR for refugees but also aligns with the preferences of host countries and the refugees themselves. Host countries often discourage the construction of permanent structures to encourage refugees to return to their homelands. The 'superadobe' technology enables the creation of shelters that last for a single season, unless waterproofed and completed as permanent houses.

UNDP and UNHCR have chosen this technology for temporary shelters for displaced persons due to its distinct characteristics:

- Flexibility in size, surface area, and design.
- Affordability.
- Rapid construction speed.
- Minimal on-site skill requirements.
- Potential for temporary shelters to be expanded and upgraded into permanent homes.

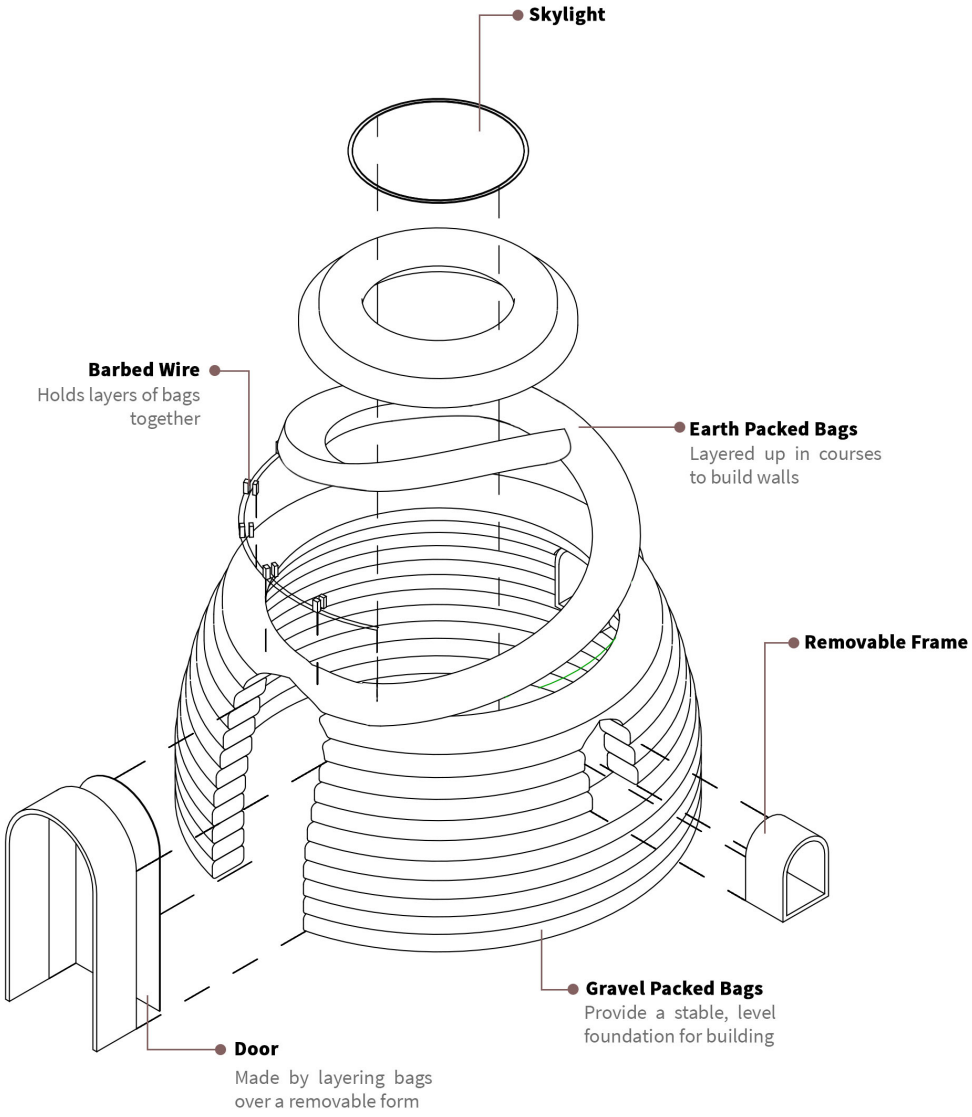


Figure 3.30 shelter construction technique, Iran - Author

Size: 14 M^2
Material: Polypropylene tubing, Sand, Gravel, Barbered Wire
Duration of Construction: 7 Days
Shelter Life Span: Several Years
Construction Team: 3 People

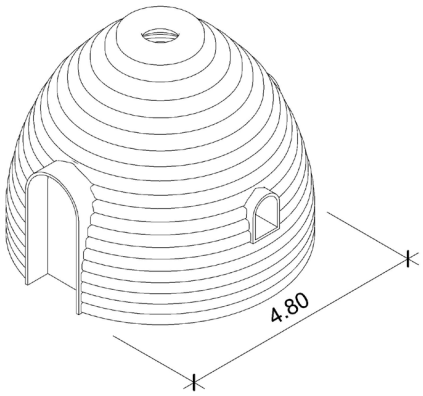


Figure 3.31 shelter unit, Iran - Author

Architectural Features:

The system utilizes enduring architectural forms such as arches, domes, and vaults to construct shell structures with single and double-curvature designs, combining strength with aesthetic appeal. While these load-bearing or compression forms harken back to the ancient mud brick architecture of the Middle East, the incorporation of barbed wire as a tensile element evokes the portable tensile structures associated with nomadic cultures. The outcome is an exceptionally secure structure. The introduction of barbed wire into compression structures enhances earthquake resistance, the aerodynamic shape proves effective against hurricanes, sandbags contribute to flood resistance, and the natural properties of the earth provide insulation and fireproofing (Cal-Earth, 2004)

Project Highlight:

- The use of a an abundantly available material, that can be easily found
- The method of using sand along with sandbag can be easily manipulated to form various strong shapes
- The dome shape is considered one of the most sturdy shapes to hold long spatial spans
- The sandbag technique for construction is easily learned and quickly built

Cross-Case Study Comparison

	CONTEXTUAL				ARCHITECTURAL				CONSTRUCTION			
Case Studies	Location	Crisis	Year	No. of People Affected	Shelter Size	Family Size	Space per Person	Number of Units Built	Material	Duration of Construction	Shelter Life Span	Cost
Philippines	Cebu, Philippines	Typhoon Haiyan (Yolanda)	2013 - 2017	16,078,181	18 - 24 M^2	6	3.6 M^2	500	Concrete, Coconut wood frame, Amakan and Bamboo Splits	3 - 5 Days	-	1904 USD
Chad	Ouaddaï, Chad	Sudan Conflict	2023	2.5 Million	17 M^2	5	3.5 M^2	50	Galvanized steel frame, Polyolefin foam panels	5 Hours - 1 Day	3 - 10 Years	1150 USD
Chile	Valparaiso, Chile	Forest Fire	2014 - 2016	12,500	18 M^2	3.4	5.3 M^2	-	Wood panels and wood frames, wood/concrete foundation	2 Days	-	1300 USD
Somalia	Garowe, Puntland, Somalia	Draught/ Conflict	2011 - 2013	1.4 Million	16 M^2	5.9	2.7 M^3	1,200	Stone block, Timber, Wood	10 Days	10 - 15 Years	1693 USD
Iran	Ahwaz, Khuzestan, Iran	Iraqi Conflict	1993	-	14 M^2	-	-	-	Polypropylene tubing, Sand, Gravel, Barbered Wire	7 Days	Several Years	-

Table 3.1 Table of comparison between the different Case-Studies - Author

3.6 CONCLUSION & LESSONS LEARNED:

- “Shelters” and “Settlements” represent an ongoing process integral to the project’s continuity.
- Engaging public authorities to leverage existing governmental programs and aid can yield substantial benefits.
- Housing and shelter represent profoundly intricate facets of recovery, demanding a long-term approach.
- Transitional shelters ought to possess the capacity for future upgrades.
- The abundance of local materials stands out as a crucial factor influencing the design solution, thereby bolstering the sustainability of the architectural approach.
- Temporary shelters need to exhibit resilience and robustness to prolong their lifespan beyond the immediate crisis, ensuring longevity for years to come.
- Simplicity of design along with empowering individuals with necessary knowledge and materials can enable them to create their own shelters.
- The strength of building material in accordance to the utilized building technique contributes to the life span of the shelter
- The severity and length of the disaster highly influence the architectural design of the shelter

CHAPTER IIII COUNTRY PROFILE (SUDAN)

Figure 4.1 Pyramids of Meroe, Sudan – Encyclopedia Britannica, Inc

Population: 45,561,556 (July 2020 est.)

Language

- Arabic [official] – spoken by majority of the population
- English [official] – most widely spoken foreign language

Religion

- Sunni Islam 97.0%
- Christianity 1.5%
- Traditional African Religion 1.5%

Ethnicity

- Sudanese Arab – approximately 70% of population
- Roughly 20 minority ethnic groups, including the Fur, Beja, Nuba, Zaghawa, Nubian, Massalit people.

Prior to Sudan secession in 2011, the country ranked as Africa's third-largest country. Sudan expands along 1.9 million square kilometres (almost half of the size of the European Union in comparison). Sudan is homogeneous country located between the Arab worlds in the African continent. It boasts with rich diverse cultures and traditions.

Figure 4.2 Sudan geolocation – Encyclopedia Britannica, Inc

4.1. GENERAL DESCRIPTION

Location, Physical & Topographical Data

Sudan shares borders with seven bordering countries: Ethiopia, Eritrea, South Sudan, Ethiopia, Egypt, and Chad. Sudan is situated at the crossroads of the Middle East and Sub-Saharan Africa near the Red Sea. The nation's capital, Khartoum, is situated where the White and Blue Niles converge to form the world's longest river, the Nile, which finally empties into the Mediterranean Sea. The topography of Sudan is made up of a variety of landscapes. The first is the northern Sahelian belt, which is characterized by deserts. Second, the Nile valleys, which cross the areas of Darfur, Blue Nile, Kordofan, and Kassala, are located along the Gezira region and provide rich, fertile ground for agricultural activity.

Sudan's geographic location and natural landscapes highlight its paramount importance. The country's natural landscapes and agricultural potential are enhanced by the Nile River, which flows through it. Additionally, Sudan's varied topography fosters the cultural diversity that is distinctive to its people. (Berry 2015)

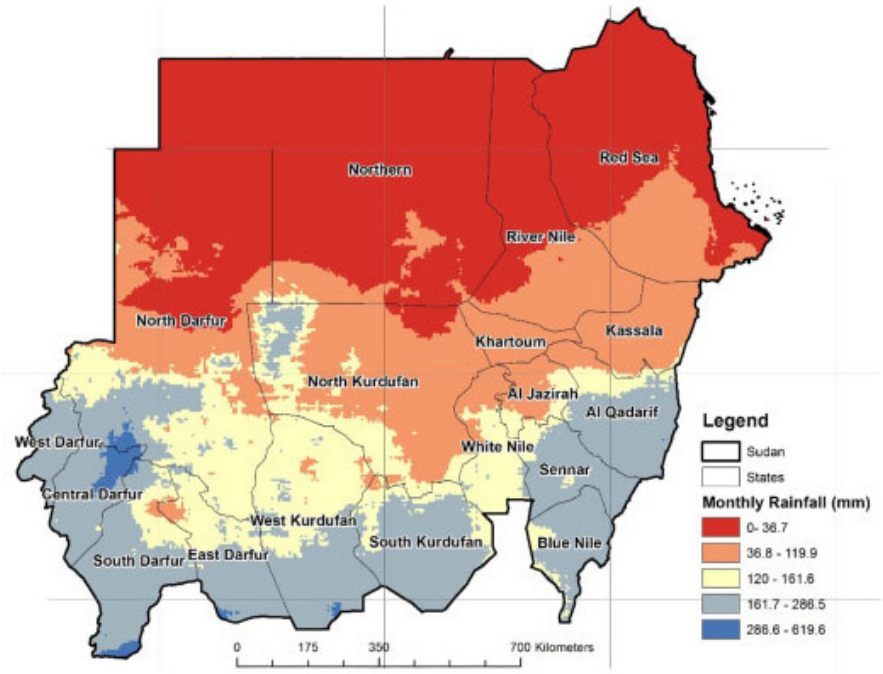


Figure 4.3 Sudan climatic map - OCHA ReliefWeb

Climate

Sudan experiences a wide range of temperatures ranging from 26°C to 32°C. The primary rainy season is between March and October with the highest precipitation between June and September. During summer the country encounters high temperatures of 43°C in the northern areas with unpredictable an inconsistent rainfall and minimal rainfall, less than 50 mm annually. On the contrary, in the southern regions experience a milder summer temperatures and higher rainfalls over 1,500 mm annually. In central areas, rainfall varies between 200 mm and 700 mm per year.

The design of building is highly influenced by the climatic conditions, a vast majority of houses relay on passive design strategies to improve thermal comfort such as natural ventilation, utilizing thermal mass and solar shading. (Berry 2015)

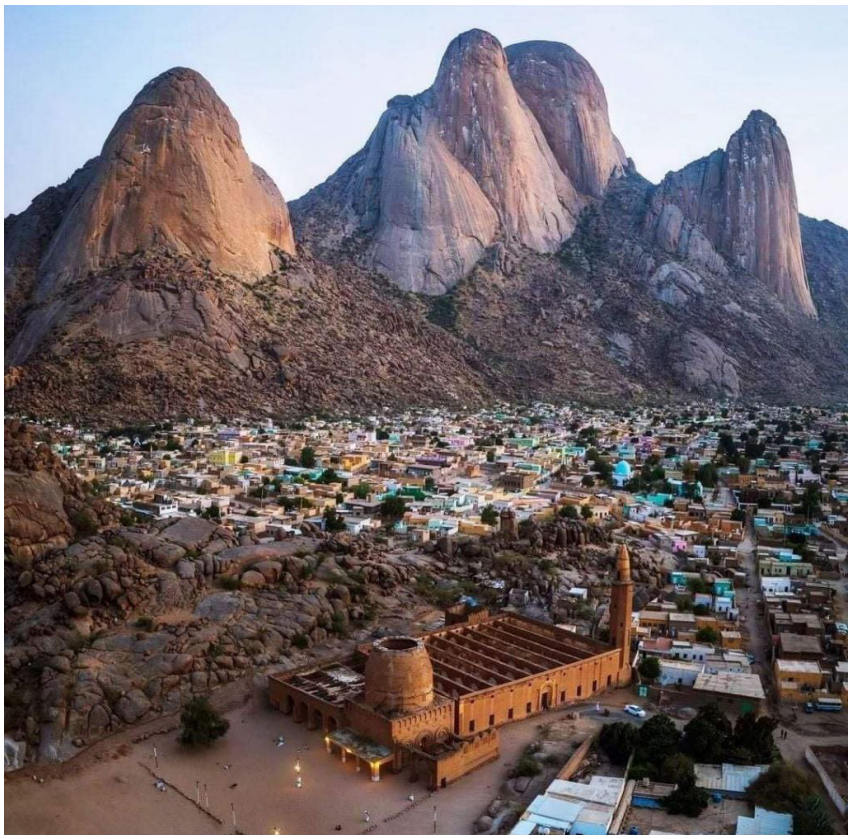


Figure 4.4 urbanization level in the city of Kassala, Sudan - Alamy

4.2. KEY DEMOGRAPHICS, CULTURAL, SOCIAL & ECONOMIC DATA

Urbanization:

Sudan's urbanization is still very low and mostly confined to a small number of significant metropolitan centres and it is highly influenced by variety of historical, social and economic factors. Urbanization in Sudan began to take shape during the British-Egyptian colonization (1899-1956), with the growing of key infrastructure projects including railways and roads which started growing cities like Khartoum, Omdurman and Portsudan as administrative and commercial hubs. After independence, urbanization continued driven by state-led development projects. The pattern of urbanization in the major cities in Sudan, induced with various conflicts has led to major migrations from rural to urban centres. This rapid urbanization resulted in continues housing shortages and various informal settlements within and around cities.

