# Holistic Transitional Approach of Humanitarian Shelters Through The Implementation of Adaptable Design Strategies.

# منهجية التحول الشاملة لسكن المهجرين من خلال تطبيق استراتيجيات التصميم المتجاوب


**By**

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# Abstract

The issue of forcibly displaced portions of a population has become an emerging global trend that is driven by significantly increased numbers of displaced people. This is caused by increases in natural disasters due to global warming, war, and other conflicts. It is also driven by the growing average displacement time (ADT) due to a decline in the durable solutions available due to widespread insecurity, ongoing conflicts, small numbers being accepted for population resettlement, and the struggle of host communities in the integration of displaced populations. In addition to this, the most recent movement restrictions and the suspension of some solution programmes due to the COVID 19 pandemic, coupled with poor performance of provided sheltering solutions, ineffective humanitarian response, and recovery delays, exasperated the effect it has had on the displaced population, host communities, and their environment.

Whilst the aim of international community to provide some relief in this area is not new, there has been renewed efforts to try to link relief to recovery in an effort to provide more durable solutions and sustainable development. The models that have been suggested and which have evolved over time in order to address this aim include Build Back Better, LRRD (linking relief, rehabilitation and development), and the concept of Early Recovery. However, many researchers have identified a gap between the international aim to effective transition, and the inefficient implementation in reality, as the process tends to divide the humanitarian response into separate stages due to the different nature, tools, and aims of each stage. Moreover, rigid solutions lack the required adaptable capacity to allow a smooth transit to recovery and sustainable development. This causes multiple and repeatable humanitarian efforts and results in increased waste, costs and time. This escalates the unwelcomed results and environmental impacts and fails in achieving population recovery, community resilience and self-reliance.

Therefore, this research has investigated the alternative Humanitarian Sheltering Response (HSR) approaches and solutions. The overall aim is to provide recommendations that would lead to an increase in the adaptable capacity of the sheltering solutions and enhance the transition capability of the HSR.

A literature review has been conducted which discusses the provision of adequate shelter as a human right, and specifies the adequacy means, the terminologies of the different sheltering solutions, and the different approaches of response. Additionally, it identifies the characteristics of adaptable design strategies (ADS) for adaptable shelters, and its correlated principle panels.

Furthermore, an extensive review has been carried out on more than 43 projects, case studies, and solutions , both existing and novel, from a variety of trusted resources such as the UNHCR (United Nations High Commissioner for Refugees) and IFRC (The International Federation of Red Cross and Red Crescent Societies) reports, global shelter clusters, shelter projects, and shelter centers. All of these different climate conditions, response stages, vulnerability levels and crisis types. This was done in order initiate a reliable and holistic case study to avoid obtaining biased results. The reviewed case studies have been categorised according to the type/nature of the solutions and the specified solutions terminologies.

The categorised solutions have been evaluated using a pros and cons list for each category as a logical decision-making tool against the specified evaluation themes that are specified in the literature review. They were then compared to each other using a strength and weakness comparison table.

The table shows that there is no single sheltering solution that can be considered appropriate for the whole life span of the displacement and shows a clear difference in the strengths and weaknesses of the response between global and local solutions. Global solutions are more likely to be suitable for the relief aim of a response and local solutions are more likely to be suitable in achieving the aim of early recovery and sustainable development. This result highlights the importance of a transitional approach in providing more adaptable sheltering solutions.

As a result, further investigation was carried out to identify the potential transition enablers of adaptable shelters from the reviewed case studies. As a direct result of this, ERD (Entity relationships diagrams) was used as a data analysis tool which uses a logical hierarchy flow chart to graphically represent how entities relate to each other. This helps to determine their potential role in the transitional process. Thirteen ERDs have been created that present two different types of transition - hybrid transition and integrated transition. It also identifies the self-supported BUR (Build, upgrade, and repair) as a key transition enabler. In addition to this, extended lifespan, liable structure, technical ease, LAMs (locally available materials), and local building skills and training are identified as core enablers and additional enablers that help to expand the adaptable capacity of the shelters as the following: Ease of dismantled & reassemble, transportable, expandable designs, and the integration of the renewables & passive strategies. Additionally, a further 28 sub-enablers have been identified.

Based on that, an integrated aim model (IRRD Model) of relief, early recovery, and sustainable development has been proposed and visualised. The model shows that all stages are related to each other and allows for the understanding that each stage of response is part of the other stages, all whilst focusing on the purpose of each stage. It also prepares the groundwork for the purpose of other stages. Additionally, it does consider the potential for alteration in the process due to the varied people and circumstances and defines the targets for vulnerability reduction, adequacy enhancements and self-reliance strengthening through the transition process.

This integrated aim requires a transitional approach (hybrid and/or integrated) with adaptable sheltering solutions and its ADS characteristics to maximise the adaptable capacity of the proposed sheltering solutions to the status of transition and use the transition enablers to facilitate the smooth transition of the adaptable shelter solutions within the proposed holistic approach of HSR.

# ملخص البحث


إن مشكلة النزوح القسري (التهجير) قد تحولت إلى مشكلة عالمية وذلك لأسباب عدة ، أولها الإزدياد الكبير في أعداد النازحين الناتج عن الإزدياد في تواتر الكوارث الطبيعية بسبب الإحتباس الحراري وانتشار الصراعات والحروب. وثانيها تنامي متوسط المدة الزمنية لحالة النزوح القسري لدى المهجرين نتيجة لتناقص وغياب الحلول الناجعة نظرا لانخفاض عوامل الأمان وتوسع رقعة الصراعات ومعاناة المجتمعات المستضيفة في دمج هؤلاء المهجرين ويزيد على ما سبق صعوبات التنقل المطبقة مؤخرا و تعليق بعض الحلول بسبب جائحة كورونا بالإضافة إلى الحالات الموثقة التي تعكس سوء الأداء لحلول الإسكان الموفرة للنازحين قسريا (المهجرين) والإستجابة الإنسانية الغير فعالة مما يؤدي إلى تأخر التعافي وتضخم تأثير الإنعكاسات السلبية على كل من المهجرين والمجتمعات المستضيفة والبيئة المحيطة بهم.

إن محاولات المجتمع الدولي لربط العمل الإغاثي بالحلول الناجعة والتنمية المستدامة عبر تعافي المجتمعات النازحة قسريا (المهجرين) ليس بمسعى جديد حيث أنه تم طرح العديد من المقترحات مسبقا ومحاولة تطويرها مع مرور الوقت بهدف تحقيق هذا الربط مثل مقترح إعادة البناء بصورة أفضل و نموذج ربط الإغاثة بإعادة التأهيل والتنمية المستدامة بالإضافة إلى مقترح التعافي المبكر ولكن العديد من الباحثين أكدو على وجود فجوة بين هذه المساعي العالمية لتحقيق الربط والانتقال الفعال وبين حالة التطبيق الغير فعالة في الواقع، حيث أن آلية التطبيق تميل إلى تقسيم الإستجابة الإنسانية إلى عدة مراحل منفصلة عن بعضها تبعا لاختلاف طبيعة وأدوات و أهداف كل مرحلة ، ونظرا لغياب أو نقص المرونة اللازمة في الحلول المقترحة فإن التحول السلس إلى حالة التعافي والتنمية المستدامة أصبح صعبا. هذه الفجوة بين ما هو مرجو و ما يتم على أرض الواقع يؤدي إلى تكرار طلب المساعدات الإنسانية المتعددة مما يسبب عدم فعالية الإستجابة وازدياد نسبة الهدر وارتفاع التكاليف وإطالة المدة ، الأمر الذي يزيد من التأثيرات البيئية ويؤدي إلى الفشل في وصول مجتمع المهجرين إلى حالة التعافي والفشل أيضا في القدرة على الصمود والإعتماد على الذات.

وعليه فإن هذا البحث ينظر إلى الحلول والمساعي البديلة في الإستجابة الإنسانية لإيواء النازحين قسريا ويسعى لوضع توصيات لغرض رفع درجة التجاوب/التكيف الخاصة بالحلول المقترحة وذلك لتحسين قدرة هذه الحلول لإحداث تغييرات مرغوب بها.

وعليه تمت مراجعة أدبيات هذا الموضوع، والتي ناقشت حقوق الإنسان في السكن الملائم، وعلى رأسها مجتمعات النازحين قسريا (المهجرين) وتمت مناقشة صفات السكن الملائم واستعراض المصطلحات التعريفية التي تتناول أنواع

الحلول المختلفة لإيواء النازحين وطرق الإستجابة الملائمة ، إضافة إلى ذلك تم تحديد خصائص استراتيجيات التصميم المتجاوب وذلك لغرض الوصول إلى حلول مرنة لمساكن المهجرين.

وإضافة لذلك تمت مراجعة ما يزيد عن 43 دراسات حالة ومشاريع قائمة أو مقترحة وذلك من خلال العودة إلى ما وثق عنها في مراجع تعود إلى جهات موثوقة مثل مفوضية اللاجئين والاتحاد الدولي لجمعيات الصليب الأحمر والهلال الأحمر والكتلة العالمية للمأوى (مشاريع المأوى). هذه المشاريع أختيرت للمراجعة لغرض تغطية عدة ظروف متباينة من حيث نوع الكارثة و المناخ ومرحلة الاستجابة ودرجة الخطورة وذلك لهدف بناء قاعدة معلومات موثوقة و واسعة تسمح باستخراج نتائج أكثر توازنا وتتجنب الإنحياز. وكخطوة أولى تم تصنيف هذه الحالات الدراسية تبعا لطبيعة ونوع الحل المقترح ووفقا للمصطلحات التعريفية التي تم تحديدها في المراجعة الأدبية.

وبعدها تم البدء بتقييم الحلول المصنفة وذلك عن طريق إعداد جداول المقارنة و التي تحتوي على الإيجابيات والسلبيات لكل صنف من أصناف الحلول المحددة لتشكل تلك الجداول أداة مساعدة في اتخاذ القرار بصورة منطقية وذلك عند مقارنة الحل موضوع النقاش مع موضوع التقييم ذو العلاقة وذلك لتحديد قوة الحل من عدمه في إطار موضوع التقييم المحدد ومن ثم تم جمع هذه النتائج في جدول لتفعيل إمكانية المقارنة بين الحلول المختلفة

أظهر جدول المقارنة بأنه لا يوجد حل إسكان معين يمكن اعتباره مناسبا لكامل فترة النزوح ، كما أظهر أيضا اختلاف واضح بين نقاط القوة ونقاط الضعف الخاصة بكل من الحلول ، المحلية و العالمية، بحيث ظهر بأن الأخيرة قد تكون أنسب لاستجابات الإغاثة غير ان الحلول المحلية قد تكون أنسب لغرض التعافي المبكر والتنمية المستدامة، الأمر الذي يؤكد على أهمية المنهج التحولي في الاستجابة من خلال حلول الاسكان المتجاوبة ، بمعنى آخر، تسلط هذه النتيجة الضوء على أهمية النهج التحولي لحلول إيواء أكثر قابلية للتكيف.

وعليه تم عقد المزيد من البحث لغرض تحديد العوامل/الممكنات المحتملة و التي تسهل من تحول مساكن اللاجئين الى مساكن متجاوبة/ قابلة للتكيف حيث تم استخراج هذه العوامل من المشاريع والحلول التي تم مراجعتها وذلك عن طريق إعداد مخططات للعلاقات بين العناصر المحددة واستخدام مخططات العلاقات هذه كأداة لتحليل البيانات وذلك عن طريق بناء العلاقات في إطار التدفق الهرمي المنطقي الأمر الذي ساعد على إظهار بشكل بياني لكيفية ارتباط تلك العناصر المستخرجة مع بعضها البعض مما مكن أيضا من تحديد دورهم المحتمل في آلية التحول المطلوبة.

وعليه تم إعداد 13 مخطط علاقات والتي أظهرت نوعين أساسيين من التحول و هما التحول المختلط والتحول المدمج وأدت هذه المخططات إلى تحديد منهجية دعم الإنشاء و التحديث والإصلاح الذاتي للمسكن كآلية مفتاحية لتمكين الحالة الإنتقالية/التحولية للأفراد والمجتمعات المهجرة كما وتم تحديد كلا من إطالة العمر التشغيلي والهيكل الإنشائي المتجاوب و السهولة التقنية و توافر المواد محليا ومهارات البناء المحلية و التدريب كممكنات/عوامل جوهرية لتمكين الحالة التحولية للأفراد والمجتمعات المهجرة بالإضافة لممكنات أخرى تساهم في تعزيز عامل التجاوب/التكيف في مساكن المهجرين وهي كالتالي سهولة الفك والتركيب و التصاميم القابلة للتوسعة و النقل ودمج الطاقات المتجددة واستراتيجيات التصميم السلبي (أي ذاتي الكسب) وهذا وقد تم تحديد 28 ممكنات/عوامل فرعية آخرى إضافية.

وبناء على ما سبق تم اقتراح و تصور نموذج استجابة ذو مسعى مدمج من اهداف ثلاثة ألا وهي الإغاثة والتعافي المبكر والتنمية المستدامة. يظهر هذا النموذج المراحل المختلفة للاستجابة وكأنها محتواة في بعضها البعض كما يوضح النموذج أيضا أن كل مرحلة من مراحل الإستجابة هي جزء لا يتجزأ من المراحل الأخرى بحيث وأنه خلال السعي لإنجاز هدف المرحلة الحالية فإنه أيضا يؤسس لتحقيق أهداف المراحل اللاحقة كما وأن النموذج يأخذ في الاعتبار إمكانية التغيير في العملية تبعا للأشخاص والمجتمعات والظروف ذات الصلة كما وأنه يحدد مجموعة من الأهداف كمسعى دائم لآلية التحول وهي تخفيض مستوى الخطر و تحسين الملاءمة و تقوية الإعتماد على الذات.

أن نموذج الاستجابة هذا ، ذو المسعى المدمج، يتطلب اعتماد منهج تحولي (مختلط أو مدمج) مع حلول سكن متجاوبة تحمل من المرونة ما يمكنها من التجاوب مع حالة الانتقال (أو التحول) من حالة إلى أخرى ومن مرحلة إلى أخرى وإن ممكنات/عوامل هذا التحول تساعد على ضمان سهولة التحول ضمن المنهجية الشاملة للاستجابة الإنسانية لسكن المهجرين.

## Dedication

To all of those who are forcibly displaced.

وَالَّذِينَ هَاجَرُوا فِي اللَّهِ مِن بَعْدِ مَا ظُلِمُوا لَنُبَوِّئَنَّهُمْ فِي الدُّنْيَا حَسَنَةً ۖ وَلَأَجْرُ الْآخِرَةِ أَكْبَرُ ۚ لَوْ كَانُوا يَعْلَمُونَ. سورة النحل ﴿41﴾

صدق الله العظيم.

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Thanks to Dr.Wael Sheta for the support and Guidance in supervising this Dissertation.

Thanks to my Mother for her prayer for me and sowing the seeds of goodness.

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Thanks to my brother and my two sisters for their containment and understanding.

Thanks to my friends for their positivity and encouragement.

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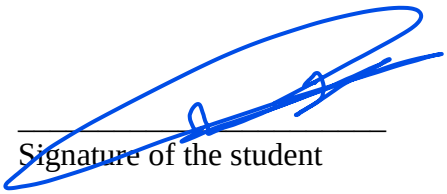

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# Abbreviations

**UNHCR**: United Nations High Commissioner for Refugees, known as UN refugee agency.

**OHCHR**: Office of United Nations High Commissioners of Human Rights

**UNDP**: United Nations Development Programe

**IFRC**: The International Federation of Red Cross and Red Crescent Societies

**IDPs**: Internally displaced population.

**FDP**: forcibly displaced population.

**PDPC**: Post Disaster / Post Conflict.

**HSR**: Humanitarian Sheltering Response.

**DHSS**: Divers Humanitarian Shelter Solutions

**LRRD**: Linking Relief, Rehabilitation, Development

**IRRD**: Integrated Relief, Early-Recovery, Sustainable Development

**ADS**: Adaptable Design Strategies

**HDPE**: High-density Polyethylene fibre

**LAM**: locally Available Material

**ICEB**: Interlocking Compressed Earth Blocks

**USAID**: The United States Agency for International Development

**LOG**: Lari Octa green shelter

**NFIs**: None food Items

**CSEB**: Compressed Stabilised Earth Block

**IOM**: The International Organization for Migration

**SSBs**: Stabilized Soil blocks.

**PDPC**: post-disaster / post-conflict

**ADT**: average displacement time

# 1. Chapter 1: Introduction

Sudden events such as conflict or crises caused by natural causes or other causes like war, conflict, persecution, violence, and human rights violation. could affect the public order and cause sudden displacement. This affected population requires urgent relief assistance, such as providing shelter, food, water, hygiene, and medical aid. The shelter is an essential need for humans that provides protection, and privacy and enables the required daily activity. Therefore, it can be said that humanitarian shelter assistance and settlements are necessary as lifesaving measures as well as a life recovery enabler.

## 1.1. An overview of the current situation

In the last ten years, this trend had become an emerging global issue driven by the significant increase in the numbers of forcibly displaced people (FDP) caused by an increase in natural crises due to global warming in addition to war, conflicts, and several major crises. UNHCR (2020b) reported in mid-2020 the global number of forcibly displaced people (FDP) had exceeded 80 Million which is considered the highest reported data ever. Interestingly the proportion of FDP of the world population continues to raise as 1 of every97 people is now forcibly displaced compared to 1:159 in 2010. (NHCR, (2019b), also estimated that in the year 2019 37.8 million new people lost their homes, which means that a new family lost their home every 5 seconds throughout the year. (global shelter cluster, 2020). In addition to that, a lot of displaced populations failed to find a reliable solution to start again. In 2019 Philippo Grandi the UN High Commissioner for Refugees reported that:

"We are witnessing a changed reality in that forced displacement nowadays is not only vastly more widespread but is simply no longer a short-term and temporary phenomenon"

Usually, the provision for shelters and settlements response for post-disaster / post-conflict (PDPC) tends to be an emergency response with temporary means in order to provide urgent protection, privacy, and other basic services which are limited by factors such as time, cost, available resources, and expertise. However, the PDPC shelter response can save lives in the initial stage after crises, but the average displacement time (ADT) has continued to increase at times reaching decades of displacement. This is the situation in many refugee camps today, such as the Kakuma refugee camp in Kenya which was established in 1992 and has reached 188,794 displaced population (DP) as of the 12 May 2019 (UNHCR, 2019). This means that the lifespan of the camp is 18 years as of the time of this study. Another example is the Zaatari camp in Jordan, which was established in 2012 and now in 2021, it is home to 78,000 Syrian refugees (UNHCR, 2020a). This camp has had a lifespan of 9 years to this day. So, why are ADT getting longer?

In order to improve the displacement situation of an affected population more durable solutions should be sought such as reconstruction, resettlement, and reintegration. But nowadays, durable solutions for refugees have declined in the last 10 years as only half per cent of them are resettled, and 2 per cent are repatriated as reported by UNHCR global trends 2019 (UNHCR, 2020c). Also, UNHCR trends in their mid-year report of 2020 (UNHCR, 2020b) showed increasing difficulties in achieving durable solutions for the forcibly displaced population, driven by the widespread insecurity, ongoing conflicts, the small number of accepted populations for resettlement, and the struggle of host countries in the integration of the displaced population. In addition to the most recent movement restrictions and the suspension of some solution programmes due to the COVID 19 pandemic, these circumstances caused an increasing number of FDP.

**"Long-lasting displacement situation with little hope of durable solution"**.

(UNHCR, 2020b)

On the other hand, many research papers have addressed the poor performance of the PDPC shelter response in different aspects including health and comfort of the occupants such as indoor environmental quality, thermal comfort, and poor waste disposal. Also addressed are the environmental impacts, energy consumption, and its equivalent CO2 emissions, in addition to the cultural, privacy, safety, and security issues. But, people after crises are naturally aiming to recover, and seek safer and better situations, which means after crises people are in a transition process to recover. If the

humanitarian assistance does not respond to the need for the transition process this will cause a frustrated population. However, long-term displacement with poor performing shelters with the declined potential of durable/permanent solutions will escalate health and environmental impacts and eventually increase the affected population's vulnerability, which risks the failure of the recovery of the affected population.

In addition to that, different types of organisations including the UNHCR, UN-Habitat, OHCHR, the Sphere Project, and others have declared the right to adequate shelter for the displaced population under the protection of international law. With this in mind the aim of delivering adequate shelters to the displaced population should be prioritized, so shelters should not be erected in only emergency aim as a lifesaving measure but also should allow for the transition toward adequacy. Therefore, the recovery assistance should be carried out during the process of the humanitarian response with a provision for adaptability. This allows organisations to respond to the different needs of the population in order to transform to adequacy, instead of waiting until a durable solution is available.

### 1.2. Problem Statement

This is not a new aim that the international community is trying to achieve by linking relief to recovery towards more durable solutions and sustainable development. and Models have been suggested and evolved over time in order to address this aim such as Build Back Better, LRRD (linking relief, rehabilitation and development), in addition to the concept of early recovery. Disconnectivity between emergency relief and the recovery process will increase the cost and time to recover, also rigid solutions and approaches are not dynamic enough to respond to the different needs of the different families and individuals. This will eventually cause the failure of achieving adequate shelters. Many researchers such as Ramet (2012) and Wagemann and Moris (2018) have identified a gap between the international aim for effective transition and the inefficient implementation in reality, as the process tends to divide the humanitarian response into separate stages which are rigid and do not have enough flexibility or adaptability. This causes multiple and repeatable humanitarian assistance due to the resulted increased waste, cost and time instead of allowing for incremental development that converts with a relatively short period of time into a self-sufficient process with little support. This gap between implementation and the international aim raises questions about:

- What if these shelters and settlements were established not only in emergency aim but as a new opportunity?
- How can we link emergency response with recovery and sustainable development?
- What are the sheltering solutions that are reliable and could enable an effective transition to achieve adequate shelters and link the relief with recovery and beyond?

### 1.3. Aims and Objectives

The aforementioned introduction highlights the need for more investigation into effective and efficient approaches, applications, and solutions that are flexible and adaptable enough to ease the transition toward adequate shelter and successful recovery. Therefore, this paper is assisting in the filling of this gap by investigating the characteristics of Adaptable design strategies (ADS) to maximize the adaptable capacity of the sheltering solutions and the potential transition enablers that could facilitate the transition of the Forcibly displaced population (FDP) toward adequacy and its correlated livability enhancement. Another aim to be addressed is the possibility of successful HSR transitions from relief to recovery and the initiation of sustainable response and development.

### 1.4. The Motivation of The Research

In 2011 the revolution of freedom and dignity started in Syria, which has been faced by controlled power that caused widespread long-lasting clashes, resulting in the largest forced displacement crisis in the world in decades. UNHCR reported a total number of 13.6 million registered forcibly displaced Syrians, which accounts for more than half of the total population of Syria. Currently ten years after the start of the crisis, the situation is more or less the same where conditions are not safe or dignified, and only 279,684 have returned to sustainable conditions (voluntary returners), as reported by the UNHCR between 2016 and 2021 (UNHCR, 2021a). Companies with a limited number of resettlement places reduced in 2016 by more than 50% in contrast with the increased number of refugees, especially

in 2017. On the other hand, a huge portion of the Syrian displaced population, which is almost 93% of them resides within host communities in urban areas and only 7% of them are in camps (3RP, 2021). This leads the UNHCR to support the self-reliance approach as a durable solution instead of the aim of reconstruction (UNHCR, 2021a). But as the crisis continues, in addition to the pandemic impact and the increased spread of poverty, UNHCR has described the situation today which is 10 years after the crisis started as an emergency.