In Sudan, rural settlements are typically concentrated near watercourses due to the scarcity of water, particularly during the dry

months. In the northern regions, villages often form clusters along rivers. The types of houses constructed vary across different regions. Despite the trends toward urbanization, a significant portion of Sudan's population remains in rural areas. Roughly 60-65% of Sudan's population still lives in rural areas that relies primarily on agriculture and pastoralism with agriculture being the backbone of the rural economy. As a result, while larger urban centres will likely see moderate growth—albeit within industrial constraints—smaller urban centres will probably continue their slow decline. (Berry 2015)

Demographic Break Down

Sudan is habitat for an expanding population of 41 million individuals, with over half of this population comprising children below the age of eighteen. Sudan is undergoing a significant demographic change, tilting towards a predominantly youthful population base. (UNICEF, 2021). The female population in the country amounts for approximately 22.84 million in comparison to 22.81 million male inhabitants, the youth population in the country is attributed to Sudan high fertility rate with 4.54 children per women in 2020. Even so, various complicated factors influence the demographic rates in the country, this includes low use of contraception, low life expectancy (between 63 and 68) due to poor living conditions and high fertility rates among the adolescent which leads to delivery and health complications for many women. (UKBA 2012)

Figure 4.5 street art-work by Galal Yousif - africanarguments.org

Figure 4.6 rural roads in sudan - Photo by Aya Sinada

Infrastructure:

In regards to transportation routes, Sudan's inadequate transportation infrastructure poses a significant impediment to the country's economic progress. Due to its large size, the nation only has one main seaport, which makes internal transportation of goods and services challenging. This puts a great deal of burden on the main transportation network, especially on the government-owned Sudan Railways.

In the past, railroads were essential to the movement of cargo in Sudan. But in the 1970s and 1980s, the country's raw resources were increasingly transported by trucks and other motor vehicles as a result of significant investments made in road infrastructure and neglect of the railway system. The road system in Sudan is made up of both paved and unpaved routes, with the majority is unpaved roads. As for electricity, Sudan produces very little electricity using hydroelectric power, even though the country has a large hydro-power potential. Khartoum and the Gezira Scheme receive some electricity from the Sennar Dam, which is situated on the Blue Nile. Moreover, hydroelectric dams have been built at Meroe on the Nile, Al-Rusayris on the Blue Nile, and Khashm Al-Qirbah on the Atbara River.

In Sudan, access to electricity is mostly restricted to urban areas, and cooking is not a common usage for electricity. Instead, firewood, gas, charcoal, and paraffin are the main energy sources used in the nation for lighting and cooking.

Sudan's water infrastructure is in dire condition as a result of the nation's varied environment, difficult political situation, and financial limitations. Despite having excellent water resources due to the Nile River, which serves as Sudan's main water source, the nation struggles to provide its people with clean, easily available water. Particularly in arid and semi-arid areas, groundwater is a valuable resource; yet, excessive extraction and slow recharge rates are alarming.

Similarly, major cities like Khartoum have considerably improved water infrastructure, including as piped water supply systems and treatment plants. Wells are the primary source of water in rural communities, where accessibility and water quality are important problems. (UKBA 2012)

Figure 4.7 Sudanese woman cooking food outdoors in the house – SkynewsArabia

Economy

Sudan is regarded as one of the world's least developed and poorest nations. Roughly one-third of the population makes their living from farming and raising animals. Despite contributing almost one-third of Sudan's GDP, the sector's contribution to the economy has significantly decreased since the country's independence. After oil production started in the late 1990s, petroleum soon overtook all other exports as the nation's most significant export. However, half of the oil production has stopped since South Sudan's secession. Five and a half percent of Sudanese people live in multidimensional poverty, and another 17.7 percent are considered vulnerable to multidimensional poverty.

Considering the difficult economic conditions for a lot of the Sudanese people with the growing rates of inflation, poor economy and lack of quality exported products, they typically adopt self-sustaining practices by cultivating their own crops and raising cattle and other domestic animals within their households. Furthermore, they utilize most of the waste products generated by these animals and plants for the production of clothing and other essential items. In some parts with poor infrastructure where electricity is not abundant to use refrigerators, they rely on sun-drying food for preservation. Additionally, although imported/industrialized building materials are available in big urban cities of the country, the majority rely on locally sourced materials because of their low-cost and availability.

Figure 4.8 Sudanese woman preparing produce to dry - photo by Aya Sinada

Figure 4.9 Sudanese men gathered for community festive – DW

Cultural Habits

The key to an understanding of contemporary Sudanese culture is diversity. Each major ethnic group and historical region has its own special forms of cultural expression.

Cultural Identity:

Sudanese Arabs; are commonly defined in Sudan by their cultural association as Arabic-speaking Muslims. The majority of Sudan's population identifies with Arab culture in this context. However, most Sudanese Arabs have mixed ethnic backgrounds, often descending from both Arab and African tribes and possessing Cushitic ancestry. Many Sudanese Arabs retain knowledge of their family's original local language before adopting Arabic, which serves as a linguistic tie to their tribal heritage and ethnic origins. Due to the diverse ancestry of most Sudanese Arabs, their physical appearance may not distinguish them from individuals who identify as more 'African' or non-Arab.

Non-Arab Sudanese; those identifying with non-Arab ethnicities primarily speak local languages rather than Arabic. While many in urban areas learn Arabic for inter-ethnic communication and commerce, non-Arab tribes outside cities maintain traditional lifestyles in their ancestral lands. Sudan houses various non-Arab ethnic groups, such as the Nubians, Beja, Fur, Zaghawa, and Nuba, consisting of over 500 sub-tribes. Detailing each tribe's cultural, religious, and linguistic identities within this profile's scope is impossible. Nevertheless, Sudan's social landscape reflects remarkable diversity.

Figure 4.10 celebration of "Sitti Mariam" the noble sufi ladies of the Khatmiyyah in Sinkat town in East Sudan - Photo by Zofa_Photography

Identity and Religion:

Non-Arab ethnicities in Sudan exhibit diverse ancestry and religious beliefs. Groups hailing from the northern and eastern parts of the country often share closer ancestry with Egyptians and Eritreans. These groups typically uphold more “Middle Eastern” cultural practices and traditionally follow Islam, exemplified by communities like the Nubians and Beja.

In a general sense, the farther one moves away from the Nile in Sudan, the more the social demographics and customs of tribes tend to embody an “African” essence. Some African tribes have gradually embraced Islam, such as the Fur and Zaghawa people, integrating specific ethnic traditions within their practice of Islam. However, numerous African ethnic groups predominantly adhere to Christianity or follow traditional animist religions. The majority of non-Muslim tribes reside in the central Nuba Mountains or the southern regions of Sudan, including groups like the Nuba and Acholi.

Social Hierarchy:

In Sudan, social mobility is limited due to widespread poverty. Most people belong to the lower class, residing in rural villages or urban areas around cities. A small elite class, usually with government connections and displaying conspicuous wealth, exists. In cities, a separate ‘middle class’ lacks steady employment but may receive remittances from overseas relatives.

Wealth differences don’t lead to significant social divisions. During events like Ramadan, communities gather for feasts, where varying food quantities are noticed but not discussed to avoid embarrassment.

Respect in Sudan isn’t solely based on wealth or education but on integrity, treatment of others, and honour. A common saying emphasizes that being educated doesn’t guarantee being a good person. Elderly individuals generally receive the most respect in social settings.

Figure 4.11 Islamic prayer during the month of Ramadan - Ali Alshalali Tumbler

Figure 4.12 Sudan flood in Tutti Island, Khartoum 2023 – CNN

4.3. NATURAL HAZARDS

Sudan is exposed to several geophysical and climate-related hazards, some of which are increasing in frequency and magnitude. Several vulnerability indices rank Sudan among the most vulnerable countries in the world to climate variability and change. As see in figure (4.15) flood is considered the most reoccurring natural disaster in Sudan followed by epidemics and draught.

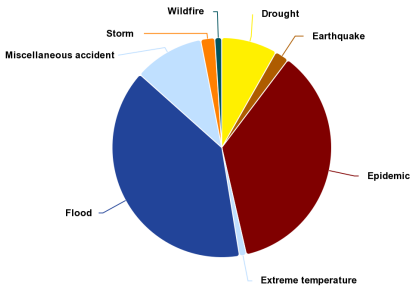


Figure 4.13 average annual natural hazard occurrence for 1980-2020 - Worldbank

Regional floods are the most common type of flooding that occurs where the Nile banks are filled in a very short time due to seasonal rainfalls. Beyond the natural destructive factor of the flooding In Sudan, many of the houses are not built to withstand even minor impacts. Additionally numerous houses have been permitted to be built near river canals where the overflown water usually flows, leading to loss of life among residents. Local authorities' interventions in such cases is significantly inadequate, leaving civilians to control the damage that comes with it, many of them lose their lives in the process.

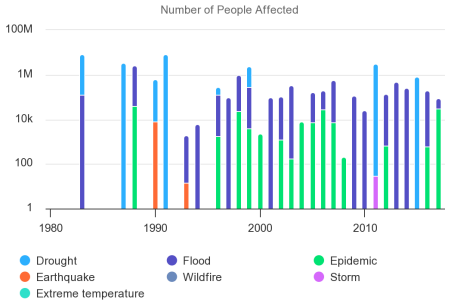


Figure 4.14 Key natural hazard statics for 1980-2020 - Worldbank

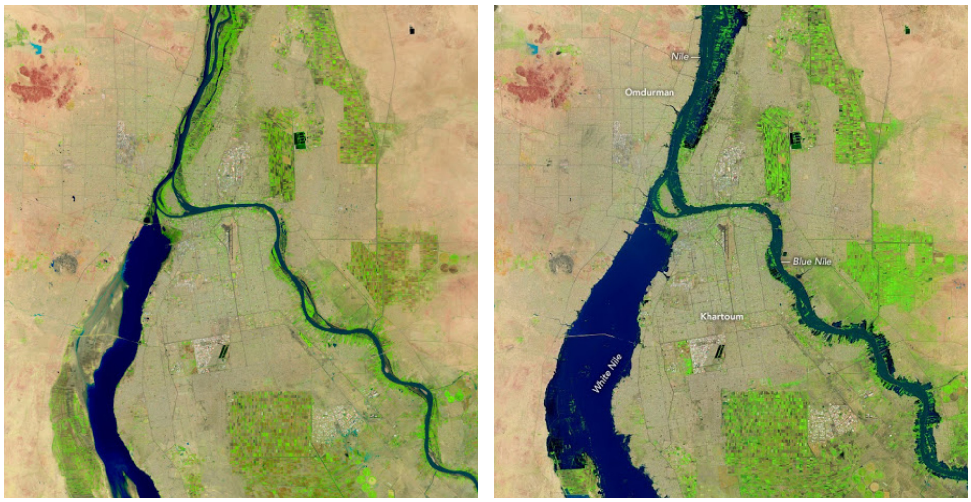


Figure 4.15 Flooding of the Nile in september 23rd 2016 and september 2nd 2020 in state of Khartoum – NASA Earth Observatory

Floods

Floods are considered the most occurring natural disaster in Sudan. It holds the biggest impact on population, its devastating effects shows in the spread of food shortage, massive displacement and destruction of houses and infrastructure. Between 2017 and 2021 floods affected an average of 388,600 people each year. The most significant flooding in recent years occurred in 2020 affecting more than 850,000 people and damaging 37,000 houses across all states. The 2020 flood was one of the biggest that Sudan has ever faced that led to major destruction of agricultural lands, roads and bridges, spread of diseases, damage of electrical and water supply infrastructure and most importantly loss of life and houses.

The rainy season typically occurs between June–September, with the rains and flooding peaking from August–September. Heavy rains often result in the Nile and its tributaries and Gash River overflowing, leading to flooding and landslides that damage property, infrastructure, and crops, compounding humanitarian needs. The heavy rain affects 14 out of 18 states in Sudan, Aj Jazira, Gedaref, Kassala, Sennar, and the states bordering South Sudan, such as White Nile, are typically the most vulnerable to flooding. Typically, the central and southern regions experience more annual rainfall than the rest of the country. Blue Nile had the highest annual precipitation sums among Sudanese states between 1991–2020, while Northern state had the lowest. As of September 8th 2020 there were nearly 100 Fatalities, 46 injured people, thousands of people displaced and over 100,000 houses destroyed or damaged across the country but more specifically in the aforementioned states. After months of heavy rainfall that left more than 875,000 people has been affected by the unprecedented flooding. (OCHA, 2020)

Figure 4.16
Draught in
Sudan - CNN

Draught and Desertification

Desertification is a critical natural phenomenon that negatively impacts vase areas of land, it happens when relatively small deserted areas of land start to gradually spread to form big desert area. The continent of Africa is mostly affected by it mainly due to climate change and the improper use of land, it adversely effects the quality of soil and disrupts the ecological balance. (Issam A.W. and Kamal M. 2011)

Draught in Sudan is the second most occurring natural disaster, the draught of 1984 was the most severe one that the country has ever faced. It led to the reduction of water resources, eradication of vast agricultural lands, and famine that spread mostly in the vulnerable parts of the country, in the state of Kordofan and Darfur that saw major displacement to Khartoum and Aj Gazira states. Areas affected by draught and desertification are mainly in the northern part of the country; Northern state, North Kordofan, North Darfur, the affected area amounts to 650 thousands km2 which are the most agriculture rich area (Issam A.W. and Kamal M. 2011)

Figure 4.17
displacement in Sudan
- UNHCR

4.4. DISPLACEMENT IN SUDAN

Displacement can occur naturally in response to certain threats, which are usually unforeseen. It often involves the movement of people in groups or as individuals seeking safety and economic opportunities. Scholars differentiate between internal displacement and migration, noting that migration involves being forced to move from one's usual place of residence to another location outside of the country, while displacement is the relocation of residents within the borders of a single state.

Displacement in Sudan is a chronic and long-lasting adversity dating back to before independence, but they started escalating significantly in the 1970s due to drought, desertification, and the declining rates of natural resources. This decline has led to conflicts over water, pasture, agriculture, and land, exacerbated by administrative and political weaknesses. The crisis was further intensified by weak development projects, widespread unemployment, and the proliferation of weapons in some parts of the country. Major internal migration was from rural parts of the country to cities peripheries and especially the capital of Khartoum and its surrounding agricultural lands.

Considering the impacts of climate change and the increase of events of natural disasters worldwide, Sudan has seen a rise in the number of floods and drought incidents, with severe consequences. The Sudanese people have suffered from natural disasters due to poor infrastructure and lack of preparedness for natural disasters. Notably the most recent 2019 floods that affected approximately 400 thousands people, as well as the draught in 2011-2012 that caused critical food and water

Figure 4.18 destroyed houses after the war in Khartoum - Le Monde

shortages, affecting the livelihood of hundreds of thousands of people.

Before the war in 2023, most of the displaced population was from the southern and western regions of the country. The majority of the displaced were concentrated in the northern regions, the national capital, and some safe southern areas. Many IDP camps were set to accommodate them and those camps continued to expand over time to accommodate even more displaced people. Furthermore, the Darfur war that broke out in 2003 that led to human suffering on a large scale, with armed militias engaging in extensive battles against the government. The humanitarian crisis was exacerbated by an increase in refugees, rising mortality rates, a surge in violence, and the displacement of people from their homes and farms to makeshift camps or other areas within the region. The Darfur crisis remains one of the most sever humanitarian disasters in the world. (Issam A.W. and Kamal M. 2011).

Today, the United Nations has expressed grave concerns about the ongoing conflict in Sudan, describing it as a “crisis of epic proportions” with catastrophic humanitarian consequences. Since the war began over a year ago between the Sudanese Armed Forces (SAF) and the Rapid Support Forces (RSF), over 14,000 people have been killed, and 25 million people—half of Sudan’s population—require life-saving assistance. More than 8.6 million people have been displaced, creating the world’s largest displacement crisis (UN Press, 2024). Armed conflicts are the primary reason of displacement in Sudan. Followed by Natural disasters - mostly flood and draught. Those two phenomena are further discussed from a historical, political and humanitarian perspectives in the following section.