The UNCHCR (2021c) reports that 'every day is an emergency for Syrians to flee' which decreases the hope of achieving durable solutions and show the potential of recovery failure. This carries the humanitarian efforts back to 'square one' which means that in addition to the unwelcomed impacts on the displaced population that are still in a vulnerable situation, even after a long period of time, further cost, time, and effort are still required. As a result, a call was raised by Filippo Grandi, UNHCR High Commissioner, on the12 March 2021 where he said:

"The gravity of this crisis must not weaken our solidarity for Syrians. On the contrary, we must redouble our collective effort to support both refugees and the communities hosting them. "

(UNHCR, 2021b).

Supporting self-reliance and seeking an increased number of accepted resettlement plans are good in helping a wide range of the displaced population. However, when looking at the population in both planned and unplanned camps and after 10 years of displacement are still living in tents or poor performance shelters with poor waste management, limited access to a livelihood – this indicates a continued problem, which resulted in almost yearly repeated calls for winterization, shelters maintenance and enhancement. This is an indicator of the failure in the approach of delivering adequate shelters to the displaced population no matter how long they remain in place.

However, it is not only about Syria, as the world today is witnessing an increased number of crises that causes widespread displacement throughout the world, such as Ethiopia Tigray, DR Congo, Nigeria, Sahel, Yemen, Burundi, Central America, Rohinga, South Sudan, Venezuela and the most recent crises in Ukraine.

With this in mind, this investigation aims to reduce the potential of failure of post crises recovery caused by rigid solutions that are not flexible enough to respond to the diverse and dynamic needs of the displaced population. This would be done by investigating more flexible and adaptable solutions, designs, and approaches in humanitarian shelter response that allows for evolving and ongoing transition to adequacy even though there are conditions of unsolved land tenure or lack of resources. This would ensure a greater success rate in the delivery of adequate shelters to the displaced population.

### 1.5. The importance of the research topic

An overview of the conducted research and papers highlighted the significant importance of digging deep into the alternative approaches and design strategies to humanitarian sheltering in order to reverse or at least mitigate the escalated impacts on the DP (displaced population) and the environment. In newly conducted research by Opdyke, Goldwyn and Javernick-Will, (2021) priorities deeper investigation into the topics of transitioning to recovery and self-recovery. Furthermore, this investigation could contribute to the risk reduction of the FDP and help in facilitating a continuous transition to a less vulnerable situation as they survive the crises. Also, it could help in the aim of humanitarian shelter performance enhancement and mitigate the unwelcome result on occupants and the environment. Additionally, it could contribute to the aim of linking the humanitarian response with sustainable development which provides hope and potential for a better future that could accelerate the recovery of the affected population. Most importantly, it is promoting more realistic targets of adequacy that could overcome the problems related to the current low potential of achieving durable solutions. Investigating adaptable shelters solutions does not only contribute to solving the displacement population issue but also has the potential to help in providing more adequate solutions to a wider range of population categories such as homeless, youth housing, lack of affordable houses and seasonal sheltering needs.

# 2. Chapter 2: Literature review

## 2.1. Overview

Much of the published research discusses the performance of the PDPC shelters for displaced people, and reports on the poor performance of the humanitarian shelters especially emergency and temporary shelters. The literature shows many potential enhancements, some focus on the quantitative qualities such as the indoor air quality and thermal comfort including its energy consumption and the related greenhouse gas emissions, whilst others address more qualitative qualities such as dignity, security, safety, and other socio-cultural aspects. Parts of the reviewed research also address aspects that are both quantitative and qualitative in nature in accordance with the aim of the research.

So, one of the critical aspects in conducting an emergency humanitarian sheltering is the constraints of both time and cost which is critical to meet the urgent needs of the population in a cost-effective solution.

A recent study (Salta *et al.*, 2020) examined the integration of advanced technologies and optimization tools as a solution to supply the sudden demand for emergency shelters, and discussed the possibilities of digital fabrication to achieve fewer costs and delivery time while providing better-performing emergency shelters with a more cost-effective production method. Hence, the paper proposes a generative investigation for an emergency shelter design and defines the most suitable shelter morphology in particular geolocation, then employs an algorithm of topological material distribution for the customization of the static behaviour, and optimises the cost and time of large-scale 3D printing. In addition to changing the shape and performance of the structures, these advanced methods change the process of designing the structures as well. So instead of proposing a universal shelter design for any situation, this paper suggests providing a component library that allows the generative design algorithm to calculate the customised design depending on the input parameters, such as location. Furthermore, the inadequate performance of the existing temporary shelters in terms of occupant health and comfort was a key issue in many of the research papers reported.

Another study (Yu *et al.*, 2016) compared the thermal performance of various existing temporary shelters in various locations after the Wenchuan earthquake in 2008 and the Lushan earthquake in 2013 in order to improve the comfort of the transitional shelters for displaced people in natural disasters. According to the study, the relative humidity in an occupied shelter is always much greater than in an empty one by 6 to 9 percent. The in-house shelter is also 3 to 4 degrees celsius higher than the outdoor one, and an empty shelter is only 2 degrees higher than the outdoor one, which reflects the need for heaters in shelters during the cold seasons and reflects how these shelters are thermally uncomfortable due to poor thermal performance. Due to inadequate thermal performance in existing shelters, three different prototype shelters were produced with different insulation materials. The experiment revealed that the model with corrugated roof sheets tends to have the highest indoor temperatures with the biggest temperature fluctuations. However, the fibreglass cement roof has the highest temperature stability. Also, Asfour (2019) evaluated a proposed conceptual shelter design using shipping containers. The study shows that it is quite difficult without well-studied insulated envelopes to achieve a sufficient level of comfort when occupying such a shelter.

Wagemann and Moris (2018) Discussed the term habitability as representing the suitableness of shelters for human living that depends on shelter characteristics such as design, materials, and comfort and shows that these standards will vary depending on the socio-economic situation in different locations. Several studies have been conducted in order to discuss the potential enhancements results through the use of different approaches or different materials.

Ameen (2017) evaluated the appropriateness of sustainable shelter upgrading strategies in the Domiz refugee camp in Iraq and recommend implementing on-site materials that are both affordable and available. The study also highlighted the importance of both culture-related design and thermal comfort of the camp occupants and proposed a new "improvementary shelter" or "incremental home", based on the process of updating shelters in four phases. A smooth transition took place from management to occupants, which enables self-decision making. The phases began with cluster design and orientation

optimisation, resulting in durable shelters that provide protection against weather conditions such as wind and rain, and then progressed to a more advanced phase, focused on envelope performance enhancement and ending with the integration of passive strategies for heating and cooling. Researchers conclude that hybrid passive strategies offer the easiest and most effective way to reduce heating and cooling loads and achieve comfort.

A paper has revealed that some very low-cost materials could serve as effective heat preservation materials, such as cardboard and air-bubbled polythene while weatherproofing could reduce the need for electric power in winter. It examines ways to improve thermal comfort in cold weather by improving the thermal envelope, reducing infiltration, as well as, using renewable energy systems to achieve a comfortable temperature. Analysis of the collected data has been undertaken to identify the most effective and affordable method of providing guidelines and recommendations for post-disaster accommodation in China. (Yu *et al.*, 2016)

Barreca and Tirella (2017) presented a prototype of a temporary shelter made from wood and cork, studied the thermal, acoustic, and fire resistance improvements in terms of thermal insulation, and discussed how flexible and simple assembly could be improved for temporary shelters, as well as discussing alternative uses for temporary shelters other than disaster relief, such as nature tourism shelters and agricultural seasonal shelters for workers, which provide more reusability ideas. During the prototype, there was a shift in heat transfer time of 3 hours and 45 minutes. While the outdoor temperature was 28 degrees celsius, the indoor temperature was 24 degrees celsius, so the results are enough to ensure the occupants of the shelter are comfortable. Through the experiments on alternative solutions, we may be able to prove that temporary shelters can be made better in terms of sustainability and enhance the welfare of occupants using cheap, fast, and easy to assemble renewable resources and materials Additionally, the provision of easily transportable and assembled prototypes, coupled with the size and weight limits minimised the use of heavy equipment.

Asfour (2019) outlined three essential measures to enhance the thermal performance of the building envelopes, being attached shelters to reduce the area of external surfaces, increased insulation, and reducing solar gain. Prior to that, the paper discusses the policies and solutions implemented to provide relief for the displaced Gaza population. This includes residents dwelling in UNRWA schools, renting housing, supplying materials and funding for reconstruction, and providing temporary shelter for a relatively long period of time. This study shows that these solutions for the Gaza population are recommended globally, but their effectiveness is highly dependent on the individual circumstances.

Another research (Wang *et al.*, 2019) recognizes the importance of utilising rapid installation methods of passive indoor thermal performance solutions for the temporary houses of the displaced. Given the widespread problem of indoor thermal control in prefabricated temporary houses, which are occupied for an average of nine years by displaced victims, he conducted an experimental study on the application of phase-changing materials (PCMs) on prefabricated temporary houses (PTHs) for disaster relief to determine its potential improvement of thermal performance in summer and make recommendations on its application to the PTHs for future use. It has been shown that designs that can be installed inside during the day and moved outside at night to recharge from the cooling effect of sky radiation and cooler night air provide the best results. In addition, the numerical study demonstrates that increasing PCM thickness from 0 to 20 mm can improve the results, but there was no noticeable effect when the thickness exceeded 20 mm, as a result, this thickness was recommended as a future standard. Additionally, the study recommends distributing the PCM within the PTH envelope in a balanced manner, as opposed to putting it in specific locations within the envelope.

A number of researchers highlight the short-term sheltering approach, which does not take into account that some people are displaced for extended periods of time.

A paper (Pomponi *et al.*, 2019) addresses the fact that post-conflict and post-disaster (PCPD) shelters have always been assumed to be temporary arrangements regardless of the fact that many of these shelters turn out to be semipermanent arrangements. It uncovers also that sustainability is rarely considered, despite PCPD settlements reaching the size of a medium city in many cases, and when it is, it tends to be either too technical or too social, causing the balance between pillars to be lost. According to the study, the use

of locally developed building techniques and natural materials is a better option for PCPD sheltering from a technical, economic, social, and environmental standpoint.

Another document (Seike *et al.*, 2019) found that the disaster relief act in Japan specifies that the ETH (Emergency Temporary Houses) are typically being used for just two years, but in fact, some displaced people stayed for up to seven years after the great east Japan earthquake.

Asfour (2019) demonstrated that providing emergency shelter for short stays, such as tents, had the problem of making it difficult to remove people from these temporary shelters, as it took more time than anticipated. Thus, the option of providing well designed temporary shelters to be used for a longer period of time with more adequate means of living was more strongly supported by the survey results, whereas those who were not in favour of this option cited previous failures caused by inadequate temporary shelters for a long-term living period. Additionally, some papers point out other quality aspects such as social, privacy, security, and safety.

Another research has used the AHP's (Analytical Hierarchy Process) and shows that solutions that include social factors like local involvement and familiarity with the neighbourhood achieve better performance. (Pomponi *et al.*, 2019)

According to a study that is conducted following the Great East Japan Earthquake of 2011, the impact on both the physical and mental health of displaced people living in temporary shelters over the long run resulted in stressful conditions and low quality of life for those residing in temporary housing in Rikuzentakata. **(Sakisaka *et al.*, 2017)** which emphasises the importance of considering the social aspects when planning for displaced housing. Their findings are based on a cross-sectional investigation of households living in temporary housing in Rikuzentakata. A structured questionnaire revealed that 33% had suffered deteriorating physical and mental health over the previous year, and living conditions were also distressing.

**In addition to this (Asfour, 2019)** stated that among the acquired results collected through a survey, it was found that other factors such as the security of the living area and social satisfaction are valued highly in the provision of a healthier environment and thermal comfort. In addition to this, the possibility of assembling or building units in a short period of time was also valued, as well as the use of local materials and recycling.

The effects of PDPC sheltering on the environment were discussed by others.