Figure 4.19 recent potage of the displaced people escaping the battles in Sennar - Sudan Tribune

4.4.1. Natural Disasters and Forced Displacement

Globally, there has been a significant rise in the occurrence of natural disasters. The world has witnessed a tenfold increase in the number of such events since the 1960s. While natural disasters affect both prosperous and impoverished countries, the repercussions are disproportionately severe in poorer nations. In Africa, Sudan is one of the countries mostly affected by natural disasters, experiencing numerous natural disasters over the past five decades, including droughts, floods, desertification, famines, wildfires, and various diseases. Due to the country's high exposure to natural disasters, compounded by inadequate infrastructure, insufficient disaster preparedness, and persistent security issues, Sudan is considered among the most vulnerable nations to the impacts of these calamities. (Hyati 2009)

Certainly, flooding and draught are the most reoccurring natural disasters in Sudan. Flooding is exacerbating during seasonal heavy rains, particularly from June to September. The rain season attributes to the overflow of the Nile River, leading to widespread flooding. The most catastrophic and recent flood happened in 2019, it affected around 400 thousands people and caused extensive destruction of homes, infrastructure and crops, loss of lives and outbreak of diseases. Additionally, draught is the second natural disaster in Sudan. It happens usually by prolonged periods of below-average rainfall that is directly linked to climate change. The draught of 1983-1985, was one of the longest draught periods in the country. It affected millions of people, particularly in the Darfur region and it has led to sever famine, significant loss of life and agricultural productivity.

The aftermath of natural disaster are usually hard to recover from. Not only does it causes tremendous loss of lives and destruction of homes and infrastructure, the destruction isn't easily recoverable in a country like Sudan with harsh economic conditions. In addition, the widespread of displacement that holds an intense social impact on both the original place of displacement and the receiving states. It creates imbalances of the demographic age group in the community, as the youthful young demographic age group are displaced from their farms and homes in rural areas and are forced to maintain incomes in urban cities that require high technical skills, which they usually lack. (Issam A.W. and Kamal M. 2011)

4.4.2. Armed Conflicts and Displacement in Sudan

4.4.2.1. Historical Overview:

Sudan, one of Africa's largest nation-states, shares borders with ten other countries and similar to artificially created former colonies of the British Empire, the region is characterized

by remarkable ethnic and religious diversity (Kohnert 2023). The population speaks over 20 different languages with 600 sub-dialects. Religiously, Sudan is predominantly Muslim, with 70 percent of the population adhering to Islam, while the remaining 30 percent practice indigenous African beliefs and Christianity. Ethnically, Arabs constitute 39 percent of the population, and Africans make up 61 percent. These diverse characteristics present significant challenges to any government. (TAR 2006)

For decades, the country has been going through continuous civil wars and governmental instability. The root of most of these conflicts can be traced to the injustice, repression and exploitation of the country's resources mostly by the Arab-controlled government, especially when dealing with non-Arab citizens domiciled in south and west Sudan. (TAR 2006). Even before independence, the country became evidently divided along ethnic and religious lines as a tradition of predatory government extends back to the colonial period. When the British accentuated the difference between the north and south by ruling them as separate entities. The country's military, developed during the colonial era, has remained influential in an independent Sudan. Since independence, the Sudan Armed Forces (SAF) have been a major factor in the country's instability. Internal conflicts between armed militias and the government have caused immense suffering, from 1956 to 1972, from 1983 to 2005, and during the harrowing Darfur war from 2003 to 2010. During these periods, conflicts plagued Darfur, South Kordofan, Blue Nile, and northern and eastern Sudan. Despite the country's instability, the SAF has remained the most stable institution, frequently being deployed for political gains through successive military coups run by power-thirsty generals. Sudan's post-colonial history is marked by ongoing conflicts and superficial peace agreements between the central government and regional armed groups, which essentially serve as power-sharing arrangements that benefit the top ranks of these groups. (Berry 2015)

The Sudanese people living in conflict-prone areas have endured profound devastation due to prolonged warfare spanning decades, often finding themselves caught in the crossfire between armed forces, with no power to influence their situation. Amid brutal clashes, thousands of civilians are consistently forced to flee their homes in search of better security, food, medicine, and shelter. The consequences of these wars have been unprecedented, culminating in the secession of South Sudan in 2011, which had severe economic, political, and social repercussions for both nations. The Darfur conflict alone resulted in the estimated loss of several hundred thousand lives due to ethnic cleansing, famine, and the forced displacement of millions into refugee camps or across borders.

To capture this part in proper perspective and before further discussion on the 2023 war in Sudan, it is important to shed some light on two of the major armed conflicts that had the greatest impact on the geopolitical scene of recent Sudan and resulted in the biggest displacement flows that ultimately paved the way to the current 2023 war in Sudan.

South Sudan Civil War

Historically, state resources has been mainly concentrated in the central Nile areas in the north, reflecting the long-standing dominance of groups from this region. This has been evident in the lack of development and poor economy in the southern parts of the country, benefiting key political groups in the capital Khartoum. The growing inequalities and exploitation of the country's resources on behalf of it's the Sudanese people has resulted in long lasting civil war between the political power groups in the north and south Sudan. (Strand 2009). The south Sudan civil war was multifaceted but it was mainly described as being a conflict between the Muslim-Arab-North Sudan against Christian-South-African south Sudan. Certainly, the conflict was more complex than (Muslim vs Christian) or (Arab vs African), as the war progressed many political, ethnic, racial and cultural aspects were at play further complicating the situation. (Nilsson 2000)

After General Numairy authoritarianism rule that put a temporary hold on the civil war that lasted for 17 years in1972, which ended in a peace agreement that has been dismantled shortly after Gen. Numairy introduced the law of sharia in 1983 that sparked the second wave of civil war between southern Sudan and the north central government. In 1989, the military staged a coup under the leadership of Omer Hassan Al-Bashir who ruled with the support of his political party and military force for 30 years. Al-Bashir dictatorship aggravated the tension between the central government and the National Islamic Front (NIF) led by Hassan Al-Turabi in the north. In addition to the Sudan People's Liberation Army (SPLA) headed by john Garang in the south, which was the main opponent to the regime. (Nilsson 2000). After years of unsuccessful peace agreement facilitated by the United Nations Security Council (UNSC), the government ended the civil war with the south in January 2005 by signing the Comprehensive Peace Agreement (CPA) with the SPLA and its political arm, the Sudan People's Liberation Movement (SPLM). The pact established a power-sharing government in Khartoum with autonomy governance of the Southern Sudan.

Consequences of the South Sudan Civil War:

Under the terms of the Comprehensive Peace Agreement (CPA), South Sudan seceded from Sudan on July 2011 that ended Sudan's 22 years civil war. Nonetheless, the SPLA has experienced internal division that led to deadly inter-ethnic fighting among people in the South that is still going even after South Sudan secession. Until the secession of South Sudan in 2011, the war has resulted in estimated 2 million casualties and more than 4 million internally displaced people (USCR, 2000). (Nilsson 2000)

State	Population	IDPs
Northern	1,139,000	80,000
Khartoum	3,111,000	1,800,000
Nile River	4,090,000	320,000
Red Sea	3,338,000	-
Darfur	3,180,000	60,000
Kordofan	3,594,000	70,000
Bahr Algazal	3,689,000	413,500
Sennar	1,748,000	800,000
Nile River	3,041,000	563,470

Table 4.1 South Sudanese displacement numbers – UNHCR

Figure 4.20 displacement due to the war in south Sudan - CNN

Table (4.1) depicts the number of internally displaced people by the civil war in south Sudan approximately (4,104,970) spread mostly in the capital and other safe southern cities. The huge number of displaced people accounts for 10.24 percent of the total population in the south, of which 1,800.000 have moved to live in Khartoum and represent 10.24 percent of the total population of the capital. (Issam A.W. and Kamal M. 2011). Aside from the internal displacement many Sudanese people had left Sudan altogether. As of 2005, it is estimated that 700,000 had left Sudan altogether, of which 600,000 are from south Sudan. Uganda and Kenya hosted the majority of them. (Berry 2015)

The repercussions from the South Sudan civil war marked the beginning of numerous catastrophic outcomes that the Sudanese people have endured over the years. This conflict set the stage for subsequent disputes, highlighting the deep-seated divide between the central government and beneficiary groups on one side, and the minority groups and the broader Sudanese population on the other. Examining the South Sudan civil war underscores this persistent division. Since the 1990s, the war has led to a significant increase in internally displaced persons (IDP) camps and humanitarian aid efforts. Displacement has escalated in various regions of the country, prompting substantial migration flows to neighbouring countries.

Darfur Crisis

Darfur region is the largest region in term of landmass in west Sudan with an estimated population of about four or five million people, yet it is the least developed region in the country. It has always grabbed the attention with the ugly scene of violent clashes between the mainly settled farming communities “African” ethnic groups (Fur, Masalit and Zaghawa) and “Arab” Nomads. The Darfur conflict that began in 2003 as a resources grappling conflict between the two groups subsequently turned into one of the worst humanitarian crisis and ethnic genocide. Similarly to the south Sudan war, the source of this conflict is deeply rooted in ethnic segregation between the Arabs and the African groups. (TAR 2006)

The instability of the region dates back to the early 2000s, which were mainly farmland and livestock disputes between African and Arab ethnic groups. Initially, these disputes were temporarily resolved by local mediation led by community leaders and tribal chiefs. However, these resolutions were superficial and failed to address the deeper issues. Simultaneously the central government was more focused on dealing with South Sudanese rebels, and largely ignored the escalating clashes in the west. The crisis intensified in 2003 when the Darfur Liberation Front (DLF) emerged, capturing the town of Gulu and transforming into the Sudan Liberation Army (SLA/M). They attacked El-Fashir, the capital of North Darfur, destroying and looting military aircraft and munitions facilities. This led to the rise of the Justice and Equality Movement (JEM), supported by the government, further fuelling the conflict. The fighting only grew bigger, eventually involving biased citizen who were put in a position to join one of the militia groups for survival. Furthermore, President Omar al-Bashir government’s ethnic agenda exacerbated the conflict. In which they continually armed Arab militias (Janjaweed) instead of taking concrete steps to reduce ethnic tensions. (TAR 2006)

Consequences of the Darfur Crisis:

The conflict in Darfur resulted in significant human suffering, and forever changed the political landscape of the country. Resulting in one of the most persistent humanitarian crisis that involved international agencies interventions, which the UN has established one of the largest peacemaking missions in the world. By 2014, the death toll in Darfur was estimated to be around 300,000 people, who died also from related effects such as disease and malnutrition (Issam A.W. and Kamal M. 2011). Additionally, the conflict has caused massive displacement. Nearly 2.5 million people were internally displaced within Darfur and around 700,000 Darfurian refugees were living in neighbouring countries.

Location	IDPs
Fur Amr	10,826
Abu Jabrah	5,619
Abu Karnka	2,864
Jad Elsaid	2,060
Frrob	2,732
Adeela	6,144
Elgoz	2,146
Sherif	3,185
Snam Elnaga	332
Gw Gana	1,779
Sbeel	2,561
Sanya Delbya	3,433
Muhageria	2,299
Abu Ajorah	2,399
Abu Salatah	856
Algomla	49,205

Table 4.2 Darfur displacement numbers– UNHCR

One of the most dangerous strategic blunders committed by the government in dealing with the rebellion is its refusal to come to terms with the rebel group, and the greater one is its decision to arm the Janjaweed militia. They eventually went out of control expanding their ethnic hate and growing power around the entire country. The consequences of this war has been tremendous with the surge in power of Al-Janjaweed, which later on has been reformed to the Rapid Support Forces (RSF) led by Gen. Hemedti Mohamed Hamdan Dagalo, who are now one of the two main fractions of the current 2023 Sudan War.

Although large parts of the country appeared to be in a state of peace, fostering the government's portrayal of Sudan as a peaceful nation, the ongoing conflicts in the neglected regions have exacerbated security issues nationwide. Since Sudan's independence in 1956, the majority of conflicts leading up to the 2023 war exhibit empirical interconnections. The repercussions of each conflict are seldom fully resolved, and subsequent analyses are often inadequate. This deficiency in thorough examination has hindered the development of comprehensive mechanism for the resolution of future conflicts. As a result, displacement and migration have become pervasive phenomena within the country, significantly influencing the cultural, social, and political dimensions of Sudanese society.

Figure 4.21 burnt villages in Darfur - CNN

Figure 4.22 war torn Khartoum, Sudan - Jordan Times

4.4.2.2 Sudan Conflict 2023

The 2023 Sudan war marks a significant and catastrophic chapter of the nation's history, characterized by extreme violence and a profound humanitarian crisis. This conflict erupted as a result of the long-standing political instability, deteriorating economy and major social issues. The power struggle between the two rival fraction of the war, notably between the Sudanese Armed Forces (SAF) and the paramilitary Rapid Support Forces (RSF), escalated into a widespread warfare, the cost of this war has immensely disrupted the country, with major civilian fatalities and broad humanitarian disaster.

The research argues that the recent conflict is not an isolated phenomena. The origins of this conflict are deeply embedded in Sudan's complex geopolitical landscape, which mainly served the interests of the power elites, often to the disadvantage of the broader population. The prolonged struggle for control over the country's resources and power has involved various factions, including governmental authorities, rebel militias, and tribal groups. The current dreadful war is a direct manifestation of this dynamic and It is fundamentally rooted in previously discusses conflicts, most importantly the Darfur crisis 2003.

Timeline of events

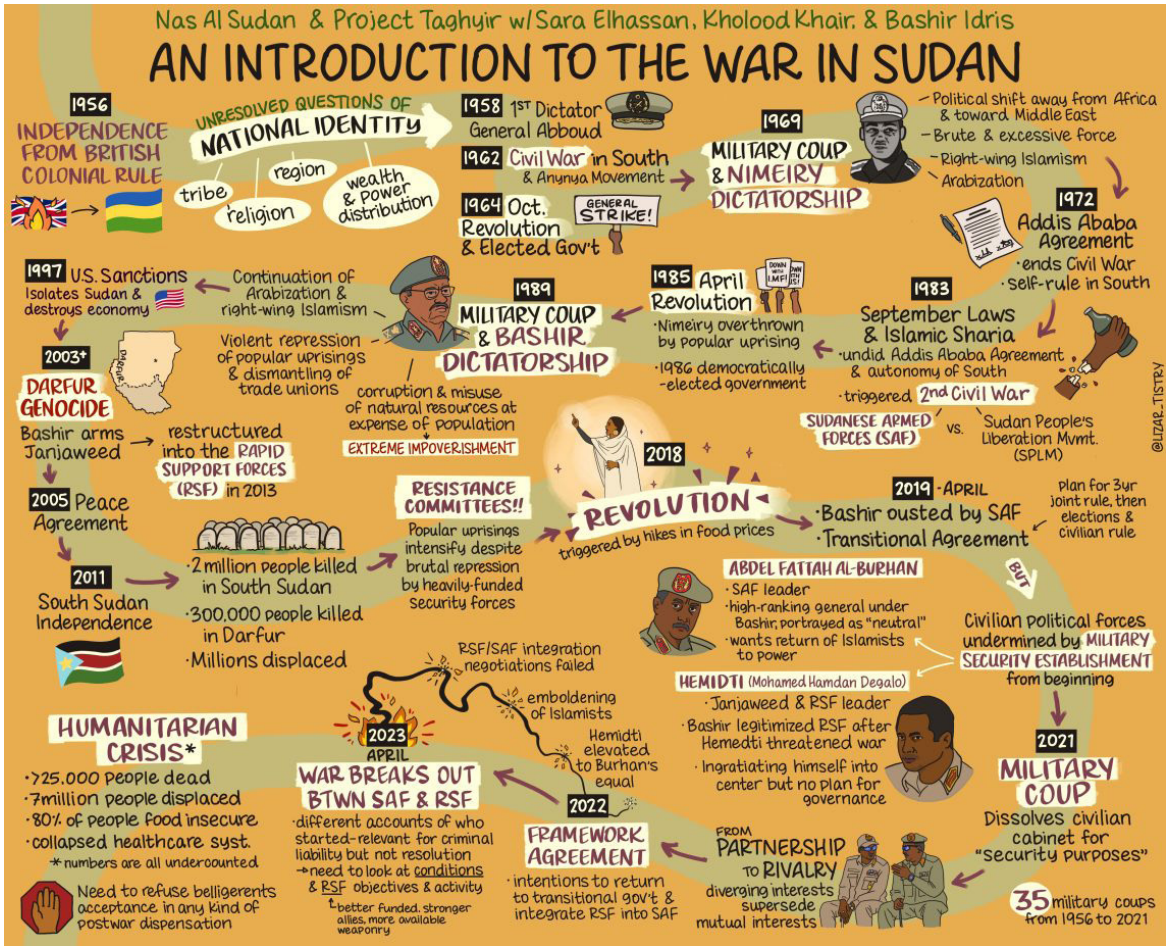


Figure 4.23 Illustration of a brief timeline of the war in Sudan since independence - Art work by lizar_tistry

2019

In April 2019, General Omar al-Bashir, who had been the seventh head of state of Sudan from 1989 to 2019 and was re-elected three times in controversial and undemocratic elections, was overthrown in a military coup. This coup was orchestrated by the Sudanese Armed Forces (SAF), led by General Abdel Fattah al-Burhan, and the paramilitary Rapid Support Forces (RSF), also known as Janjaweed, which was led by his rival, General Hemedti Mohamed Hamdan Dagalo. These forces had been established by al-Bashir himself using a long-standing government tactic of divide and rule. The Sudanese revolution of 2019 culminated in the proclamation of a new political framework and a roadmap aimed at restoring democracy in the country. According to the provisions outlined in a constitutional charter, a transitional government comprising both military officers and civilian representatives was established, with plans to transition to an elected government by 2024. In the first two years of the agreement the country's instability was immaculate. It was ruled by a military coalition of (SAF) and the paramilitary (RSF), who used similar tactics of the crack down on peaceful protesters as their successor in power Omer El-Bashir, where a majority of civilians were still protesting the share of power with the military and called on full democracy led by competent civilians.

2021

On October 25th 2021 Gen. al-Burhan with the support of Gen. Hemedti attempted a military coup d'état on the Transitional government in the hopes of breaking hopes for the protesters and claiming full power over the country, but it was met with a great opposition nationally and internationally. The growing tension between the two generals has been noticed already since the coup of 2019, as both parties were pursuing full control over the country.

2023

Consequently, on April 15th 2023, igniting the fire to the current on-going war, the SAF and RSF clashed violently in Khartoum and gradually expanding the fight to 8 out of 18 states in Sudan with intensified deadly clashes particularly in Darfur which was already devastated by on-going un-resting security and humanitarian crisis. (Kohnert 2023)

The Displacement Crisis:

Displacement caused by the Sudan war has led to sever humanitarian crisis form all social, economic and psychological aspects for millions of Sudanese people. As of June 2024, the conflict in Sudan has resulted in significant humanitarian consequences. The United Nations reports that 11 million people have been displaced due to the ongoing conflict between the Sudanese Armed Forces (SAF) and the Rapid Support Forces (RSF). This includes 7.3 million internally displaced persons within Sudan and those who have sought refuge in neighbouring countries such as Chad, South Sudan, Egypt, and Ethiopia are around 1.9 million (UNHCR 2024)

The research is mainly targeted towards internal displacement among the Sudanese population due to the severity of their living conditions and the sheer number of internal displacement. It's also worth mentioning that the majority of the displaced population seeking refuge inside the country struggle to find the financial means to reside somewhere else. In addition to the already harsh financial situation of some individuals the war has been an added financial burden on them to move even within the country.

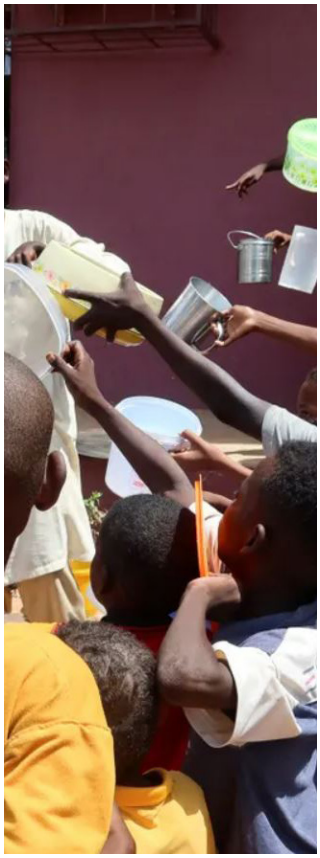


Figure 4.24 spread of famine and food insecurity - The guardian

Figure 4.25 mother carrying her children and some belongings as they flee the war - UNHCR

Figure 4.26 women carrying her belongings and fleeing to safety - InfoMigrants

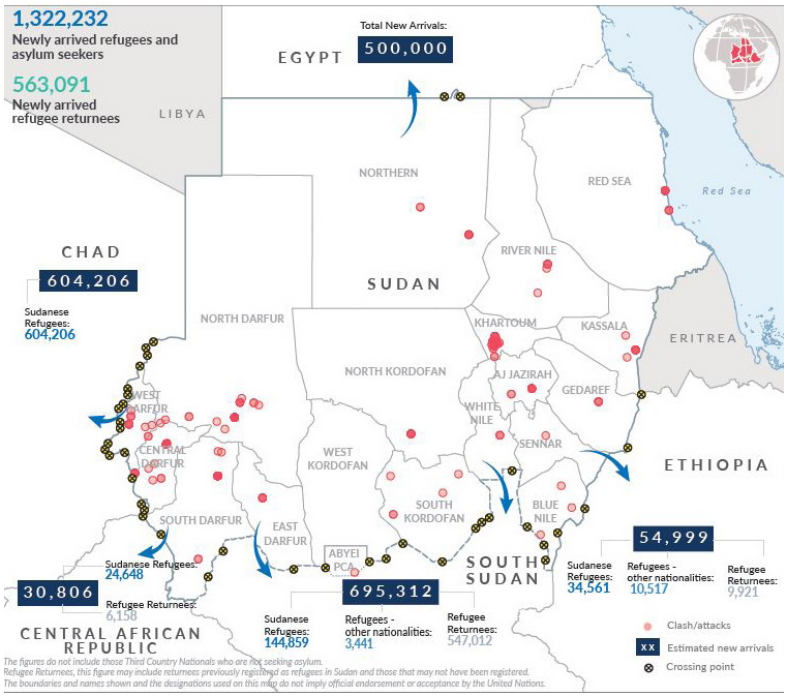


Figure 4.27 map of the number of displaced people due to the Sudan war 2023 as of June 2024 - UNHCR

Where Sudanese have been displaced from:

- (45%) Khartoum state,
- (4%) West Darfur
- (15%) South Darfur
- (9%) North Darfur
- (1%) East Darfur
- (1%) West Kordofan
- (1%) North Kordofan
- (2%) South Kordofan
- (4%) Central Darfur
- (9%) Aj Jazirah
- (>1%) sennar and White Nile

While most displaced people are from the capital of Khartoum, followed by South Darfur and the other states of the Darfur region, the White Nile and Sennar State experience the least number of displacement. The capital of Khartoum has been one of the most affected cities in the country, becoming the main battleground for SAF and the RSF. As for the Darfur region, cities such as El-Geneina, Nyala, Zalingei and El Daein have experienced sever violence due to ethnically targeted attaches by the RSF. Additionally, cities in other regions, such as Kordofan, have been heavily affected where the conflict has disrupted daily life, leading to shortage of essential services including food and fuel. (IOM 2024)

The Humanitarian Shelter Crisis:

The displaced people have pursued shelter around the country in various shelter solution, the shelter solution adopted by the displaced people depends widely on their location, resources and the nature of their displacement. For the majority of city dwellers in Khartoum, they resorted to community hosts and have moved to live with their relatives and friends in other towns around the country. Other shelter solutions are (OCHA 2024):

Figure 4.28 Refugee camp in Ethiopia - News24

Refugee Camps: many displaced individuals have found shelter in already established refugee camps managed by international organization such as the United Nation (UNHCR). Some of these camps are built in neighbouring countries like Chad and Ethiopia, others are inside the country in Darfur and southern Sudan states but they are not deemed fully safe from the raging war. The refugee camps provide basic living amenities including tents, communal kitchens, and latrines.

Figure 4.29 makeshift shelter by the displaced people - Bonblast Twitter

Makeshift Shelters: some displaced people have constructed makeshift shelters using the available materials such as tarpaulins, plastic sheets and salvaged wood. These shelters provide minimal protection against harsh weather conditions, posing significant health and safety risk to their inhabitants.

Figure 4.30 displaced Sudanese people sheltering in a school building - Middle East Monitor

Urban Shelters: in cities like Khartoum and El-Geneina, displaced people use abandoned buildings and public facilities as shelter. Some of these public facilities include schools, markets and mosques, although a relative degree of protection is usually provided, they are usually overcrowded and lack basic sanitation facilities that could help in the spread of diseases.

Figure 4.31 displaced Stansted people sheltering in the periphery of towns - The independent Uganda

Squatting: Squatting is a form of informal settlement located in the outskirts of the city. Many displaced people move to form informal settlement, but they are usually extremely poor with limited clean water and lacks safety.

In addition to the internal displacement, the conflict in Sudan has caused the Mixed Cross-Border Movements of 2,031,858 individuals into neighbouring countries namely Egypt, Libya, Chad, Central African Republic, South Sudan and Ethiopia. 68% of arrivals tracked in those countries were Sudanese nationals and 32% estimated foreign nationals and returnees. The majority of arrivals were reported in Chad (41%), Egypt (27.4%), and South Sudan (22.2%).The majority of Sudanese people migrating outside of the country to neighbouring countries like Egypt, Chad is due to their cultural similarities, presence of relatives in the these countries and ease of migration routes. These migration patterns are an added strain to the capacity of these countries to provide humanitarian aid for the new refugees (Maru 2023)

Consequences of the War:

Sudan is one of the least developed countries in Africa and this lack of development in many cases can be traced back to the unstable politics of the country. The political scene overshadowed development in the country from all aspects of education, health, social security and wealth. The conflict has imposed a great human cost and long-term consequences on the country and the civilian population. As a result of the ongoing violence, thousands of civilians has been killed and permanently injured. Densely populated areas like markets and residential neighbourhoods have been the target of indiscriminate attacks by both The Sudanese Armed Forces (SAF) and Rapid Support Forces (RSF). Also, they have used destructive missiles and artillery, causing significant damage to cities, homes, infrastructure, and livelihood.

Moreover, widespread of cases of human rights violations by both sides has been documented by the UN Human Rights Office. These abuses include ethnically induced killings that targets specific ethnic group. More specifically, the RSF and their allied militias have continually attached the Masalit ethnic community, causing thousands of deaths. Another devastating aspect of human rights violations has been sexual violence, particularly against women. The United Nations estimates that by the middle of December 2023, at

Figure 4.32 Sudanese people displacement- UNHCR

least 118 people, including 19 children, have been sexually abused. The RSF militias carried out the majority, but not all, of the attacks, which included rape, gang rape, forced marriage of minors, and a variety of other forms of sexual assault. Most victims do not report these crimes because of stigma and distrust in the justice system.

Lastly, the mortality resulting from the ongoing war in Sudan has been relentless, not only due to the active combat but also because of the horrible conditions displaced people face while trying to flee the violence. Many of this people have died while trying to cross the boarders into neighbouring countries. During the escape journey displaced people face major inhospitable environments, from both natural and human sources of threats, including harsh weathers, lack of food and water, and encounters with hostile groups. The situation is also worsen by the inadequate support and protection mechanisms available to these vulnerable population. Humanitarian corridors are often limited, and safe passages are usually restricted.

Overall, fatalities among the displaced individuals fleeing the war in Sudan undergoes the broader humanitarian crisis. As many lives are lost to the direct violence by the clashes, many more lives are lost due the hazardous conditions encountered during displacement. Addressing these challenges requires a great coordination to enhance protection and support to the affected population.

Figure 4.33 Sudanese people displacement- UNHCR

4.4.3. Effects of displacement on rural and urban life:

Last time I was in Sudan, it has been two weeks before the war broke out on April 15th 2023, Khartoum has never felt so peaceful at the time. The first heavy weeks of the conflicts has been a psychological torment between checking up on my family, friends and reading through the news. My family firstly decided to move somewhere in Sudan away from the clashes in Khartoum in the hopes of coming back in a few weeks as things settle down, to our disappointment this would be the last time they see our home. Between travelling to leave Khartoum and eventually for them to leave to Egypt, my family were one of the lucky ones who managed to leave well and safe outside of the war-torn Sudan. But ever since that day our lives have never been the same. Unfortunately, not many Sudanese people had the same displacement experience as my family. Many people have lost loved ones on their journey to escape as the roads were in shamble conditions and constantly interrupted by smugglers, thieves and many armed militia men. A significant number of families were forced to separate as the father stayed to guard their homes, the rest of the family had to leave for safety. The closed boarders between Sudan and neighbouring countries cut-down on hops for these families to reunite. Currently, thousands are trapped at Wadi Halfa border with Egypt due to the Egyptian authority's new stringent visa requirements. These people are sheltering in makeshift shelters such as schools without any adequate basic necessities like food and medicine.

And even so, the majority are still facing even more awful situations as they are forced to stay in their war-torn cities, since they don't have the financial means to evacuate to an unknown place with an unknown future. A year into this war I was able to meet some of my Sudanese friends who had to leave outside of the country, and a year since the war their lives are still unstable, with no job to provide and no savings since everything was spent on the journey to escape.

As of this month of July 2023, the fighting spread to the state of Sennar and the surrounding villages entailing an added displacement pressure. Many people were forced to escape dangerously crossing water canals on foot while carrying their belongings, in the process many lives were unfortunately lost

The displacement process is tragic because the displaced person is exposed to significant risks and experiences various forms of physical, social, psychological, and moral suffering. This suffering includes humiliation, insults, and the pain endured by the displaced, despite their innocence and inability to defend themselves. Such conditions force them to leave their families, homes, and communities, depriving them of stable work and exposing them to the uncertainty of displacement, which undermines their sense of stability and belonging.

Figure 4.34 before and after images of the destruction in Khartoum, Omdurman - Photo by Abushama

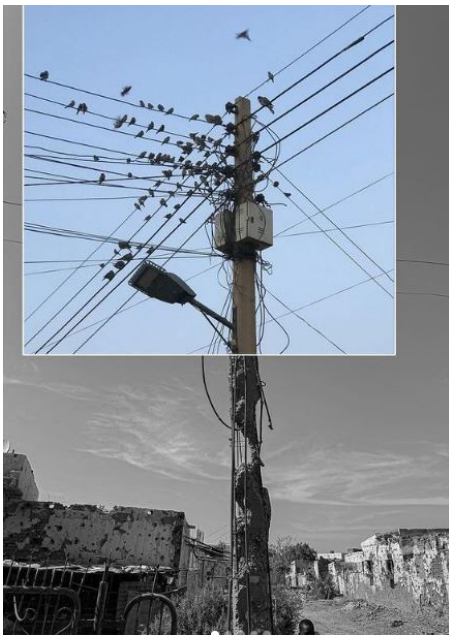


Figure 4.35 before and after images of the destruction in Khartoum, Omdurman - Photo by Abushama

4.4.4. Addressing Displacement: Strategies for effective humanitarian shelter

The Humanitarian shelter response in Sudan requires a permanent shelter solution due to its persistent chronic conflicts. A permanent solution would be beneficial for those displaced now and those who might face displacement in the future. The existing humanitarian shelters available are insufficient for the newly displaced populations, and the ongoing conflicts only exacerbate the already critical displacement situation.

To attain a more permanent solution, durable building materials and techniques become very essential for the housing problem. Such materials must last through harsh weather conditions and deterioration. Besides, durable materials are widely available locally and along with the proper construction methods it can yield very resilient and long-lasting houses.

The humanitarian crisis in Sudan is widespread, affecting people at all levels of society, but it is especially devastating for the poor who already lack resources and have limited opportunities. Many internally-displaced persons (IDPs) are experiencing secondary displacement, facing even greater danger as they struggle to find safety and stability. It is vital to ensure that these vulnerable populations have a chance at rebuilding their lives.

A locally driven solution offers a practical approach to addressing the shelter crisis. Given the unpredictable nature of the conflict, safety is relative and can change rapidly. Local solutions allow for the design and implementation of shelters to be adaptable to various parts of the country, ensuring that they can be effectively utilized where they are most needed. This approach not only addresses immediate needs but also lays the groundwork for long-term resilience and recovery.