Seike *et al.* (2019) Conduct an evaluation of the possible greenhouse gas emissions (GHG) through LCA, provides some information on construction methods and materials selection in relation to the intended usage of time, and consider the fact that some construction methods may have lower GHG emissions than others, depending on the length of time of usage. Furthermore, ETH units will be supplied in large numbers and are intended to be used for a very short period of time (two to five years) compared to conventional houses (30 to 50 years). This short period of time increases the environmental load of ETH production. Thus, an assessment of the GHG emissions of the mass production of ETH should be incorporated into local, national, and international efforts to reduce GHG emissions. Also, Seike *et al.*, (2019) documented a 40% reduction in GHG emissions due to the use of reusable components during the production phase. Meanwhile, in the ETH operation stages GHG emissions were predominantly related to space heating, but construction variations in terms of envelope insulation specifications result in a wide range of GHG emissions. This shows the significance of thermal insulation in the ETH.

However, the results of the overall LCA showed that the longer the operational period is, the greater the contribution heating of the space will have to energy consumption and associated GHG emissions, which will rise from (20 to 50 percent of the total emissions within the first two years of occupancy to around 80 percent of the total emissions by the end of the five-year period. Hence, lightweight reusable construction is the best choice in terms of GHG-e for ETH intended for less than 2 years, while better thermal performance envelopes are preferable for ETH intended for 5 years of use in terms of GHG emissions. Additionally, Seike *et al.*, (2019) demonstrated that some construction methods are associated with high GHG emissions due to waste disposal, such as the recycling of steel sandwich panels. These authors suggest a limited reduction of 10 percent from the emissions by reusing the panels during the initial construction phase.

The reviewed papers mostly reported persistent poor results on health, comfort, social, cultural, and environmental aspects of the conducted E/T (Emergency/Temporary) shelters as a result of the urgent and temporary nature of shelter response. Since companies with long-term occupancy report negative results on occupants, such as unwanted effects on the health, comfort, social, cultural, and environmental aspects of their operations, in order to mitigate these impacts, an enhanced humanitarian shelter response is clearly needed within an affordable budget.

Many of the reviewed papers indicate the potential affordable enhancements through proposing alternative solutions in different aspects such as approaches to humanitarian response, design strategies, structure methods, and materials selection, in addition to the integration of the affected population in the process of response and recovery.

A research paper conducted by Opdyke, Goldwyn and Javernick-Will (2021) aims to categorise, identify and prioritise the research needs in sheltering after a disaster by applying Delphi techniques with a panel of 16 experts who identify and prioritised 96 research needs in six different sections. The paper identifies the top priorities research needs to address such as Supporting (direct and indirect) self-recovery in the category of approaches to sheltering, and participation of the affected population in decision making in the category of shelter and settlement programming. local building practices and adaptation and modification in the category of design and construction of shelter, transition to recovery in the category of understanding impacts and outcomes of shelter, Long term impact of shelter intervention and linking humanitarian response with development in the category of disaster risk reduction and humanitarian response, in addition to the urban environment in the category of challenging contexts and topics. Interestingly, the most important topic that has been identified is transitioning to recovery and then the topic of supporting indirect self-recovery both having the highest consensus of any other identified topics in the mentioned study.

### 2.2. The importance of shelter assistance after crises

Shelters are an essential need for humans as it provides them with protection, and privacy and enable their daily activity. For a displaced population, the need for shelters is urgent as a life-saving measure in addition to water, sanitation, food and healthcare. Sheltering response is important in order for them to recover after the crises and re-establish their life activity and livelihood.

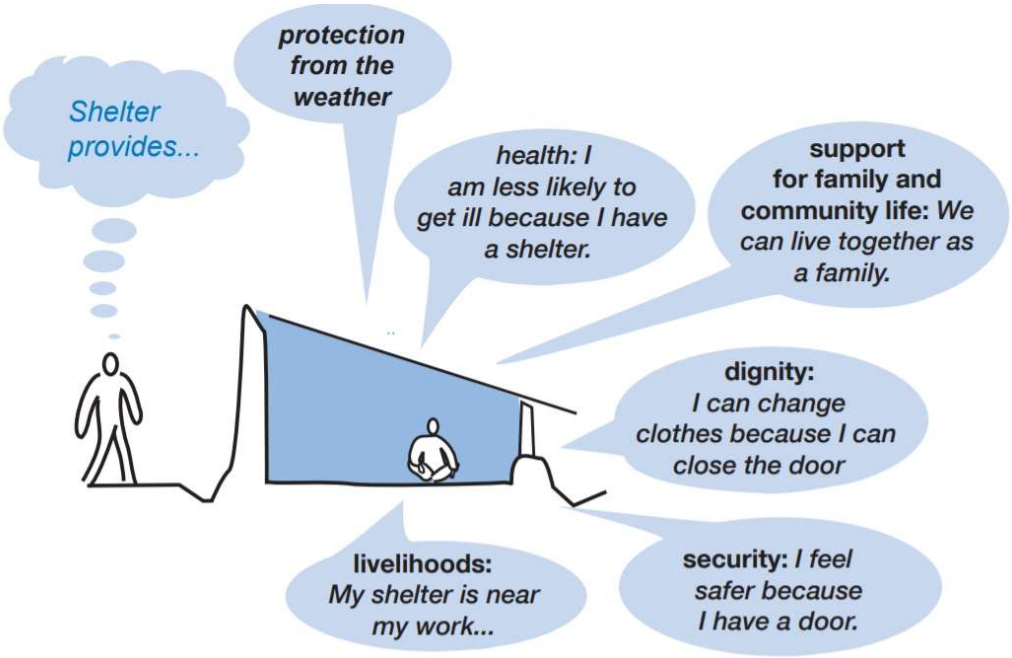



**Figure 2.2-1.** Some of the essential human needs that sheltering aim to provide.visualized by **(IFRC, 2009)**

United Nations (2004) defines a shelter as a habitable, covered, living space, and the Sphere Handbook Sphere (2018) specifies 6 initial needs, that the shelter will provide as being the following; protection from the weather, promotion of health, privacy and dignity, safety and security, support of family and community life, and provides access to a livelihood. Also, United Nations (2004) defines sheltering as the continuous process of providing shelter, which involves providing support, monitoring, and non-food items.

Therefore, sheltering is an important component of humanitarian response, however, it is one of the most difficult components to deliver, as shelters by its nature are costly and require time, power, resources, and expertise to be erected. Additionally to build a shelter is one thing, but delivering a proper adequate shelter is hugely challenging as it requires more attention to the different needs of the affected population and to address culturally appropriate solutions affordably and with limited resources. These factors need to be met in order to deliver acceptable shelters that perform well and enable the recovery of the already affected population by the crises.

Sphere (2018) considers it as an essential human need to ensure dignity, protection, security, and a safe living environment. And IFRC indicated, "shelter is about human dignity, safety, and privacy." It also highlights the role of the sheltering process in addressing vulnerability reduction and building community resilience. (IFRC, 2021)

In summary, the sheltering process is important as a life-saving measure, life enabler, recovery enabler, and building community resilience.

### 2.3. Adequate Shelter as a Human Right

The Sphere Project was created by a group of humanitarian organisations including the Red Cross and Red Crescent movement and in its handbook (2018 edition) (Sphere, 2018) declares that everybody has the right to adequate shelter under the protection of international law. This law had been enacted in Article 25.1 of the Universal Declaration of Human Rights in 1948, which considers the right to adequate housing as part of the human right to an adequate standard of living. Also, this right has been adopted in 1966 by the International Covenant on Economic, Social and Cultural Rights (ICESCR) in Article 11.1 including the right of continuous improvement of living conditions. (ICESCR, 1966), then elaborated on this in their Committee on Economic, Social and Cultural Rights (CESCR general comments No.4 in 1991 and CESCR General Comment no.7 in 1997. This is further corroborated in CESCR (1991) and United Nations (1997). were the the High Commissioner of human rights in the fact sheet no. 21. Rev1 (UN-Habitat and OHCHR, 2014) declared that adequate housing is the right to live somewhere in security, peace and dignity. It clarifies that in order for the house to be deemed adequate it should meet the minimum adequacy elements as stipulated by the following ,security of tenure, services availability, affordability, habitability, accessibility, location, and cultural adequacy.

With this in mind some questions comet to the forefront - What are adequate shelters? And as humanitarian response tends to be an emergency especially in the early response post crises, Is adequate shelter as a human right should be addressed in the post crisis affected populations? And if yes, how can adequacy be addressed for the displaced population?.

The housing and land right network in New Delhi (Hlrn, 2021) declared that it is not only the desired goal to achieve adequate housing but it is a basic human right for all human beings. The UN Refugee Agency in its emergency handbook in 2019 has defined shelters as " habitable covered living space providing a secure and healthy living environment with privacy and dignity" (UNHCR, 2019a) and confirm that persons of concern have the right to adequate shelter. Within this handbook the definition of adequate shelters are shelters which provide adequate means as the following; protection from the elements, adequate space to live and store the belongings, privacy, comfort and security and respect of culture and social appropriateness. The sphere handbook 2018 edition, considers the need to ensure dignity, protection, security, and a safe living environment as an essential human need, and promote the implementation of the minimum standards as the core of achieving adequate shelters for the displaced population.

## 2.4. Adequacy Means

The definitions above of what adequate shelter is finds agreement with what shelters need in order to be adequate. As such, shelters should provide their occupants with the the following adequancy elements as detailed below:

**Table 1**. Adequacy means, by the author (2021)

| **Adequacy Means** |
|---|
| 1- Protection, security, safety and resilience |
| 2- Health, and comfort. |
| 3- Adequate space. |
| 4- Privacy, dignity, and socio-cultural appropriateness. |

But is it possible to achieve adequate shelters in the humanitarian response as it tends to be an urgent response with a lot of potential constraints?

Sphere (2018) consideres the emergency response in the initial stage after the crises as critical as it is a lifesaving response which includes providing emergency shelters. However, this is not so with long-term displacement as recovery measures should be considered in the early stage of the settlement planning and sheltering, which start with a sense of community social cohesion and a feeling of safety. UNHCR (2019a) emphasise that even though it is difficult during the emergency response to look beyond the aim of life-saving, it is still important to support the persons of concern to achieve durable solutions. This shows the humanitarian response potential to respond to the adequacy needs of the displaced population which is already supported by widely recognised standards and international law.

## 2.5. The approach to adequate shelters

Providing adequate shelters urgently to the FDP (forcibly displaced population) is quite challenging as shelters by its nature required time, effort, and resources to be erected, and in the situations such as disaster or conflict the provided shelters should be urgent and affordable within the limitation of the immediately available resources. This is why the provision of emergency shelters tends to be basic and temporary and likely to be far from adequate living. Wagemann and Moris (2018) identified one of the problems was that emergency shelters were constructed ensuring speed but not quality. On the other hand, adequate housing for humans is more than a protective shell it is also resulted from and illustrate local needs, values and culture.

In emergency response, we focus more on the aim of life-saving with less attention to cultural and local aspects but the continued ignorance of it will result in a failure to achieve adequate sheltering as a recovery response. This causes a waste of time, cost and escalate the related environmental and health impacts. In addition to that, adequacy elements that have been defined previously are subjective elements to many factors such as the vast variety in culture between communities, different individuals needs, different geolocations, climate and microclimate, and the level of the vulnerability within the community. Also, in light of the usual limitations such as time, cost, resources and land tenure that constrain the humanitarian response, so many questions can be asked about adequate shelters such as, how much these elements are achievable? And at what level? How long does it take to be achieved? Is it all achievable at once? Or could be prioritised and programmed in an incremental process for continuous improvement in living conditions?

As an answer the sociocultural appropriateness and understanding the culture of the affected community and the circumstances of the displacement which define the level of the vulnerability of this community is a key in defining and prioritising the targeted adequacy elements and the level of adequacy that could be achieved. Therefore adequacy elements has to be addressed for each scenario separately due to its specific indicators and factors and then the approach to it should be planned accordingly.

## 2.6. Affected population types

Sudden crises will affect the population in different scenarios, as specified by (Sphere, 2018), which states that some of the affected people will manage to remain in place formally or even in informal occupations but others will be displaced from their original location and move to another location. This displacement could be locally, internally or overseas crossing borders into other countries. In addition to these three categories, there is the indirectly affected population such as the host communities. For instance, UNHCR (2021b) reports that the Syrian conflict which started in 2011 has resulted in 6.7 million people were internally forcibly displaced and 6.6 million worldwide, 5.6 million of them hosted in countries near Syria as per (UNHCR, 2021c).