4.5. ARCHITECTURE AND CONSTRUCTION TYPOLOGY IN SUDAN

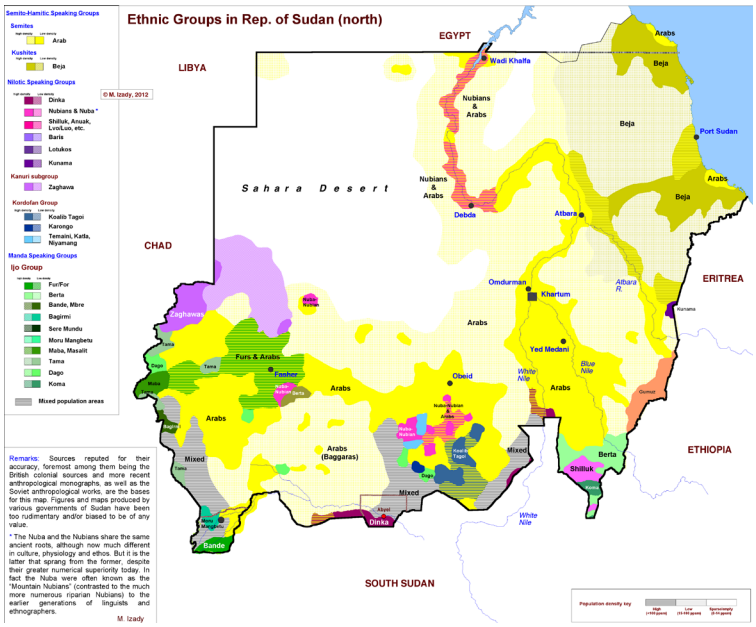


Figure 4.36 map of the ethnic groups in Sudan - NIH

This section focuses on the general architecture and construction methodology in sudan with emphasis on vernacular architecture that is mostly used in the rural parts of the country. This section delves into the typology of building architecture and construction and local material. Moreover, it discusses the methods and application of these local building material and techniques in housing construction.

Sudan, located between the Arab zone of North Africa and the African zone of central Africa, boasts a rich diversity of cultures, traditions, and building practices shaped by its diverse neighbouring sub-cultures, climatic variations, and topographical differences. Over centuries, this blend has given rise to a multiple architectural styles and neighbourhood layouts, crafted organically by Sudanese people without professional intervention, resulting in a remarkably diverse vernacular architecture (Hamid and Eltahir 2014).

Sudan being a developing nation, heavily relies on imported building materials, despite the harsh reality aggravated by the country's challenging economic conditions, which render these materials largely inaccessible to the majority of the population. With housing and shelter demands surpassing the available supply, this chapter delves into Sudan's traditional architecture within the context of its socio-cultural and economic landscape. It explores locally produced and manufactured traditional construction materials along with their role in addressing the nation's housing needs, alongside an examination of their inherent rigidity factors. Ultimately, the discussion aims to have a cohesive understanding to the overall scheme shaping housing construction practices in Sudan.

4.5.1 Housing Architecture Typology

This section relies on various research and studies done by Akram Ahmed Elkhalifa. His scholarly research on building architecture and construction in Sudan was very insightful to this research

There's a big difference of the level of construction throughout the country, this difference stems from the cultural diversity and lifestyle. The main factor driving the architectural style and typology in the country is the climatic conditions. Sudanese individuals maintain a deeply rooted connection to their cultural heritage and traditions, evident in their homes with a distinctive character reflective of this rich diversity. For instance, in the northern regions of Sudan, where descendants of Nubian tribes reside, ancient cultural practices have persevered for millennia, shaping the fabric of their daily lives. Conversely, in the eastern part of the country, predominantly inhabited by nomadic and sedentary tribes like the Beja, Hadandawa, and Rashida, a different cultural tapestry unfolds. Meanwhile, in western Sudan, stark contrasts in cultural influences are evident between the north-western and south-western regions. The former bears a strong Arab influence, while the latter is marked by a pronounced African cultural heritage. Central Sudan, serving as the social link of the nation, characterized as a cultural melting pot, where diversity influences converge to form a unique mono-cultural essence within the city. (Hamid and Eltahir 2014)

Figure 4.37 Tukul in south Sudan - wikipedia

Figure 4.38 House in Dongola (North Sudan) - Orange Dragon Foundation

Figure 4.39 House in Khartoum capital (Central Sudan) - Sudanfax

People in Sudan exhibit a profound sense of bonding with their community, including their tribes, extended relatives, neighbours and those who share similar cultural backgrounds. This communal bond is evident in the very fabric of their built environment, spanning from the macro scale of villages, towns, and neighbourhoods to the intricate details within their own homes. Houses design, in particular, serves as a tangible expression of the value placed on embracing others within the community and fostering strong familial ties.

Even as individuals marry and establish their own households, the inclination to remain in close proximity to one another persists. This preference manifests in the clustering of residential blocks inhabited by members of the same familial lineage. Consequently, towns and cities in Sudan are characterized by a cohesive social fabric, where shared values and traditions permeate through various layers of community life.

This trait is evident in the most prominent design aspect across the country “Al housh” (The courtyard); which is a semi-detach architectural style that consists of a courtyard typically placed at the eastern or northern side of the house plot surrounded by semi-detached rooms that make up the bedrooms and living rooms. Historically the courtyard is a vital element in the core of Sudanese architectural housing design, it plays an important role in the dynamic of the house and creates a harmoniums environment to carry out activities throughout the day. It encompasses various activities, during the day it serves as an area for household chores from cooking, washing clothes to a space for socializing between the women of the house. In the evening, the courtyard is transformed to family gathering space where dinner is served, followed by tea at sunset and guests welcoming space if necessary. Additionally, it is occasionally cleaned and sprinkled with water to cool the area and in cooler days it is turned into outdoor sleeping area. In many occasions the courtyard is divided into two or more yards for separation between male and female activities.

Figure 4.40 men sitting in housh space in sudanese houses - Photo by Khalid Alarbi

Classification of Housing Solution in Sudan

There exists a significant contrast in the construction standards throughout Sudan. The Darfur states, in particular, experience a limited development in their built environment, primarily attributed to the impact of war, conflicts, inadequate infrastructure, and limited economic progress. This situation is exacerbated by a scarcity of construction materials resulting from drought conditions and the pressing demand for shelter. (Elkhalifa 2011)

According to the collected data from 2008 census report, dwelling in Sudan can be classified into these types:

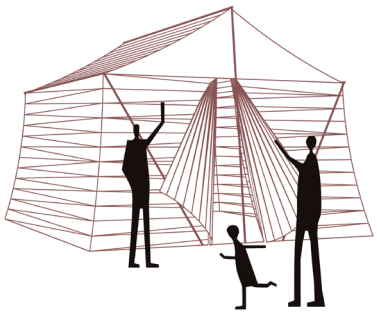


Figure 4.41 tent in empty plot in the city - Author

Tents are a very old, temporary and easy to build and dismantle dwelling which is used by nomads, it is made from local and salvaged materials. It is common to see this type of housing scattered around towns

Durability: Poor

Size: Single Family

Figure 4.42 mud gottiya - Author

Gottiya (Mud) is a mud house which is essentially made from mud, it is usually a single room or a dwelling where the walls are built from mud

Durability: Semi-temporary

Size: Single Family

Climate Zone: Climate Zone I (Warm desert climate)

Figure 4.43 straw gottiya - Author

Gottyia (Straw)

Durability: Poor

Size: Single Family

Climate Zone: Climate Zone III (Tropical savanna climate

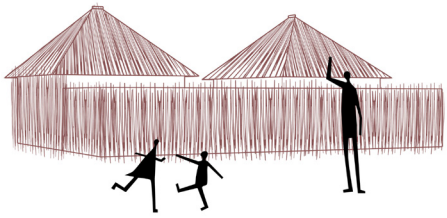


Figure 4.44 straw mat dwelling - Author

Dwelling of Straw Mats are a traditional dwelling which is made from pieces of straw mats connected together to form a room shape which is used as a shelter, it could be as a hut or rectangle shape

Durability: Poor

Size: Single Family

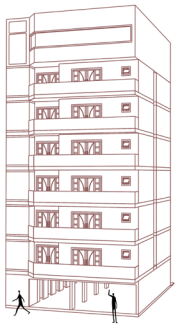


Figure 4.45 apartment building - Author

Flat or Apartment are usually built from modern materials, such as brick and concrete. They are a common housing shelter for mid to low income groups they are present in most towns and cities but are more seen in urban cities.

Durability: Good

Size: Multi-family

Climate Zone: Climate Zone II (Warm semi-arid climate)

Figure 4.46 single story house - Author

Single Story House are usually built from brick, mud or concrete

Durability: Good

Size: Single Family

Climate Zone: Climate Zone II (Warm semi-arid climate)

Figure 4.47 Villa in Khartoum - Author

Villa are a housing option mostly common within high and medium income groups, they are mainly concentrated in big cities and in certain neighbourhoods. They include large amount of land and often barns, garages.

Durability: Good

Size: Single Family

Climate Zone: Climate Zone II (Warm semi-arid climate)

In the rural population, single-story mud houses and Tukul or Gottiya stick houses are the most common housing type, while multi-story houses rarely exist. On the contrary, multi-story houses, villas and flat apartment are the most common architectural type in urban areas. Additionally, nomadic population rely on building with temporary materials like straw, mud and other temporary materials. And urban areas build with more permanent materials such as bricks and concrete (Elkhalifa 2011)

4.5.2. Traditional Building Materials

In many developing countries nowadays, as it is the case in Sudan, development efforts often focus on the modern construction sector so as to deal with growing investment programs and to meet pressing needs for urban shelter.

Sudan does not lack natural resources, but their exploitation have been severely hindered due to the weak economic status, harsh climate, conflicts and corruption. Most durable materials used in construction in Sudan is usually imported, nonetheless, there are a number of high-quality raw materials available in Sudan. Most essential raw materials required for Sudan's construction industry are likely present in ample amounts. Yet, comprehensive information regarding the quantity, quality is often lacking or unavailable, (Elkhalifa 2011).

Certain building materials are largely available throughout the country most notably is Sand and gravel of different specifications which are available in the entire country. High quality sand for the uses as a binder aggregate is scarce in many areas of the Sudan. However, acceptable sands and gravel can be found in the river-beds and near the rivers. Meanwhile, various other materials can be found in different parts of the country, limestone; which is the main substance of Portland cement is available largely in many locations, especially in the north and east. Loam and clay of different qualities is available mainly along the Nile river. Black cotton soil (Semi-clay material) used form brick clay, covers most of the central and southern parts of the country. Lastly, gypsum is only available in the coastal area of the red sea in the north of Portsudan.

Earth serves as the primary construction material for the vast majority of Sudan's population, including those residing in the capital and urban areas. Approximately 80% of urban dwellers and 90% of those in rural areas utilize earth in the construction of their homes. Structures are predominantly or partially built using soil, a choice influenced by factors such as geographical location, climate, skill availability, cost considerations, intended use of the building, and adherence to local building traditions. (Elkhalifa 2011)

Advantages of using Earth construction:

- Easy to manipulate
- Cost-effective
- Suitable thermal characteristics (excellent thermal insulation)
- Effective fire resistance and sound absorption
- Reduced transportation needs
- Promotes and simplifies self-reliance and community involvement.

Building materials use in Sudan ranges from natural to industrial based on the location and climatic condition. Generally, building materials are classified into three types:

Figure 4.48 Concrete consruction - Mkc Image

Modern Materials

Concrete

Red Bricks

Cement Mortar/Brick

Corrugated Iron Sheet

Figure 4.49 Mud cconstruction - Flicker

Figure 4.50 Brick construction - four square

Traditional/Permanent Materials

Red Bricks with Mud Bricks

Mud wall construction

Sticks roofing

Thatch roofing

Mud

Figure 4.51 Thatch/straw construction - Medium.com

Traditional Materials

Thatch roofing and walls

Figure 4.52 Fired brick - Pressenza

Fired Brick

Fired brick stands as a prevalent construction material across Sudan. The process involves several stages, commencing with brick formation and culminating in firing the material within high-temperature kilns, subsequently allowing it to cool. While brick construction is widely practiced in Sudan, it presents various environmental drawbacks, ranging from the environmental impact of kiln burning to the significant quantity of bricks deemed unsuitable after firing.

These fired bricks find application in various construction facets, including wall building, as well as in crafting vaulted and domed roofs. They are assembled using binding agents like mortar and occasionally coated with plaster (using materials such as sand, mud, or lime).

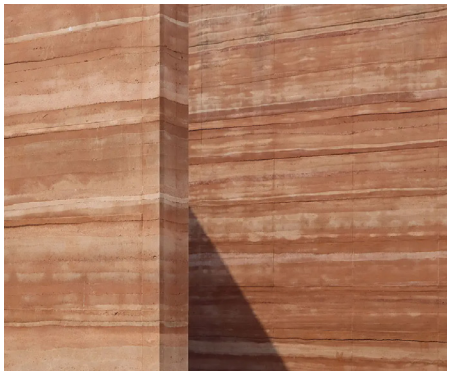


Figure 4.53 Rammed Earth- Archi soup

Rammed Earth

Rammed earth construction has a rich history in Sudanese architecture due to its suitability for the local environment and the abundance of earth as a building material. This technique involves compressing moistened soil within frames to create robust walls, commonly used in homes, mosques, and community buildings. It's valued for its eco-friendliness, thermal regulation, and resilience to Sudan's weather conditions. Its popularity stems from utilizing local materials, reducing transportation needs, and aligning with sustainable and cost-effective building practices, addressing Sudan's resource limitations and economic challenges. Efforts to modernize this traditional method aim to enhance structural integrity and insulation while preserving Sudanese heritage.

Figure 4.54 Compressed Earth Blocks-Yenuli Constructions

Compresses Stabilized Earth Blocks (CSEB)

Recently, interlocked stabilized soil blocks (SSBs) were introduced as a wall construction technology in Sudan. Many governments and international organizations have adopted the technology to address the housing deficit. The main material used in CSEBs technology is soil that has been stabilized with cement. Interlocked CSEBs are manufactured using hydraulic machines powered by fuel, particularly diesel. Block-making machines compress soil with a small amount of clay and silt mixed with cement to form soil cement blocks. When cured, these blocks can be dry-stacked without mortar, with the structure's stability coming from the interlocking and weight of the block.

Figure 4.55 Ferrocement Vaulted roof-ArchDaily

Ferrocement Vaulted Roof

The El-Haj Yousif school project implemented a new roofing technology: ferrocement vaulted roofs. Ferrocement roofs are lightweight and can be built on walls made of mud brick, fired brick, or SSBs. Steel formwork with a circular section is typically used for roof construction. A reed mat is laid over the formwork, and then a sand and cement mixture is spread over it. With an ability to be cast into thin shell elements, Ferrocement opens possibilities which are not possible in conventional brick and concrete. The ferrocement roof has been found to be cheaper by about 10% than the traditional roof

4.5.3. Application of Building Materials & Technology for Housing

Overall, across Sudan the use of wall building techniques are almost the same, the only significant difference is in roofing materials. Roofs are considered the most challenging element of building in general and more specifically in houses. The choice of using roof systems relays mainly on the availability of materials, economic feasibility, climatic performance and lastly; complexity of construction. They can be categorized into four main groups (Elkhalifa and Agib 2001):

- Flat Roofs

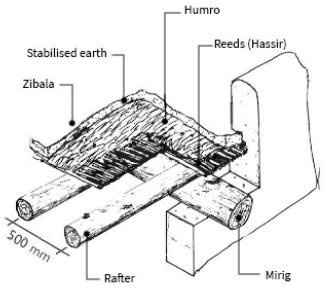


Figure 4.56 Baladi Flat Roof - (Elkhalifa, 2011)

Baladi (Traditional) Flat Roof

Traditional earth roofs are still used in various parts of Sudan, especially in areas of low to medium rainfall, their popularity stems from the low cost of construction and high resistance to heat. The roof is laid directly on top of earth walls for a (4x4 m) room.

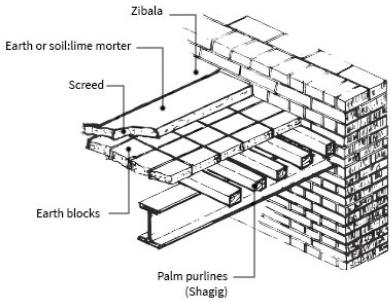


Figure 4.57 Shagig Roof - (Elkhalifa, 2011)

Shagig (Palm Purlins) Roof

Palm purlin are mainly used in the construction of flats roofs mainly in east Sudan where palm trees are abundantly available. The palm purlins are usually 4-5 meters long and arranged to cover approximately (4x4m) room. On top of the purlins special earth blocks are laid and finished with Zibala that is a mixture of earth and animal dung used to protect the exterior of earth building.