In addition to this, some people after crises, when the original location has reduced risk, some of the displaced population will choose to return to their original location even though houses have been lost Those returners also need sheltering assistance until the reconstruction process is completed.

From the above, the affected population types can be categorised as the following:

**Table 2**. Affected population types, By the Authur (2021).

| Types of the affected population post-crises | | | | |
|---|---|---|---|---|
| Affected but not displaced | Forcibly displaced | | | Indirectly affected |
| Remain in place | Internally displaced (IDP) | Refugee | returners | Host communities |

## 2.7. Forcibly displaced population (FDP) scenarios

Sphere (2018) has specified that the forcibly displaced population have different scenarios that can be sought, The FDP can be hosted by others, rent accommodation or land in a safer location also they could gather in collective centres, planned settlements, or unplanned settlements.Forcibly displaced population required an emergency sheltering response to promote the preservation of life, and adequate sheltering solutions as a recovery method and life enabler.

So the scenarios or options for the forcibly displaced population can be categorised as the following:

**Table 3.** The scenarios of the forcibly displaced population, By the author (2021).

| (FDPS) Forcibly displaced population scenarios | | | | | |
|---|---|---|---|---|---|
| Hosted | Tenancy& ownership | Settlements | | Collective centres | |
| | | Planned | Unplanned | In camps | Existing buildings reuse |

## 2.8. The stages of the humanitarian sheltering process

After crises, the population who lost their accommodation and homes will require an urgent and immediate response in order to accommodate and protect them from the external elements that could put their life at risk.This emergency response is critical for life-saving, but people will need to recover in the absence of permanent solutions, therefore the process of sheltering will require further assistance beyond emergency in order to enable the recovery of the population .The absence of a response will increase the vulnerability of the displaced population and escalate the impact on the population's health physically and psychologically, as well as, there environment which will require an extended relief measure.

Brogden and Kennedy (2021) has connected the stages of response with the displacement time frame and stated that shelter recovery has three stages starting with emergency shelter, medium-term shelter as temporary or transitional shelter Long-term recovery as an adequate or permanent shelter.

This model is not rigid as each case circumstances should be addressed, therefore other models have two stages that skip the transitional stage and directly aim to deliver permanent or durable solutions.

So the stage of the humanitarian sheltering response is related to the life span of displacement. This time frame could be divided generally into three time-frames as shown below:

| Displacement time frame | | |
|---|---|---|
| Urgent/Immediate | Med-term | Long-term |

Sphere(2018) has also defined the post-crisis sheltering response into three stages, those being the Emergency phase, the temporary or transitional phase and the recovery phase. Therefore the sheltering response stages are divided due to the displacement time frame as the following:

| The stages of humanitarian sheltering response | | |
|---|---|---|
| Urgent/Immediate | Med-term | Long-term |
| Emergency | Temporary/Transitional | Recovery |

The proper shelter solutions should be adapted to the stage of response that is related to the life span of the displacement to address the different priorities of each stage. Furthermore, UNHCR (2019a) emphasises that it is still important to support the persons of concern to achieve durable solutions, even though it is difficult during the emergency response to look beyond the aim of life-saving. So the sheltering humanitarian response (SHR) usually aims to deliver durable solutions such as reconstruction, resettlement, and reintegration. Therefore, the aim could be integrated into the schedule above to show the target of the process as the following:

| The stages of humanitarian sheltering response | | | |
|---|---|---|---|
| Urgent/Immediate | Medium-term | Long-term | Aim |
| Emergency | Temporary/Transitional | Recovery | Durable solutions |

But the real situation shows little hope in achieving durable solutions, due to many related constraints such as land tenure issues, low number of acceptable reintegrated people in other countries, and the time and cost related to deconstruction requirements. These add constraints on the way to achieving the target of durable solutions. These difficulties, resulti in a frustrated population and the risk of failure to achieve the aim of the response, which is to help the population to recover and lead their own life.

This is why Shelter Center (2012) calls for shelter solutions that support the seeking of displaced population after crises to recover which is appropriate when repair and reconstruction processes cannot start immediately, such as in the case when land owners or the securing of land rights closely connected to livelihood of tenants cannot be achieved immediately.

The provision of adequate solutions as a target allows the recovery to start early while seeking durable solutions. For the population to recover it will require a level of adequacy even in the case where durable solutions are not available at the moment, or delayed for logistical reasons where neither the displaced population nor the humanitarian support body has control over. Also a possibility is that the reconstruction process cannot start due to continued conflict, lack of support or land tenure is not yet solved. therefore the aim of the humanitarian shelter response could be not only to deliver durable solutions but also to achieve adequacy which presents a more realistic target to be achieved due to the potential of self-reliance with little support toward adequacy until a durable solution is possible. So the schedule above can be modified as folows:

**Table 4.** Multi-phased HSR, By the Author (2021)

| The stages of humanitarian sheltering response (HSR) | | | | |
|---|---|---|---|---|
| Urgent/Immediate | Medium-term | Long-term | Aim | |
| Emergency | Temporary/Transitional | Recovery | Adequate Solutions | Durable Solutions |

The schedule above represents the possible adoption of the alternative aim of HSR.

## 2.9. The approaches of the humanitarian sheltering response (HSR)

Usually, shelter recovery has three stages starting with emergency shelter, then to the medium-term shelter as temporary or transitional shelter then to long-term recovery as an adequate shelter. This model is not rigid as each case circumstance should be addressed. therefore other two stage models that skip the mid-term stage and directly aim to deliver permanent/durable solutions, still represent a multi-stage approaches however, alternative approaches can be adopted.

Brogden and Kennedy (2021), and Shelter Center (2012) both distinguished between a multi-phased approach and incremental approach that could facilitate the gradual transition from emergency toward adequacy. UNHCR (2019a) encourages the approach that remove the divisions between different operation stages (Emergency, temporary and permanent) and successfully connect relief, rehabilitation, and development. Brogden and Kennedy (2021) show that emerging terms such as progressive or incremental has been used to describe the process of build, upgrade, and maintain the shelter toward a more adequate solution.

The figure below, from the transitional shelter guideline in 2012 shows the difference between the two approaches incremental and multi-phased.

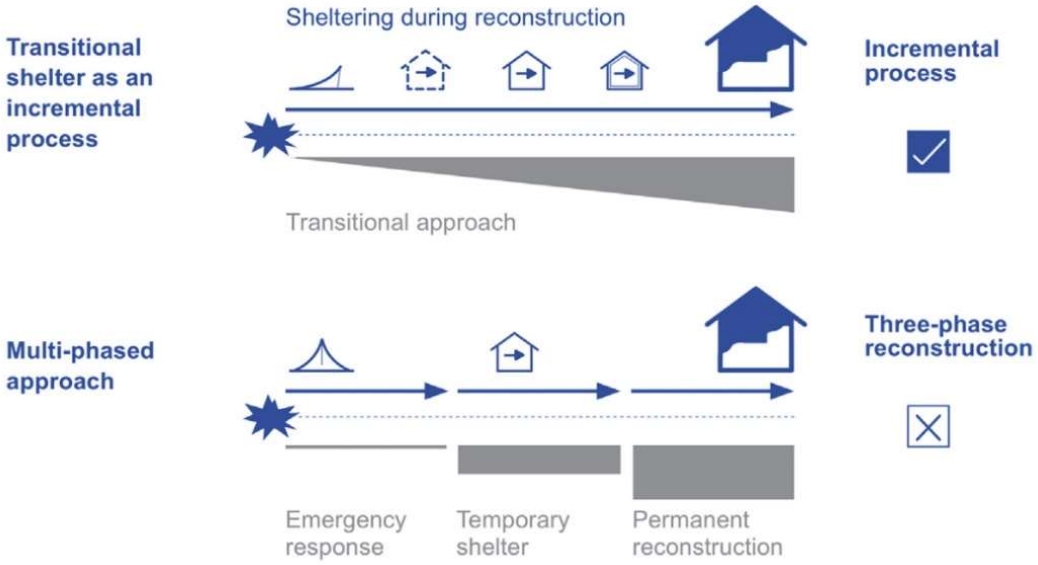



**Figure 2.9-1**. Incremental process of transitional shelter compared to multi-phased process **(Shelter Center, 2012).**

Therefore, the stages of HSR that is presented in **Table 4** can be reproduced after considering the different types of approaches Phased and incremental as the following:

**Table 5.** The different approaches of HSR, By the author (2021).

| The stages of humanitarian sheltering response (HSR) | | | | | |
|---|---|---|---|---|---|
| Type of approaches | Urgent/Immediate | Medium-term | Long-term | Aim | |
| Multi- phased | Emergency | Temporary/Transitional | Recovery | Adequate solutions | Durable solutions |
| Incremental | Emergency | **Incremental process** | | | |

## 2.10. Types of Shelter solutions and their terminologies

Many different terminologies have been used to describe humanitarian shelters such as emergency shelters, temporary shelters and transitional shelters which all seems to refer to the same shelter types but with different meaning. This is explained below:

Emergency shelter refers to the urgent and immediate response phase after crises, however, temporary shelters refer to the living place that will be provided with temporary means for a short period until better solutions can be provided. On the other hand, transitional shelter refers to the incremental process

of sheltering that starts from the emergency response stage, and continue through to the recovery stage (Wagemann and Moris, 2018). Brogden and Kennedy (2021) reproduced the original International Federation of Red Cross and Red Crescent (IFRC, 2011) framework for existing humanitarian shelters terminologies throughout the shelter lifetime. There is a possible overlap of shelter definitions which constitue six main definitions, those being, emergency, emporary, transitional, progressive, core, and permanent.