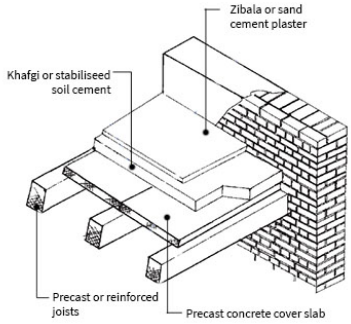


Figure 4.58 Precast Concrete Roof - (Elkhalifa, 2011)

Precast Concrete Roof

Concrete roofs are primarily confined to urban areas, mainly due to the significantly higher cost compared to traditional roofing. These roofs are typically coated with Khafji, a blend of lime, coarse sand, and crushed clay brick. While offering commendable thermal and insulation properties, it's worth noting that their thermal performance is slightly behind that of traditional roofs.

- Truss or Lean-to Roofs

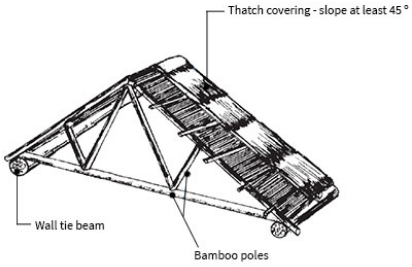


Figure 4.59 Truss Roof - (Elkhalifa, 2011)

- Vaults

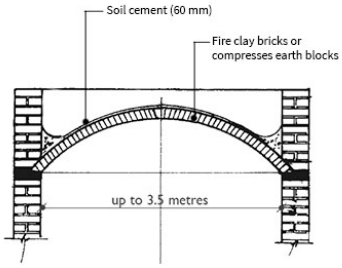


Figure 4.60 Semicircular vaults - (Elkhalifa, 2011)

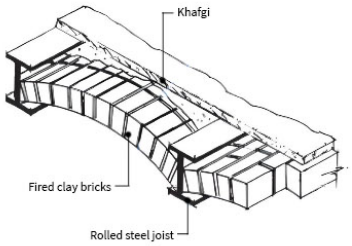


Figure 4.61 Jack-Arch Roof - (Elkhalifa, 2011)

- Domes

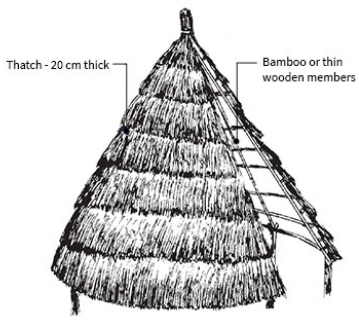


Figure 4.62 Dome Roof - (Elkhalifa, 2011)

Truss Roofs

The effectiveness of this type of roof is contingent upon factors such as the pitch angle, roof cover, materials employed, and construction approach. Common materials utilized for pitched roofs in Sudan include thatch, corrugated iron sheets, corrugated fiber-cement sheets, timber boarding, and fired clay tiles. Thatch, renowned for its efficacy, is frequently employed as a roof covering in diverse regions of Sudan, particularly in the southern, western, and eastern areas of the country.

Semicircular Vaults

This type of roofs are used for it's low cost with the possibility of construction from fired bricks and/or stabilized soil blocks (SSBs). The top of the vault is usually covered with a soil or sand cement screed.

The Jack-arch Roof

Jack-arch roofs stand out as a popular roofing system in Sudan. This distinctive roof structure consists of main joists, with bricks arranged on their edges between these joists to form an arch. Subsequently, a layer of Khafji is meticulously applied on top, serving not only to provide a robust cover but also to act as an effective sealant against rainwater. This dual functionality not only ensures durability but also enhances the insulation properties of the roof.

Dome Roofs

Domes roofs are still commonly used in some parts of Sudan. They are constructed of thin bamboo or wood members covered with thatch. Occasionally, the thatch layer is then covered with a layer of earth or Zibala to provide an additional protection against water and heat penetration.

CONCLUSION

Architecture and construction in Sudan exhibit a wide range of styles and methods, influenced by factors such as the country's diverse ethnic makeup, varying climates, and different cultural practices. This diversity makes it difficult to define a single, overarching architectural style for Sudan.

The economic and security challenges that Sudan has faced for a prolonged period have led its people to seek alternative solutions for food, safety, and shelter. As a result, there has been a notable increase in the use of salvaged materials in construction. People often build homes using whatever materials are readily available in their surroundings.

This shift towards using salvaged materials reflects the resourcefulness of the Sudanese population in adapting to their circumstances. It also highlights their ability to create habitable spaces from materials that might otherwise be discarded. Furthermore, there is a preference among Sudanese communities to construct buildings using locally abundant materials, further adding to the diversity of architectural styles in the country.

In summary, Sudanese architecture and construction practices are shaped by a combination of cultural, economic, and environmental factors. The use of salvaged materials and locally available resources underscores the ingenuity and adaptability of the Sudanese people in overcoming challenges and creating functional living spaces.

CHAPTER V DESIGN PROPOSAL

5.1 CONTEXTUAL DESIGN ASPECTS

The security situation in Sudan has proven to be unpredictable. The clashes have expanded from one part of the country to other parts that were deemed safer. Hence the transitional shelter must be ***adaptable*** to be implemented in most parts of the country. In addition, it must be ***durable*** enough to withstand harsh weather conditions with long life span that permits future expansions and supports establishment of livelihood.

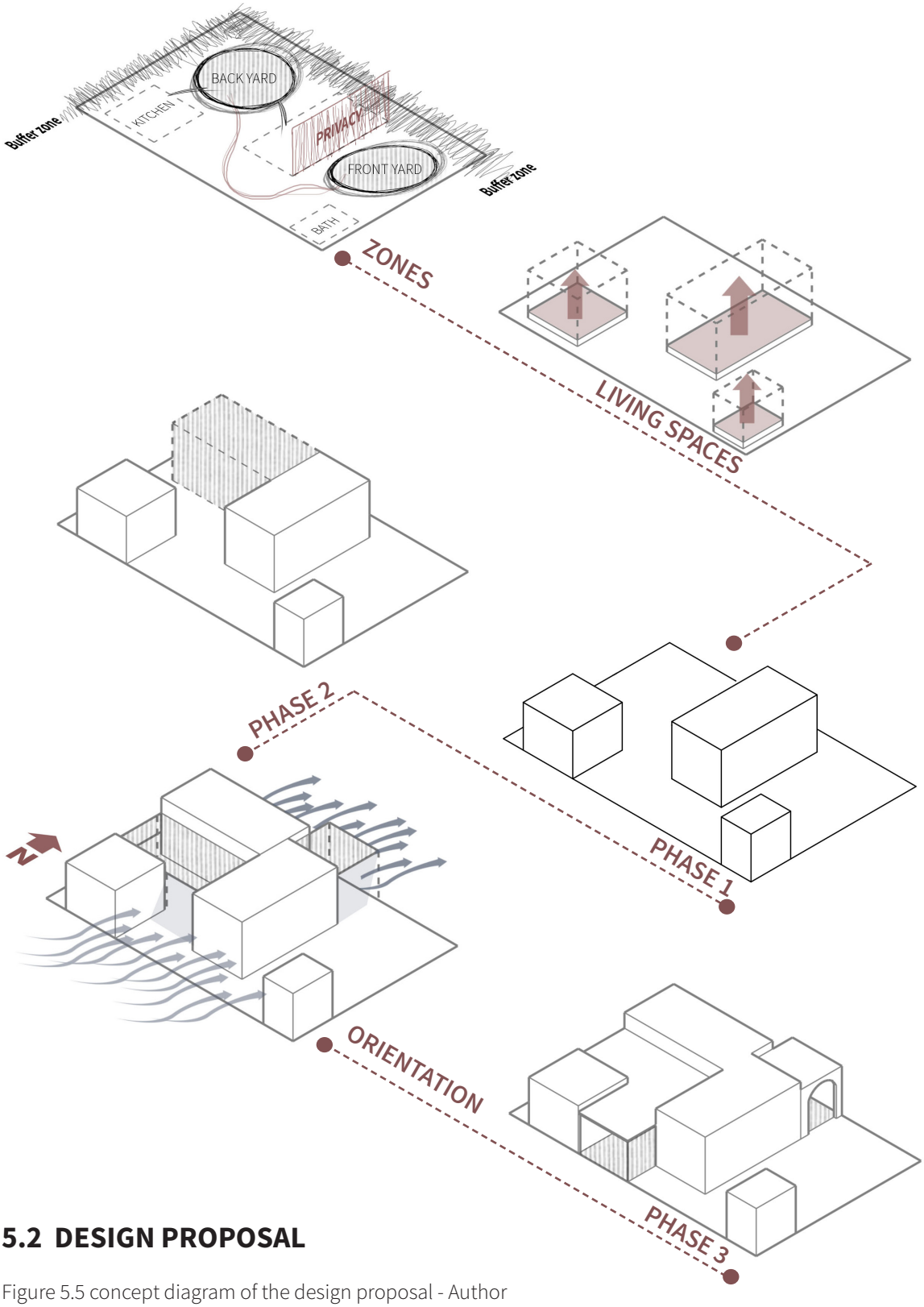
Figure 5.1 image of the shelter option adopted by the displaced people - Photo by ispionline.it

Figure 5.2 image of local construction material in Sudan - Photo by globalgiving.org

Figure 5.3 image highlights the aftermath of the conflict with the destruction of infrastructure - Photo by joyph-illips.blogspot.com

Figure 5.4 image shows the breakout of the war in the capital Khartoum - photot by Al-sharq al-awsat

Consideration for the variety of ***climatic conditions*** in Sudan are also important, that requires a traditional use of ***local materials*** that is abundantly available across the country and can be easily produced and that requires minimal transportation. ***Simplicity*** of the design and construction is key with the use of traditional building techniques, which can be easily understood and adopted by the majority of the displaced population. The possibility of the proposed unit design to be multiplied and aggregated in a way to enhance ***communal activities***



5.2 DESIGN PROPOSAL

Figure 5.5 concept diagram of the design proposal - Author

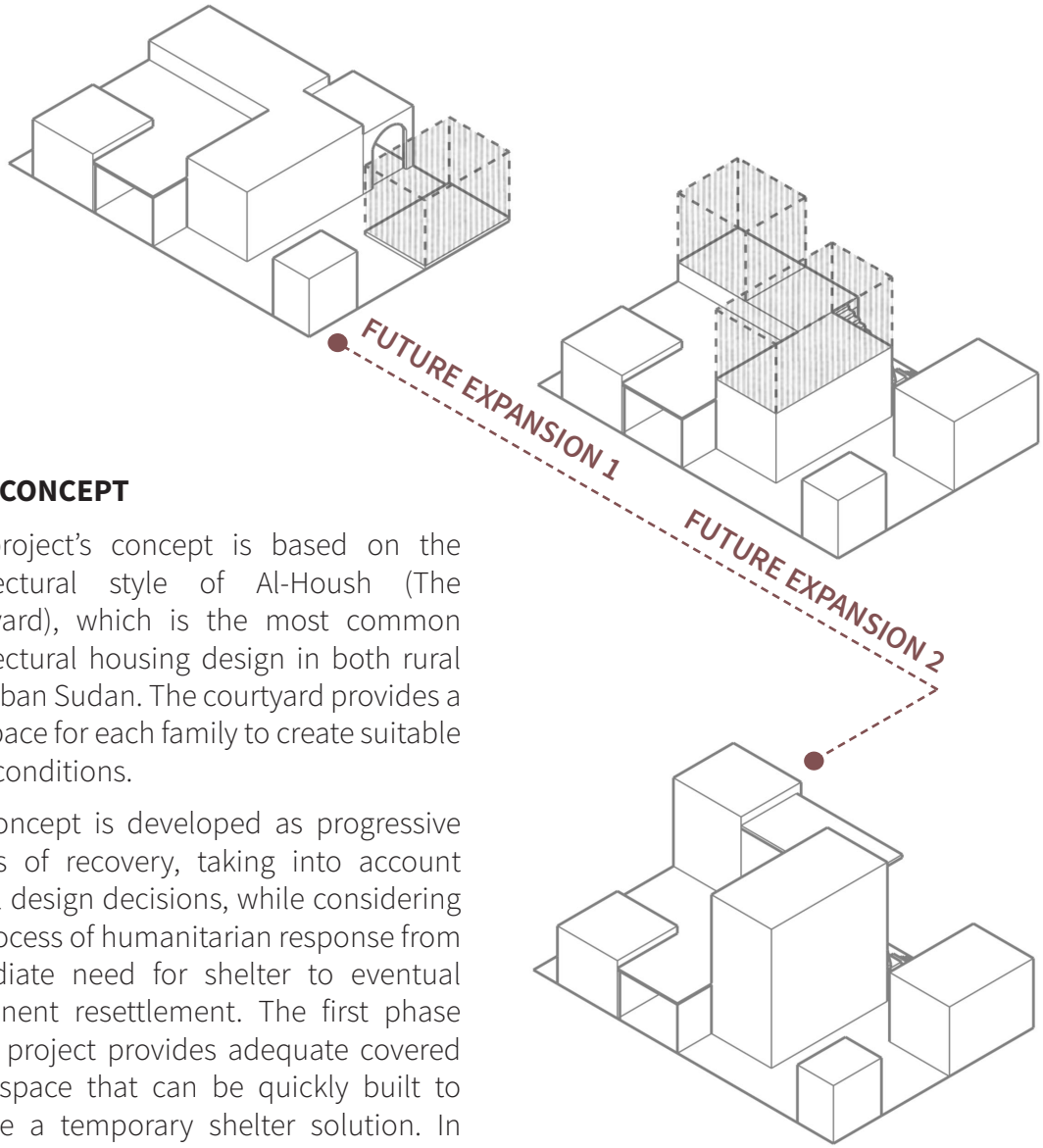


Figure 5.6 diagram of future expansion of the project - Author

5.2.1 CONCEPT

The project's concept is based on the architectural style of Al-Housh (The Courtyard), which is the most common architectural housing design in both rural and urban Sudan. The courtyard provides a plot space for each family to create suitable living conditions.

The concept is developed as progressive phases of recovery, taking into account critical design decisions, while considering the process of humanitarian response from immediate need for shelter to eventual permanent resettlement. The first phase of the project provides adequate covered living space that can be quickly built to provide a temporary shelter solution. In the second phase, an additional living unit is added to meet the SPHERE booklet's minimum space requirements of 3.5 m2 per person for an average family size of 5.5 people. The final design phase enhances thermal comfort in the outdoor areas. Furthermore, the proposed design examines future expansion, including commercial stores, workshops, studios, and additional living spaces on the upper floor. The three phases of the design can be obtained simply, individually, and over various periods of time.

In the following sections, an in-depth exploration of the three major aspects of humanitarian shelter design is provided. This includes traditional building materials and construction techniques, minimum space requirements, sanitation and wastewater management.

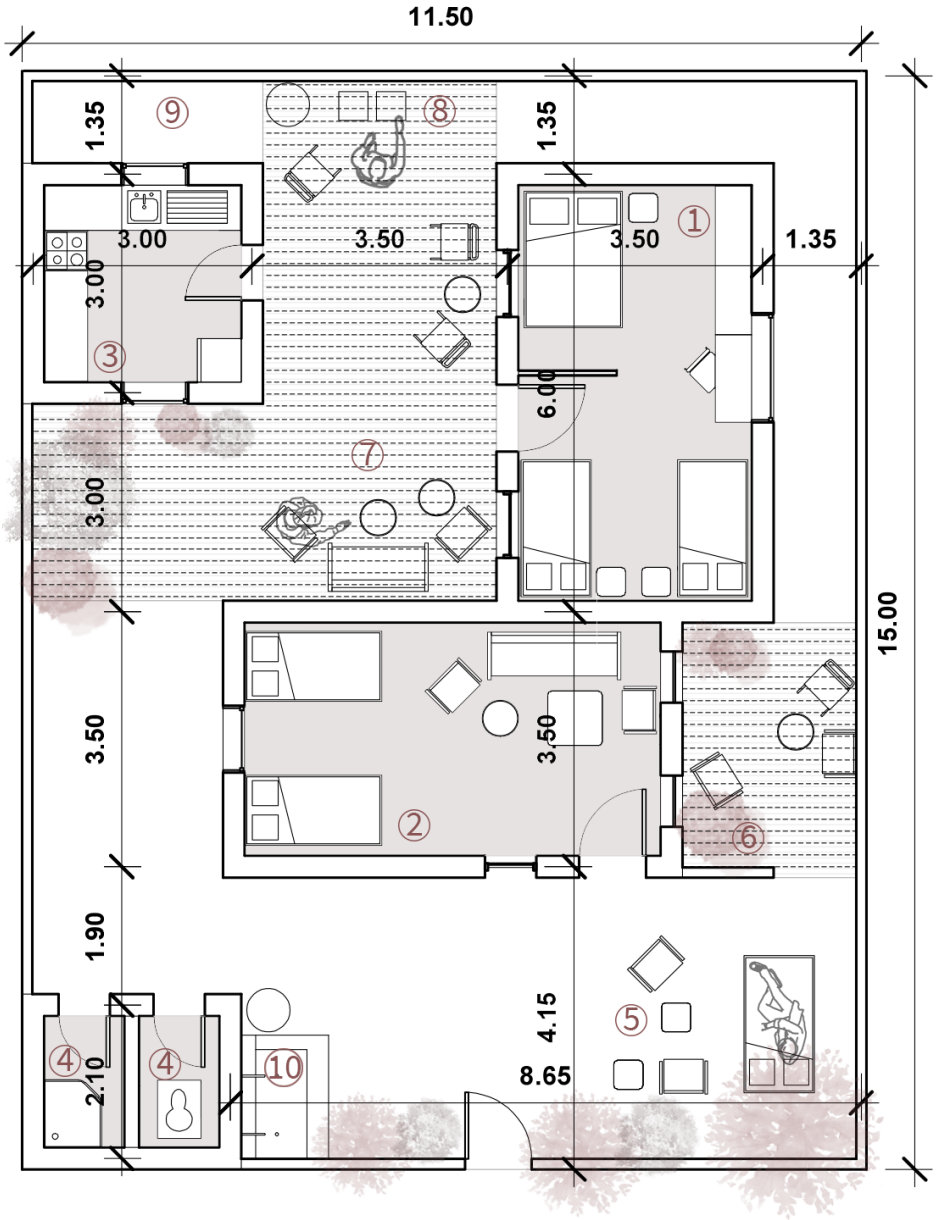


Figure 5.7 Ground Floor plan - scale 1:100 - Author

1 - Bedroom
2 - Men's Saloon
3 - Kitchen
4 - W.C
5 - Front Yard
6 - Veranda
7 - Living Area
8 - Outdoor Cooking Area
9 - Storage Area
10 - Water Source (Wadayi)

GROUND FLOOR PLAN

5.2.2 ARCHITECTURAL LAYOUT

The courtyard is divided into two sections to separate men and women; the covered backyard serves as a dynamic space for household chores; and the front yard is the main entrance to the house and serves as a recreational area for male guests and the family. The main living units are 21 m^2 each, with the main unit connected to the backyard and subsequently the kitchen, and serving as the house's main living area. The second unit is primarily for men, is used to host guests, and is connected to the main front yard. Furthermore, the bathroom is divided into two areas: toilet and shower, and it is positioned in proximity to the street for wastewater management, and further separation from the main living area considering ventilation requirements.

The housh architectural style was developed to accommodate the cultural uniqueness of the Sudanese people and every Sudanese person resides with some important memory of their experiences with the housh in their own homes. Families utilize the housh space for their daily activities. It is used to grow plants, trees and raise cattle for domestic use. The space is also used to sun dry food as a mean of preservation.

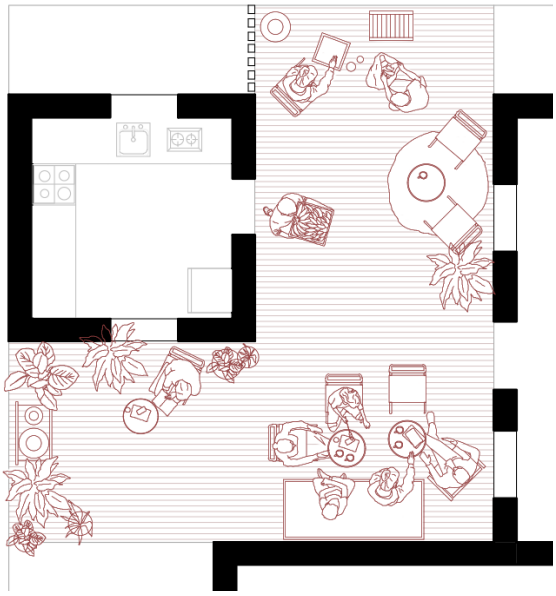
The Sudanese backyards act as the core and vibrant point of operations in households for many activities. Traditionally, this enclosed yard is versatile with furniture being arranged according to the activities that are carried out throughout the day. The Figure 5.8 illustrates various arrangements of this space from morning till night thus highlighting its liveliness and centrality to family life.

Rural Sudanese culture, members of the family prefer staying outside most of their time while rooms are reserved for activities such as sleeping. Cooking and eating are some of the main outdoor activities, as many households rely on coal and wood for cooking because gas and electricity may be unavailable at times. Consequently, women spend a significant amount of time outdoors, managing cooking duties while tending to their children and entertaining guests.

At night and in cool months, families usually sleep outside where the temperatures are often cooler compared to inside the house. Due to the multi-functional purpose throughout the day, a storage area next to kitchen is provided which can hold different kinds of furniture and tools.

VARIOUS SPACE CONFIGURATIONS

SPACE FOR EATING



SPACE FOR PLAYING

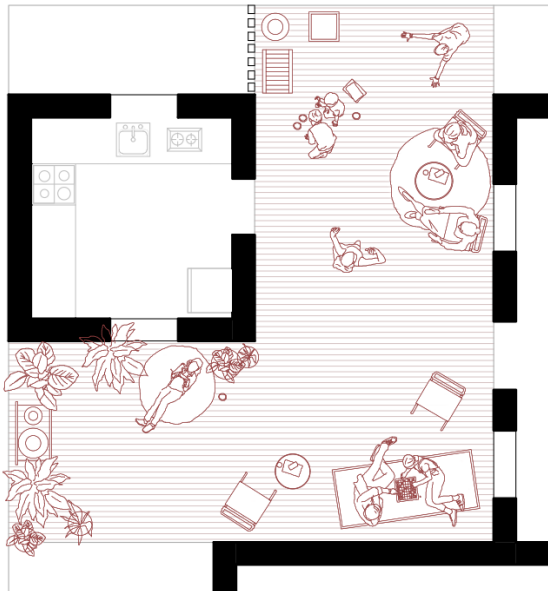


Figure 5.8 enlarged plans of the living area showing the different space configurations - Author

5.2.3 CONSTRUCTION METHODOLOGY

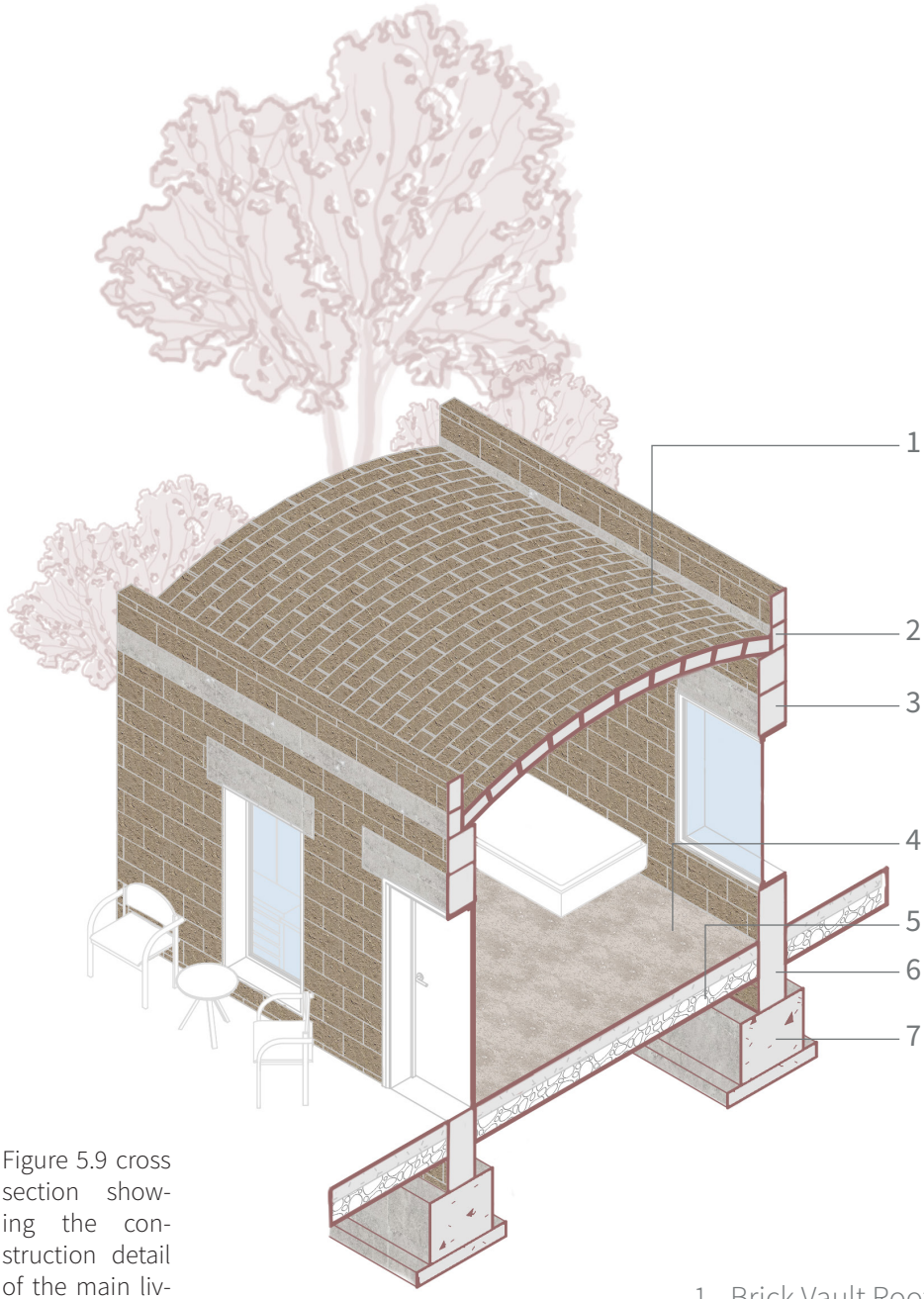


Figure 5.9 cross section showing the construction detail of the main living unit - Author

1 - Brick Vault Roof
2 - Structural Beam
3 - Door/Window Lentil
4 - Compressed Earth Floor
5 - Gravel
6 - Brick Wall
7 - Structural Foundation

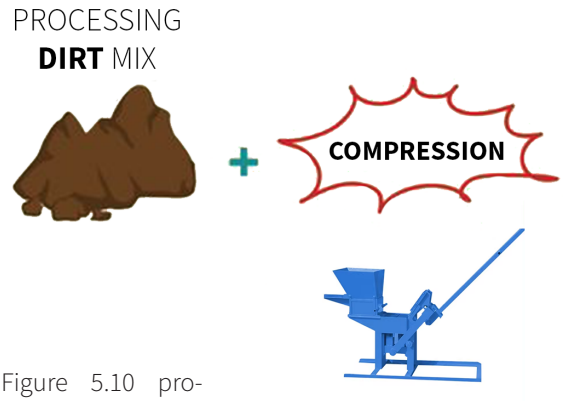


Figure 5.10 process of making the compressed earth blocks - Author

Figure 5.11 types of compressed stabalized earth blocks

The current war in Sudan has been unforeseen, pushing the Sudanese people into unprecedented circumstances. In light of this disaster, an innovative approach is needed through the improvement and application of traditional earth architecture. By leveraging on these well-established construction methods which have historically demonstrated resilience and effectiveness, a sustainable and culturally appropriate housing solutions can be attained. This approach not only meets immediate shelter needs, but also empowers communities by leveraging their existing knowledge and practices.

Earth constructed houses utilizes unfired earth as a primary component as they have a lower environmental impact, require less energy, and improve air quality and thermal comfort. Additionally, they use less energy for extraction, manufacturing, and transportation, have a high load-bearing capacity, and are fire and insect resistant. The earth technique is considered economically feasible, thus the design utilizes Compressed Stabilized Earth Blocks (CSEB) in the construction of the building envelope in the load-bearing walls and vaulted roof.

The use of Compressed Stabilized Earth Blocks (CSEB) is an innovative practice of construction in Sudan, yet very durable and efficient. Firstly, the soil is tested using to analyze the quality of the soil and to establish the right proportions of soil, stabilizer and water. Then the earth blocks are simply compressed using a manual press that can be easily operated and transported. after the blocks are formed they are cured for 7-10 days and finally can be used as durable building materials. The construction of the walls and roof relies mainly on the mechanical resistance of interlocking the blocks to provide strength with minimal use of mortar. The method of interlocking reduces the need for skilled labors and facilitates self-construction while reducing construction time.

The traditional way of building with earth is common in Sudan because this method has many solutions and encourages a strong, sustainable community. This conventional approach can provide even better solutions if it is further developed and researched on. Comparable to the vernacular housing methods employed by the New Gourna villagers in Egypt and the people in Shibam Yemen which have been refined over time and demonstrated their efficacy, these practices have a longstanding history of success. The situation in Sudan, provides a vital opportunity to contribute towards developing these traditional methods by stepping forward from where they are now and improving what exists in them.

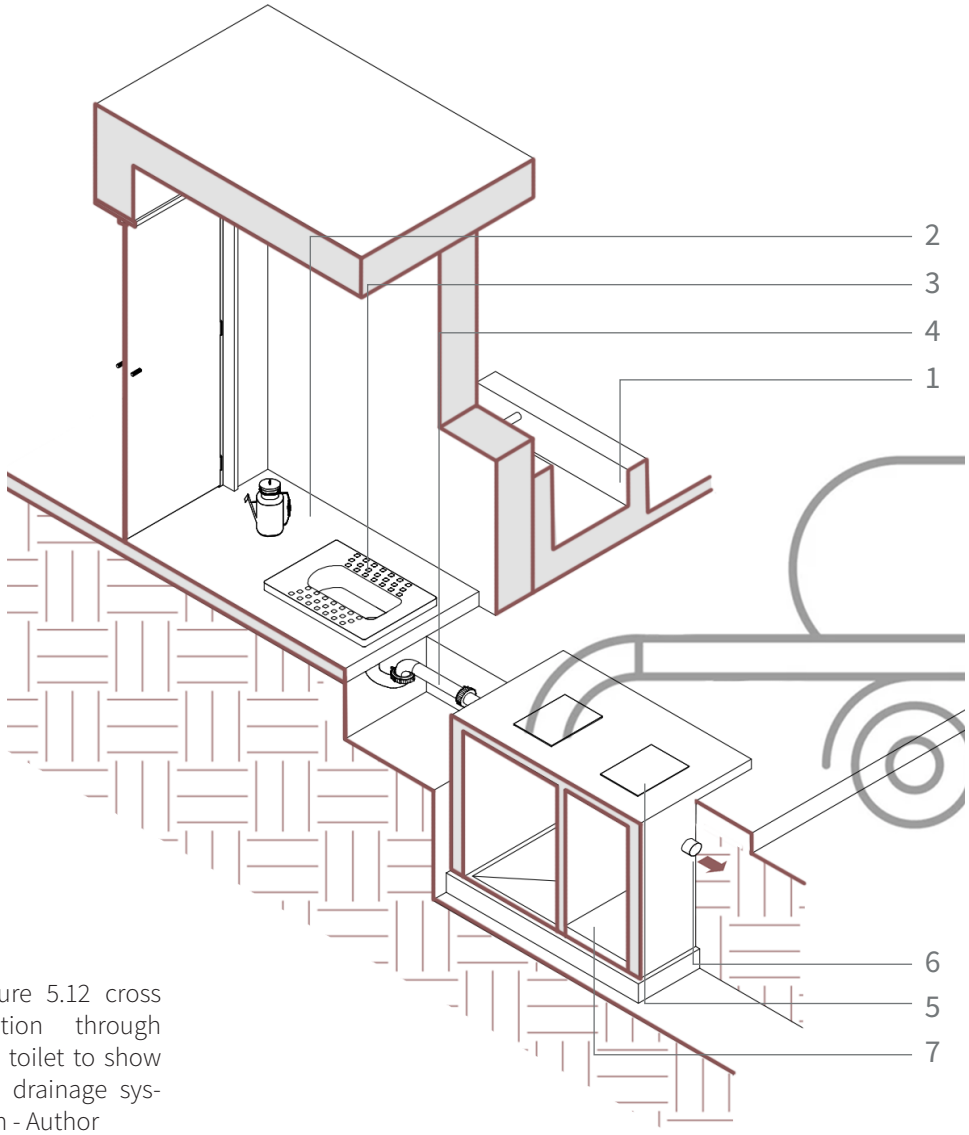


Figure 5.12 cross section through the toilet to show the drainage system - Author

5.2.4 WASTEWATER MANAGEMENT SYSTEM

1 - Water Source
2 - Concrete Floor
3 - Pedestal
4 - Inlet - Pipe carrying toilet waste
5 - Access Cover
6 - Outlet - Overflow water
7 - Two Compartment Septic-tank

Sanitation and wastewater drainage system is one of the most critical elements that concerns displaced people humanitarian needs, it is directly related to people's health and hygiene conditions. Although some post-disaster shelters are built close to existing cities or towns which make it easier to connect the newly built units sewage system to existing infrastructure, in this case this option might not be easily attainable. Considering that the country lacks appropriate sewage infrastructure in existing cities and towns, even much of the capital of Khartoum still struggle with underdeveloped sewage infrastructure.