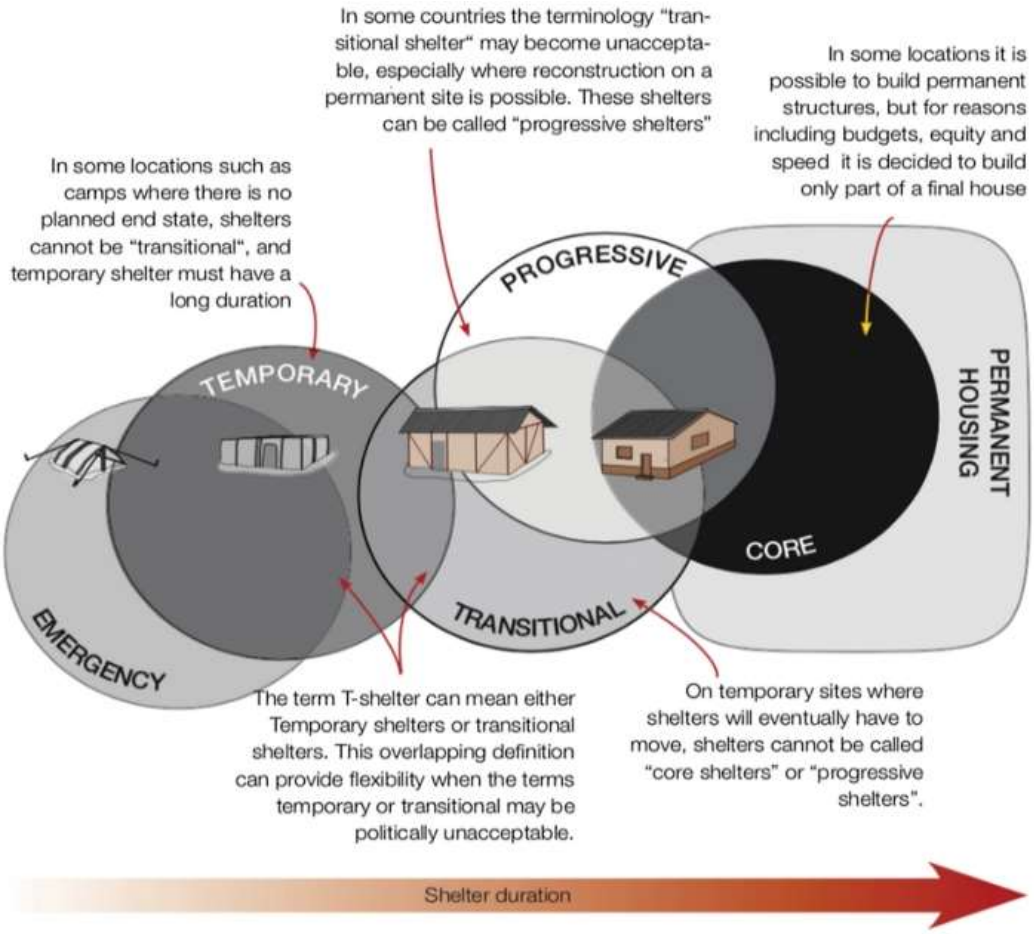



**Figure 2.10-1**. Overlapping humanitarian terminologies reproduced by **(Brogden and Kennedy, 2021)**

The reproduced framework shows that the term temporary is used when the shelter cannot be transitional, In other words, it is a structure that tends to be without further improvements or upgrades, until a permanent solution is available. And this term does not reflect the possibility of potential enhancements but is more invited to accept the existing structure as it is just temporarily. Also, the reproduced framework indicates that transitional shelters are progressive shelters that are built in temporary sites and will eventually be moved. But in the case of the permanent site, the transitional shelter can be called a progressive shelter that could be turned into a core shelter for a more permanent house. Also Sphere (2018) defines temporary shelter as a short-term solution with the intention to remove it in the next stage of response but defines transitional shelters as shelter that are designed to transit to a more permanent shelter and specify the design criteria of it as upgradable, reusable, resalable, or moveable. Shelter Center (2012) defines transitional shelter as shelter that supports the seeking of displaced population after crises to recover through an incremental process that can be upgraded, reused, relocated, resold, or recycled over the processing period that starts from the moment of receiving the first support until achieving a durable solution such as reconstruction. So it is not another stage of response but it is an incremental process that enables upgrading. and defines the core housing as the unit that is meant to be as a part of a permanent house and allows for the future extension to provide adequate space.

To summarise, the definitions above show the different terminologies that have been used to describe different shelter solutions due to the aim of response and its approaches it also highlights an important factor - In order to define a proper shelter solution which is the land tenure, we need to determine if is it temporary land or permanent?
From the above definitions of different shelters terminologies, solutions, or approaches in **Table 5** can be reproduced to reflect the relationship among shelter solutions, the aim, response stages, response approaches, and land tenure.

It must be noted, the emergency shelter in multi-phased approach (E-sh) is a temporary shelter that can be erected fast and cheap, with the aim of life-saving only, which is meant to be removed in the next stage. But the emergency shelter in an incremental approach (E-sh)+ should look beyond the life-saving to facilitate the progressive or transitional approach such as upgradability or reuseablity in the next stage of response.

**Table 6.** The Diversed shelter solutions, By the Author

| Shelter solutions due to (land tenure, the approach, the stage of HSR, and the Aim.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| land tenure | | The approach | | The stages of (HSR) | | | THE AIM | |
| Permanent | Temporary | Multi-Phased | Incremental | Urgent | Mid-term | Long-term | Adequate shelter | Durable solution |
| ✓ | | ✓ | | Emergency shelter (E-sh) | Temporary shelter (T-sh) | Core shelter (C-sh) | — | ✓ |
| | ✓ | ✓ | | Emergency shelter (E-sh) | Temporary shelter (T-sh) | Adequate shelter (A-sh) | ✓ | ✓ |
| ✓ | | | ✓ | Emergency shelter (E-sh)+ | Progressive shelter (Pr-sh) | | — | ✓ |
| | ✓ | | ✓ | Emergency shelter (E-sh)+ | Transitional shelter (Tr-sh) | | ✓ | ✓ |

Another factor that should be considered in order to define an appropriate shelter solution is the vulnerability level of the (FDP). So even if there is no issue with the land tenure, but the site is vulnerable to one or more of the three different types of hazards natural, health, safety & security, there will be a need to seek a less vulnerable situation for recovery. This would entail the need to move, relocate or upgrade to a lessvulnerable situation. Therefore the vulnerability level also defines the proper shelter solution that could address the need of the FDB to have more options to enable them to reduce the risk. Wagemann and Moris (2018) while answering the question about transition to what?, suggested that the transition of the FDP should be to a less vulnerable situation than before. Also they visualised a matrix of alternative options that is related to diverse conditions of the affected population due to the level of vulnerability of the affected population, and identified two main categories people in risk areas and people in safe areas) which serves as a supportive tool for decision making.
However, the early evaluation of any kind of potential hazards is essential in order to plan for the suitable sheltering approach, and specifying the level of hazard is required (low, medium or high). But also it is important to specify the suitable action that is required to reduce the risk, does it require relocating to a safer location? or empowering the resilience against the hazards, which can be built by adopting agreed minimum standards or construction techniques. This evaluation will directly affect the decision of sheltering approaches as relocating requires temporary or transitional means to be adopted but building resilience requires permanent means and development.

Therefore, and for the aim of this study the vulnerability levels will be considered at two levels low risk, and high risk., The low risk is the risk that will require empowering the community resilience, by the implementation of proper standards and proper construction techniques, but high risk is the risk that will be required relocation to a less vulnerable site. So, to integrate the vulnerability level in the diverse shelter solutions, **Table 6** can be reproduced as the following:

**Table 7**. Diverse humanitarian shelter solutions (DHSS), By the author 2021.

| (DHSS) Divers Humanitarian shelter solutions. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Input | | | | | | Output | | | | | |
| Vulnerability level | | Land tenure | | The approach | | The stages of (HSR) | | | THE AIM | | |
| At-risk | At low risk | Permanent | Temporary | Multi-Phased | Incremental | Urgent | Mid-term | Long-term | Adequate shelter | Durable solution | |
| | | | | | | (E-sh) Emergency shelter | (T-sh) Temporary shelter | (C-sh) Core shelter | | ■ | |
| | ■ | ■ | | ■ | | | | | | | |
| | | | | | | | | | | | |
| | ■ | | ■ | ■ | | (E-sh) Emergency shelter | (T-sh) Temporary shelter | (A-sh) Adequate shelter | ■ | □ | |
| ■ | | | ■ | ■ | | | | | | | |
| ■ | | ■ | | ■ | | | | | | | |
| | | | | | | (E-sh)+ Emergency shelter plus | (Pr-sh) Progressive shelter | | | ■ | |
| | ■ | ■ | | | ■ | | | | | | |
| | | | | | | | | | | | |
| | ■ | | ■ | | ■ | (E-sh)+ Emergency shelter plus | (Tr-sh) Transitional shelter | | ■ | □ | |
| ■ | | | ■ | | ■ | | | | | | |
| ■ | | ■ | | | ■ | | | | | | |

**Table 7** shows the potential appropriate sheltering solution and its related suitable aim of humanitarian sheltering due to the inputs that will vary from one case to another.

### 2.11. Multi phased vs. incremental approaches

The produced DHSS table has two sections (inputs and outputs). In the input section the following data should be specified vulnerability level, land tenure, and the type of approach. Two of these inputs are strongly related to the circumstances of the displacement which is vulnerability level, and land tenure. These two inputs require time and effort to be changed or resolved. But the third one which is specifying the selected approach to response, is multi-phased or incremental.This is an input of choice, which requires decision making in the early stage of the response.

Shelter Center (2012) has promoted transitional shelters and its incremental approach as a cost-effective option with better performance, even if it seems to have a higher initial cost to allow the first distributed materials to be part of the transitional or progressive shelter design which allows for an incremental upgrade instead of a phased approach. This reduces the future costs if applied properly as it tends to turn into a self-standing approach to recovery which reducing the dependency, and reflects positively on the FDP.

The incremental approach usually expands the available options for the FDP as it evolves with time as a response to the required needs, this ensures a more efficient response to the diverse needs of different characteristics of the population including thoserelated to diferences in socio-cultural and religion, and support sustainable self-reliance construction of culturally appropriate shelter.

It also allows for more appropriate addressing of the specific needs of the more vulnerable occupants such as the elderly, children, women, and special needs people such as the disabled. When there are constraints on the way of achieving durable solutions, such as land tenure, the incremental approach allows for the use of the land on a temporary basis which allows the construction to go on, in parallel with land right negotiations which provides more time and allows for early recovery implementation to the FDP during the time that is required to solve land tenure or to finish the reconstruction process.

But the incremental approach is a challenging approach as it is required to be implemented in the early stages of the response which is usually difficult to look beyond life-saving aim, however, it is still important to look for a life-enabling response to address the recovery needs efficiently.

Wagemann and Moris (2018) emphasise that the decisions that can be made in the emergency stage of response will affect the ease of transition to recovery and the delivery of adequate sheltering or houses. The research also highlights the disconnectivity between emergency, and recovery stages and the negative impacts resulting from the lack of coordination between different shelter solutions for each stage of the process from emergency to adequate shelters. These issues results in increased cost. additionally time to recover will escalate environmental and health impacts on both the surrounding environment and the displaced people. Sphere (2018) highlights that displacement often adds pressure to the existing (most likely limited) resources. So preventing and mitigating negative environmental impacts is essential by avoiding inefficient shelters and settlements that will require further investments. On the other hand, the incremental approach increases the potential of poor implementation due to the lack of expertise, poor management, and insufficient coordination which will result in unsafe practices leading to poor performance and hazardous shelters. According to Shelter Center (2012) this is one of the notable threats in the transitional shelter approach. In the instance of the absence of an exit plan or decommissioning if accompanied by poor implementation the settlement may become a slum. Finally, this process may become an unsustainable process if the local resources have been overused. In addition to that, Wagemann and Moris (2018) also highlight that the concept of the transition could cause a lack of attention to reconstruction, as it is turning the focus more toward the supporting of the incremental process. which raises questions about its suitability when durable solutions are achievable. For instance, in the 2010 earthquake in Chile, some families rejected the constructed temporary houses and chose to stay in tents as they consider that the provision of medium-term houses could delay the provision of a permanent solution. As reported by Wagemann and Moris (2018) in some cases and when the durable solutions are achievable within an acceptable period of time, such as cases of people who have been affected but not displaced , returners, a temporary means or other means such as core shelters which relys on providing one complete room from the permanent house that provides shelter while the rest of the house is completed, and semi-permanent shelters that offer to construct elements inside of the permanent house such as foundations and roof that could offer shelter while the construction complete, these solutions could become a more reasonable and affordable option that could skip some response stages and lead directly to a durable solution. For instance, in the Pakistan floods of 2010, core housing response has been recommended as a response for the returning families to their original location after the flood which affected over 80 percent of the total affected population **(Shelter Center, 2012).** Therefore analyses such as SWOT (strength, weakness, opportunity, threat) should be carried out before the implementation of the response approach as it is recommended in the transitional shelter guidelines.

To summarise, different approaches can be recommended for different displacement scenarios and contexts due to the options that are available and their potential to be achieved. Multi phased approaches can be adopted in the case of affected populations but not displaced and returnees if the reconstruction plan is in action. In such instances, temporary shelters could form part of a multi-stage approach and could be more suitable to the displaced population in cases of a high potential for relocation and reintegration to a safe host community in which the options of hosting, renting, or even owning their accommodation will be available. But in general, the FDP with a high potential of a long displacement period with little hope of durable solutions the incremental process is considered to be cost-effective and promote better performance with little help that could transform the process to a self-standing approach and allow for early recovery. That could be implemented in parallel to the seeking of durable solutions.

Transitional shelter guideline 2012 **(Shelter Center, 2012)** declares that this provision is only appropriate when the repair and reconstruction process cannot start immediately for landowners or securing land rights close to livelihood for tenants cannot be achieved immediately. Also, special care should be taken to ensure proper coordination and management, continuous consultation with the population, and training programmes, in addition to technical support and quality insurance to avoid the risk of poor implementation or the overuse of local resources and empowering the FDP.