As a result an on-site simple and effective sewage system for each shelter unite is proven to be more efficient. As the traditional "cesspool" drainage system that relies on "aerobic processing of waste" is commonly used in most of the rural parts of the country, a developed variation of this system is proposed to reduce some of the problematic factors in the traditional cesspool.

The septic tank sewage system is an on-site wastewater treatment system commonly used in rural and suburban areas without centralized sewer system. It is also one of the most commonly used sewage systems in most parts of Sudan. Wastewater flows into a buried septic tank located outside of the house plot, where solids settle and are broken down by bacteria, while liquid effluent flows to a second pit and then to a drain field. In the drain field, the effluent is filtered through the soil, removing harmful bacteria and nutrients. Regular maintenance, including pumping out accumulated sludge and scum, is essential to prevent clogs and ensure proper functioning. A general rule of thumb the pit could require external pumping every 3-5 years depending on the maintenance, usage and size. Septic systems are cost-effective and environmentally friendly but require careful water use and periodic inspections. Additionally, it supports the possibility to be connected to a public sewage system in the future.

Generally, the field of wastewater management is a very open space for innovative wastewater management solutions. Since 2012, the "Melinda and Gates Foundation" has been tackling a crucial challenge: creating "next-generation" toilets to provide safe and sustainable sanitation to the 2.5 billion people worldwide lacking access. Proposed models range widely, including waste-burning toilets, water-filtering systems, and solar-powered toilets with fuel cells for backup energy. Additionally, presented by "Hussi" in the Venice biennale 2023, Finland, the dry toilet system used for years in rural Finland that processes waste by converting it to compost in a hay-filled container. These are a few of the efforts being made in modeling a new way for wastewater management that could be effectively transported and utilized in the near future to deal with the sanitation problems in Sudan.

LOCAL OPPORTUNITY

Under the resilience goals, the construction of the transitional shelters is made by the affected displaced population with the strategical and technical consultation of experts in the field. The overall humanitarian response scheme should involve all stakeholders from local population to technical experts, researchers, NGOs as well as governmental bodies.

Initially, a well-rounded architectural pilot-shelter is developed taking into consideration local materials and culture, both aesthetically and functionally before slowly moving to large production of shelters. The design proposal poses efficient utilization of both time and man-power for various shelter units to be built at the same time in a short period of time. Additionally, an in-depth training program is presented to the refugees in advance

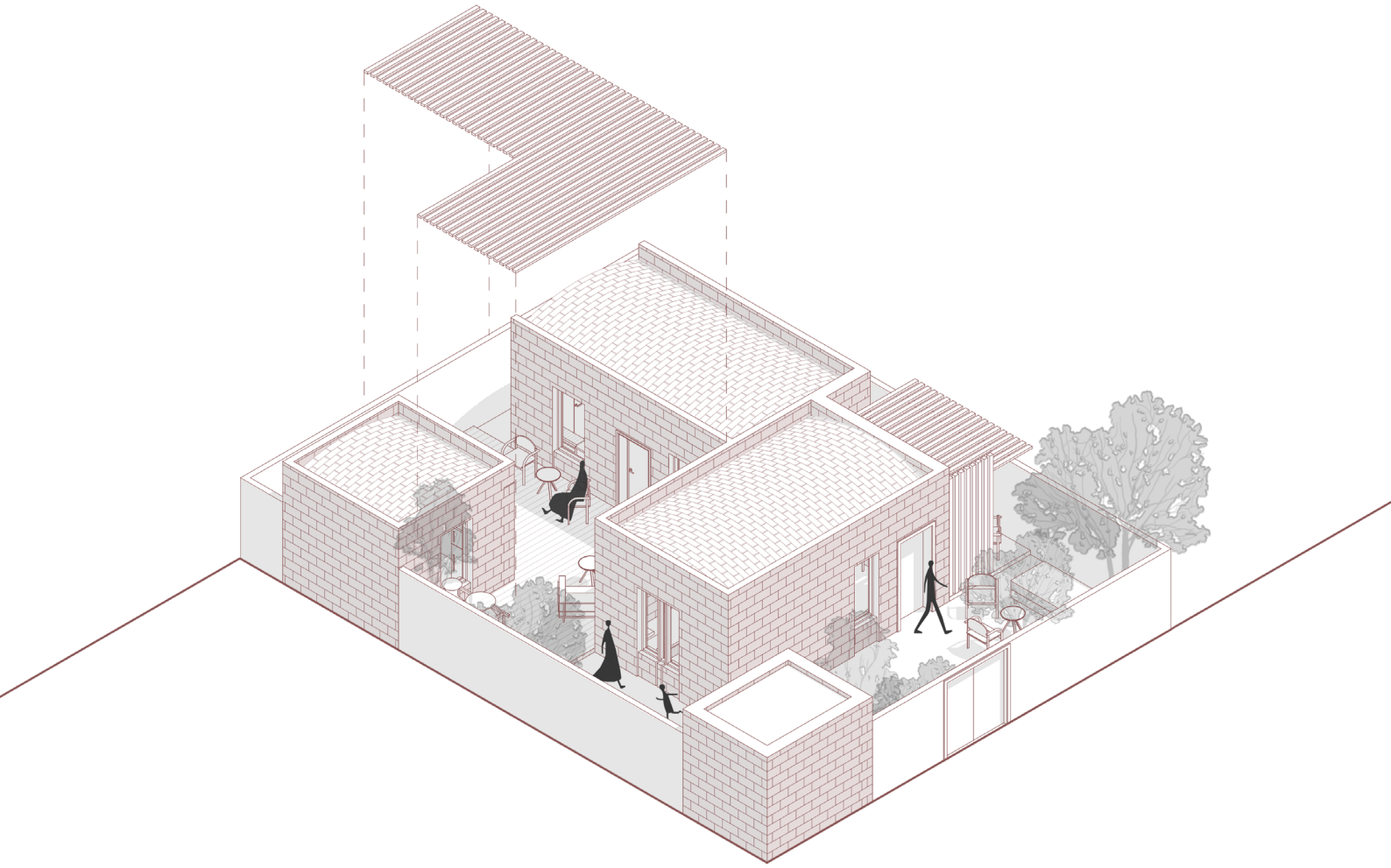
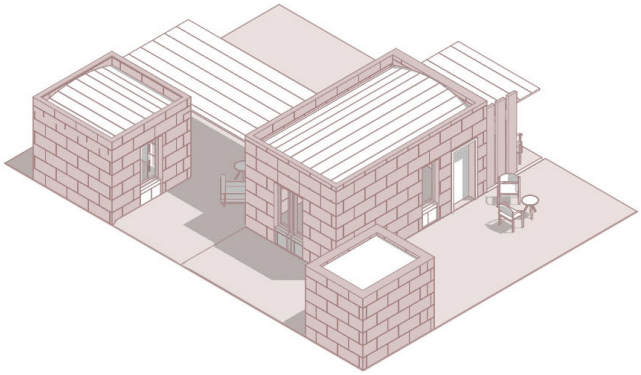
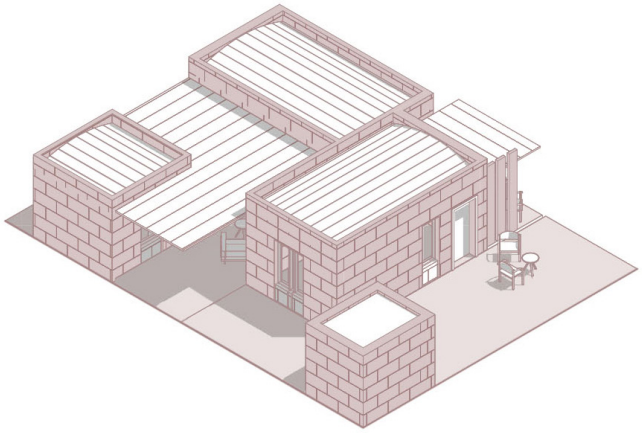


Figure 5.13 axonametry of the shelter unit - Author

Figure 5.14 axonametry of the settlement - Author





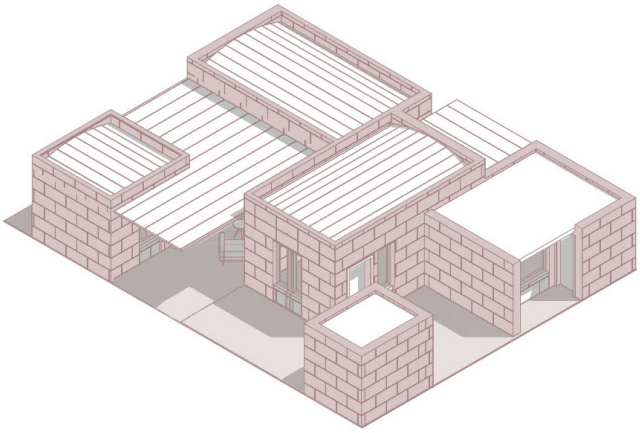
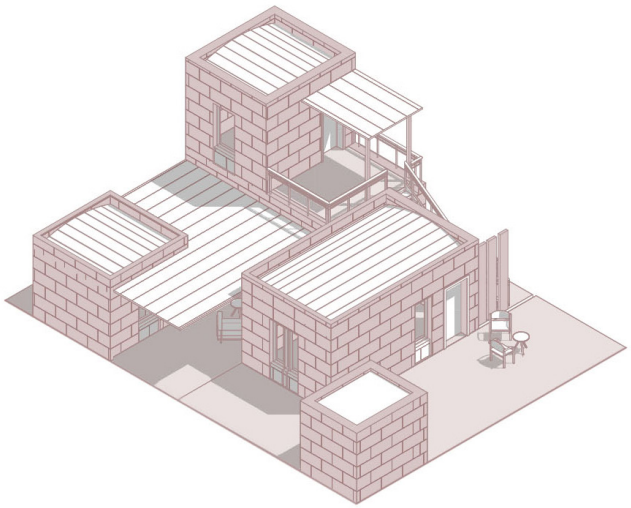


Figure 5.15 Variations of the design in different phases of the project - Author

5.3 RE- SETTLEMENT

Transitioning from temporary shelters to permanent homes, provide long-term stability and improved living conditions. Having permanent homes is essential community building, allowing for the creation of cohesive social bonds and support networks. It also supports financial stability for the displaced people though helping them to find jobs, create their own businesses and engaging in other income-generating activities so they can



transition from relaying on aid to be self-reliant. In planned resettlement, education, sanitation and health services can be incorporated to improve the communal well-being and the quality of life or the affected population, in addition to the psychological advantages by offering a sense of security and normalcy after displacement. Furthermore, long-term permanent settlement can be established with enhanced infrastructural standards and resistance to future disasters.

In summary, permanent resettlement transform the lives of displaced people by providing sustainable living environments to foster economic and social integration, access to essential services and improve overall well-being. By focusing on long-term development and resilience, these settlements offer a comprehensive solution that addresses both immediate and future needs of displaced populations.

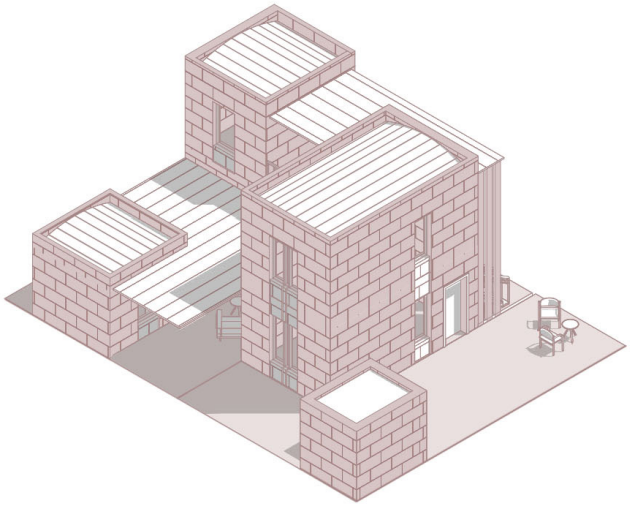


Figure 5.16 Variations of the design in different phases of the project - Author

CHAPTER VI RESULTS AND CONCLUSION

This research was conducted to establish an analytical multidisciplinary framework to consider the humanitarian response in the aftermath of the ongoing conflict in Sudan. In light of the significant displacement crisis and the precedent poor shelter conditions. Ultimately, building on local economic notions to reinforce humanitarian recovery of the internally displaced population, with the objective of contributing to the broader field of humanitarian aid and development to improve the architectural shelter response in conflict-affected regions.

The findings reveal that the security situation in the Sudan remains very frail with clashes spreading all over the country. Consequently, the humanitarian shelter proposed adapts to be implemented around the country with durability in mind, to both withstand harsh weather conditions and cultural appropriateness to accommodate the displaced population to support their future recovery and livelihood. The transitional shelter utilizes locally driven architectural and construction techniques that are simply understood and constructed by the affected population themselves which additionally strengthen the community bonds and activities between the displaced populations.

Considering the big scale of the unforeseen war in Sudan and the sheer number of displacements, the theoretical implications of this research suggest that a multidisciplinary approach with focused research on each particular body of humanitarian aid should work efficiently together in helping the displaced population. Additionally, a more practical implications indicate that inclusion of the various stakeholders such as international and national organization, governmental bodies, experts, and the affected population can ensure a proactive solution to the humanitarian crisis.

The limited access to local and national scholarly research has hindered comprehensive data collection and analysis. Additionally, the dynamics of the clashes were challenging to anticipate with constant changes in displacement patterns and the number of displaced people significantly increased from the beginning of the research until the final results. Despite these constraints, the study provides valuable insights into the evolving situation and underscores the urgent need for adaptable and sustainable

humanitarian interventions. Future research should focus on enhancing access to local data and continuously updating displacement trends to better inform response strategies.

Humanitarian shelter response is a critical component of the overall humanitarian aid effort, but it is not the sole aspect. As an architecture scholar, research on this topic encompasses not only the design and construction of shelters but also the broader implications for community resilience, cultural sensitivity, and sustainability. It involves examining how architectural practices can contribute to creating safe, durable, and adaptable living spaces for displaced populations. Furthermore, it is essential to consider how these shelters can be integrated into the local context, utilizing available resources and traditional building techniques.

Since April 15th, 2023, the people of Sudan have found themselves trapped in a war they do not claim, and the lives of all Sudanese beings have been in despair ever since. Many of whom had lost loved ones, many separated from their families, millions have abandoned their homes and he majority of the Sudanese people have lost a place where they belong. 11 million displaced people and many more who are predicted to be displaced have lost all sense of security and live in a constant migration journey.

The Sudanese people have persistently documented and voiced the dire conditions of those who are still forcibly living in war-torn Khartoum, El-fashir, Aj Gazira, and many more, the terrible conditions of the people trapped at closed borders, the displaced who are now on their second and third displacement journey. The lives of Sudanese people appear to be collateral damage in a proxy war between two generals, a conflict that is targeted towards unarmed, defenceless civilians who bear no responsibility in such an outrageous war. Given the massive crisis, regional and international interventions have been substantial. However, regardless of whether the war proceeds to continue in the coming years, the Sudanese people are entitled to a dignified existence, with better living conditions and a better chance at life to resist the harsh years ahead.

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