# 3. Chapter 3: Applied Methodologies

PDPC (Post-disaster and Post-conflict) sheltering livability and performance enhancement has been the subject of studies involving a wide range of research methods for example literature reviews, field measurements for existing shelters, experimental studies including prototype development and testing, life cycle evaluations, and numerical assessment. As each methodology has its own strengths and weaknesses, the best method is chosen depending on the study's objectives, goals, and topic. The multi-faced nature of the PDPC is reflected directly in some of the methods used in the reviewed papers. Many were mixed-methods studies attempting to develop more comprehensive and balanced findings, combining qualitative and quantitative data collection with interviews and surveys for information gathering. Some also conducted a digital simulation or field measurements on prototypes to conduct quantitative experiments to determine their effectiveness.

Recent research (S.Asfour, 2019) used a survey in order to evaluate the shelter's performance and numerical analysis to assess potential enhancements. An initial survey was conducted among local experts from different organisations to assess the appropriateness of the existing shelters. The survey looked at the frequency of the response, which was then calculated using a relative importance index (RII) equation to reveal weak points in the implementation of solutions and policies for displaced populations in Gaza, specifically poor thermal performance. Afterwards, a numerical analysis was carried out to simulate the proposed conceptual design for a shelter constructed from reusable shipping containers, with the goal of reducing solar gain and improving thermal insulation. To model the thermal environment, a programme called Design Builder 5.3 and Energy Plus was used. Consequently, the predicted mean vote (PMV) and percentage of dissatisfied people were calculated, and the PMV number has been corrected by applying an expectancy factor. Since non-air conditioned spaces have been considered in this analysis, the difference between people used to being in air conditioned rooms and other people who live in non-air conditioned rooms is reflected. This method is approximate but is still considered to be valid in this type of analysis as it serves to provide guidelines for future improvements.

Another paper (Yu *et al.*, 2016) aimed to examine how temporary shelters could be improved through thermal improvements and incorporated a field measurement study along with a questionnaire survey that spans various seasons distributed to different settlement occupants. Two sets of data loggers were also installed in an existing bamboo-wood shelter for the purpose of measuring humidity and temperature. One set was occupied and the other empty. The aim was to find out if the existing shelters performed well thermally. To obtain and analyse the results, three typical prototypes with different insulation materials were also examined experimentally.

Ameen (2017) reviewed the literature to identify design guidelines, typologies, and materials. In addition, the study discussed existing alternative solutions which could be applied in the same context, and the study highlighted various design approaches. A qualitative comparison with UNHCR references was also conducted (Ameen, 2017), as well as, a quantitative assessment of the thermal performance of the proposed scenarios, using the IES-VE software to simulate eight scenarios including the standard UNCHR tent as a base case and different systems scenarios using hybrid passive design. A comparison of the reductions in heating and cooling loads was done to determine the optimal performance scenario.

As a primary method of gathering information, many researchers conducted structured interviews and surveys in order to gather enough information that could be evaluated by applying data analysis techniques. An assessment of existing shelters may include sending out questionnaires or conducting surveys to allocate a higher weight to what factors are most important to PDPC sheltering, or it may take another approach, such as gathering information from product manufacturers concerning the material sources used in sheltering and determining what level of comfort is suitable for shelter occupants.

Brogden and Kennedy (2021) carried out a literature review in order to define and categorise the vast number of terms describing different types and approaches to humanitarian shelters.

Another paper (Pomponi *et al.*, 2019) performed a process of many steps including a literature review, a Delphi survey, data analysis by analytical hierarchy process (AHP ), and a preliminary assessment of the economic viability and technical performance of PDPC sheltering based on the literature review. Four key factors emerged from the literature review regarding the sustainability of PDPC sheltering that including the environmental impact, as well as, the social suitability regarding it. Therefore, both existing solutions and new designs were thoroughly analysed. For the roofs of the shelters and the load-bearing structure, the Delphi method was applied to specify some of the solutions that emerged from previous analyses conducted by two separate teams, one in Edinburgh Napier University in theUnited Kingdom, and the other in Cape Town, South Africa. Based on the previously determined sustainability criteria and the Delphi method, scores for the specified solutions were calculated. Similarly, AHP has been applied as a tool for data analysis for the weighting of the sustainability factors, based on the averaging of scores from different experts, since each expert included their own scores, and eventually a final score module for both loadzbearing and roofing was been determined.

Opdyke, Goldwyn and Javernick-Will (2021) have assembled a Delphi panel of experts to define the needed research topics in the field of post-disaster sheltering. The process started by identifying and categorising the key future research topics by conducting an online survey in 2017. This resulted in six main areas of research being identified which were then subjected to rating criteria to be prioritised by the specialist panel after the respondents replied to three open-ended questions in the questionnaire with the research areas, a review carried out by the authors to ensure the categorisation of each topic and ensure that there were no missed topics. The Delphi method was then employed as a systematic tool in three rounds. The first round focused on the validation of the topics list but the second and the third round rated the importance of each research area. The criteria for candidate selection in the expert panels was to have a minimum of ten years of experience in humanitarian shelters and settlements. Twenty–two experts participated in the first round with 16 of them completing the three rounds. A Likert scale was used for the rating (not important, slightly important, moderately important, important and very important) and resulted in six themes being validated in the first round. The research topics that did not receive consensus were rated using a median rating to avoid bias. In addition to the list of statements to be rated, the researchers were then asked to re-evaluate their rating accompanied by a justification. In the end, a consensus was determined using a median absolute deviation (MAD) which calculates the variance from the median, and the consensus is considered to be achieved when the deviation is less than 0.5 points from a scale of 5.

Sakisaka *et al.* (2017) used a structured questionnaire to gather cross-sectional data, which also included open-ended questions, primarily based on a scale of five levels from strongly agree to strongly disagree. This case study focused on temporary housing in Rikuzentakata, and measured occupant satisfaction based on six criteria, security, peacefulness, comfort, elderly-friendly, child-friendly, neighbour concerns, and communication. The higher the score, the higher the level of distress. In addition, the questionnaire collected data on four major aspects of living such as living environment, physical health, social relationships, and mental health by giving one point per symptom, so a high score represented a poor quality of life, then the resulting QOL (Quality Of Life) is calculated and compared to the national averages. Additionally, open-ended questions about the resident's social interactions and relationships were also asked. Statistical analysis was used to analyse the collected data, as well as logistic and linear regression to determine any correlation between the living conditions and the other variables.

Other researchers collected numerical data by carrying out real-time field measurements for an existing shelter and undertaking experiments on prototypes, working with digital simulations, and presenting their results as charts, tables and figures.

Recent research (Wang *et al.*, 2019) examined 16 different placement designs for placing PCMs (Phase change materials) into the prefabricated temporary house (PTH) envelope in order to determine the options that resulted in better indoor thermal comfort. The study focused on the optimal placement of the PCMs first, then determined which placement options resulted in improved thermal comfort in the PTH. The option with the highest acceptable indoor air temperatures hours and the most effective design was chosen. Secondly, the thickness of PCM in the optimized design was evaluated to determine the effectiveness of thickness increments, and the final recommendations have been developed for

future applications. A validation model has been established by establishing different design applications for PCMs. A total of 16 different application methods were identified, and then the model that was most effective was determined by checking the acceptable thermally comfortable hours for each application and then choosing the model with the highest number of acceptable hours. The energy plus model has also been developed to allow future experiments with other application methods in different climates.

Salta *et al.*(2020) developed a computational simulation method to determine the most appropriate shelter design under specific conditions based on a generative study. Similarly, some researchers built a prototype and performed a field measurement to prove their simulated results, resulting in a more reliable and confirmed claim.

Barreca and Tirella (2017) simulated the assessment of a proposed temporary shelter for long-term sustainability with software (Energy Plus and Design-Builder), and then built and tested an actual prototype as a verification of the simulation. As a result, an energy and thermal comfort analysis was carried out after setting the parameters and the topographical layers with their parameters, and the occupancy pattern was determined to be a one-bedroom household. The cooling demand was calculated based on solar heat gain as an external heating source and occupant heating as an internal source, Afterwards, a simulation analysis for the year was conducted and the results were obtained, and then an actual prototype was built by three workers within six hours. Delta Ohm Hd32.3 a micro-climate instrument was used to measure the temperature indoors, and a weather station, to measure the temperature outdoors. During that time, extensive weather data was collected and including the lowest and highest temperatures for some time. Actual collected data validated the simulation and subsequently, the developed design was also used to compare it with the same design using block as an option and other options using steel and the results obtained by the simulation enable the comparison which allowed for conclusions to be drawn from the better performance of crock panels.

Additionally**,** one of the reviewed papers utilised LCA (Life Cycle Assessment) for a more holistic approach to evaluate a specific aspect of GHG (Green house gases) emissions from ETHs (emergency temporary houses) in Japan and collected information about the materials' source from the manufacturers. As a result of the differences in ETH technology regarding building construction (lightweight steel, prefabricated steel, and wooden buildings), and the various usage periods, the LCA took into account the specified 2-year life span in the DRA (Disaster Relief Act) as well as a minimum of 5 years because this is what the displaced people would have experienced, and a maximum of 7 years since some ETH are still in use. There are three sizes of the ETH provided (19 m2, 29.7 m2, 39.6 m2), and the LCA was conducted based on the medium-sized unit since it's the most commonly provided unit and the average unit size across all types (Seike et al., 2019).

Furthermore, Seike *et al.* (2019) used information gathering and survey interviews with manufacturers to identify the materials used, which were mostly from local manufacturers. The LCA also took into account the GHG emissions caused by the extraction of raw materials. Moreover, the construction stage used little heavy machinery as ETH was a one-story building; therefore, more attention was paid to the GHG emissions caused by the transportation of materials. Since ETH repair was not conducted due to the short period of operation, the main causes of GHG emissions during the operation stage were heating, ventilation, hot water, and lighting. The cost of disassembly, disposal, and recycling has been calculated at the end of life stage as the majority of disassembly is done by workers, so heavy machinery has not been included in the assessment. This document determines the boundary of the system, and although some applications were not considered for the assessment of GHG emissions, the assessment was still sufficient. IDEA databases that are compatible with ISO 14044 are used for the energy uses overseas for the LCA, in addition to a hybrid, statistical, and cumulative Inventory Data Base for Environmental Analysis (IDEA) from the National Institute of Advanced Industrial Science and Technology, the GHG emissions were calculated for the four stages (production, construction, operation, and end-of-life) for various construction methods with and without recycling, and for three different periods of operation. A discussion was conducted as well as conclusions and recommendations were offered.

### 3.1. Pros and cons of the applied methods

#### 3.1.1. Literature review methodology

It is important to conduct a literature review in order to gain a broad perspective on the topic, then to specify the points of interest within it, identify the type of issues and problems related to it, as well as to avoid duplication of the work and ensure the added value of the paper. Additionally, it can also be used to identify some key aspects of the topic that can be used as a basis for further study. Research such as (Pomponi *et al.*, 2019) Despite the fact that  laid the groundwork for his investigation, literature reviews do not add much new knowledge, particularly pertaining to PDPC sheltering livability and enhancements. Literature reviews are valuable for emphasising the importance of the topic, identifying the current issues with the FDP (forcibly displaced populations), evaluating the factors and establishing the basis for the suggested enhancements or solutions, but not adequate in confirming the validity of those suggestions, which are better done through other methods that will provide more accurate and reliable results.

#### 3.1.2. Surveys and interviews method

Surveys are a great way to collect qualitative data directly from the stakeholders of your topic, which makes the data more reliable because it is collected directly from the source and gives a lot of information that can be analysed. Several researchers have used surveys in the topic of PDPC sheltering to assess occupant satisfaction and to get suggestions for preferred practical solutions for displaced people, such as those used by a reasearch (S.Asfour, 2019)  that assess the effectiveness of existing shelters, and also can be used to weigh the importance of specific aspects, as proposed by Pomponi *et al.* (2019) in order to rank the proposed building criteria. But surveys could be biased if the wrong population is chosen for the survey or the survey does not have the proper scale and diversion. In addition to that, it is time-consuming, can be costly, and can be hard to find participants if the question is poorly designed.

#### 3.1.3. Field measurements method

Throughout the research topic, field measurements are employed to report the actual performance of an existing E/T shelter in a quantified way, such as microclimate, thermal performance, and indoor air quality. Similar to Yu *et al.* (2016) who used a field measurement to report the poor thermal performance of an existing bamboo-wood shelter, also used a prototype as a verification method to verify simulation results in a real-life application, as applied by Barreca and Tirella (2017)  to verify the performance of a cork shelter prototype.

A field measurement could be the most accurate way to report actual situations and performance quantitatively. However, accuracy depends on the accuracy of the measurement tool and the correct conditions of the measurement. This is because the researcher does not have control over the conditions, so it should cover a sufficient time and be done according to the aim of the study. Therefore, field measurements are costly since they require the availability of the equipment and space, and additionally, it requires a considerable amount of time to observe to collect enough data that covers the changing real-time conditions such as weather changes, occupancy patterns, and proposed activities.

#### 3.1.4. Experimental research method

Experiments may be conducted in the real world or in a controlled environment as lab experiments. Researchers are unable to control variables of their experiments when conducting them in real-life situations. Because of this, the test needs to undergo a full cycle to get an overview of all conditions. That's going to take time and money, but the results will be reliable in the end. In contrast, an experimental study can be carried out using digital simulations that provide researchers with complete control of variables and testing a wide range of options similar to the one conducted for the application of the PCM as a passive thermal control method within a temporary shelter by Wang *et al.* (2019). Although this method would seem to be the most affordable and the fastest for experimental study, there is still a need for further correction and verification as the real measurements might contradict the simulation results.

### 3.2. Research aims and objectives

Coming out of the literature review, it canbe seen that the emerging global trends around the issue of forcibly displaced populations is driven by significantly increased number of displaced population, the growing average displacement time, and the decline in the durable solution's availability. in addition to, the ineffective humanitarian response and the recovery delay, caused by the gap and disconnectivity between relief aim and the sustainable development post the crises in the real implementation of the HSR and its correlated unwelcome escalated results on both the displaced population and their environment. Therefore, the research will aim to investigate alternative approaches and specify recommendations to HSR that is adaptable to the need of an effective transition to the adequacy and could initiate a successful linkage between relief, recovery and sustainable development of the humanitarian response.

The research objectives are detailed as follows:

- Specify the different types of shelter solutions and identify their terminologies.
- Specify the different approaches to humanitarian sheltering.
- Categorise the existing sheltering solutions.
- Establish evaluation criteria and evaluate the categorized existing solutions.
- Propose a possible approach to linking relief to sustainable development.
- Identify the characteristics of ADS (adaptable design strategies.) of adaptable shelters.
- Specify and categorize the potential transition enablers.
- Identify the relationship between the transition enablers and the identified ADS characteristics.

### 3.3. Research methodology selection and justification.

After the previous review of the different research methodologies and as the aim of the research is to establish recommendations for the humanitarian sheltering approach and the design of adaptable shelters solutions. This qualitative research can provide a deeper understanding of the HSR context and valuable data about why the HSR tends to fail and how alternative approaches could reduce this risk and ensure more effective response due to the divers' situation of the affected population. However, each objective of the research would require a certain method to best achieve it, therefore, a literature review has been conducted to identify the gaps that possibly cause the failure of the response, as well as, define the characteristics of both adaptable shelter design and HSR approach(es) in a qualitative way. Furthermore it defines the evaluation themes in order to evaluate and compare the existing solutions.

For the purpose of establishing an acceptable and balanced database, a survey of more than thirty-six previous cases of response that has been conducted and reviewed by well known humanitarian agencies was done. In addition to this seven cases of potential novel solutions and together established an acceptable, balanced, and reliable database, for further analysis. Additionally, in order to ensure that the collected database was not biased, a categorisation process of the selected cases has been conducted to ensure that the cases fall into different solutions types, responses, displacement situations, climate conditions, and cover the saturation of solutions terminologies.

For the evaluation purpose, a pros and cons list has been used as a suitable tool that enables the logical judgemental process for decision making in order to tag the strength or weakness of each solution against the specified themes of the evaluation criteria that is specified due to the conducted literature review. This process resulted in a trength and weakness table being compiled of all categorised solutions which enabled the qualitative comparison and discussion between the existing solutions.

Furthermore, and for the purpose of identifying and extracting the possible enablers of transition from the established database, entity relationships diagrams have been used which enable the research not only to count the possible enablers but to identify its role and relationship to other enablers and to the characteristics of adaptable shelters. Furthermore the ERDs has enabled the researcher to identify the different patterns of transition.

### 3.4. Research stages, methodologies and data analysis methods.

Through the five main stages of a literature review, data analysis techniques, evaluation, comparison, and relationships diagrams, to obtaining results, conclusions, and recommendations, the research proceeds through five phases.

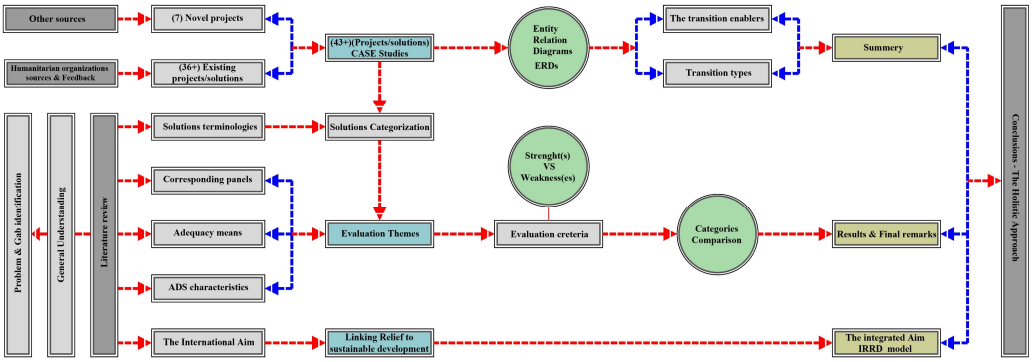



**Figure 3.4-1.** The research process chart, by the Author, 2021

The first step is conducting a holistic literature review as much as possible It can be for many purposes firstly to create a general understanding of the topic also, identify the topic research gaps, limitations, possibilities, trends and current problems, secondly to identify the sheltering solutions terminologies, thirdly to specify the Adequacy means, and the characteristics of Adaptable shelters, and more importantly the adequacy of the shelter means, thirdly it helps in understanding and addressing the international aim for linking the relief response to sustainable development.

The second stage was to initiate as much as possible a liable and holistic case study in order to enable an evaluation and comparison of the solutions and most importantly to investigate and extract the possible transition enablers, therefore a wide review carried out of more than 43 projects, case studies, and solutions for both (Existing and Novel) from a variety of trusted resources such as (UNHCR & IFRC reports, Global shelter cluster (shelter projects), and shelter centre.) and cover different climate conditions, response stages, vulnerability levels and crises type In order To avoid obtaining biased results and creating a liable and wide base case study for further data analysis, secondly then the reviewed case studies has been categorized due to the type/nature of the solutions and the specified solutions terminologies.

The third stage was to evaluate and compare the evaluated categories of the existing solutions with each other. So firstly a (Pros and Cons) List has been established separately for each category as a logical decision-making tool, that enables the argument to make more sensible and informed decisions in the evaluation process of each category against a specific evaluation theme. secondly, a table of evaluation themes has been specified due to (the Adequacy means, ADS characteristics, and the principles panel) that is previously specified in the Literature review stage, thirdly the evaluation criteria of three Levels (Strength(s), Weakness(es), and a combination of Both or non.) has been adopted to be assigned for each category due to its related evaluation theme, this result in a table of strength and weakness analysis, that enables the comparison discussion between the different solutions categories and shows a clear different response results between (Local & Global) solutions.

The fourth stage entity relationship diagrams have been used as a data analysis tool that uses a logical hierarchy flow chart to graphically represents how entities- which are in this research the extracted transition enablers from the reviewed (Projects /solutions)- relates to each other, which help to determine their potential role in the transitional process. Therefore, 13 (ERDs) has been created that help in identifying one Key enabler, 10 enablers, and 28 sub-enablers. Additionally, the ERDs present two main different types of transition.

Then in the fifth stage, conclusions and recommendations have been obtained due to the final remarks that have been specified from the comparison of the sheltering solutions, and the final summary of the specified Transition types and their potential enablers, in light of the developed Integrated aim model, Which resulted in a recommended holistic approach.

# 4. Chapter 4: The case studies of the different sheltering solutions

This chapter provides a more elaborative discussion of the types of sheltering solutions and the reviewed projects and/or case studies.

## 4.1. Tents

One of the most common humanitarian responses is providing temporary tents. Tents are simply a structure with a cover that together provide a portable temporary shelter. Tents come in a variety of shapes and designs, but still, tents can be classified into three main categories due to the cover layers -


**Figure 4.1-2.** Tents Classification, adopted from **(United Nations, 2004)**

those are single-fly tents with one layer of fabric, double-fly tents with one layer of fabric and flysheet, and winteried tents that consists of a fabric layer, a cotton lining, a flysheet, and an opening for the stove pipe. The figure down which adopted from (United Nations, 2004) explain the tents common components

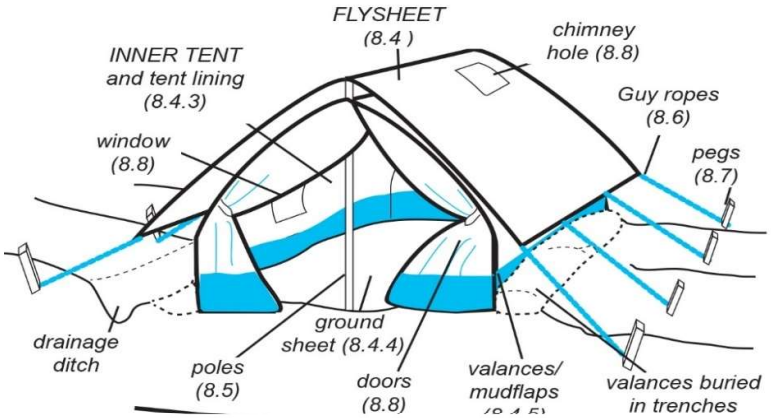



**Figure 4.1-1.** Common tents components with flysheet, by **(United Nations, 2004)**

Tents also can differ due to their structural frame method. **Figure 4.1-3** shows different types of structural frames for tents such as tunnel, ridge, dome, and geodesic.

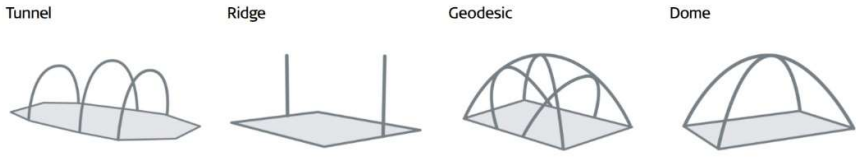



**Figure 4.1-3.** Types of tents frames, by **(Nordisk, 2018)**

However, tents provide the occupants with very basic adequacy means as they can address a little privacy for the families living within, and protection against weather that will keep the occupants' bodies dry, covered, with an internal temperature that is acceptable as a life-saving measure, but not necessarily providing comfort especially in the time of extreme weather and/or long-term displacement.

However, a different climates require a different design of tents, for instance in a hot dry climate, tents need shade from the sun and ventilation for cooling, flysheet for shading, opening for ventilation, and external space shading. But in the desert, it could be cold at night so winterised tents may be required. And in a hot-humid climate, tents fabric should drain condensed water out of the shelter and should

have an anti-rotten fabric in addition to the importance of providing shading from the sun. However, in cold climate tents may not be suitable due to their poor thermal insulation and high level of air infiltration that cause the tent to lose heat very quickly. After all, when only tents can be used in a cold climate winterised tents can shelter the occupants with special care of draughts blocking to reduce infiltration and upgrade the insulation of the tents lining layer, in addition, to keeping people off the ground with proper clothes and blankets. Moreover, in times of extreme weather hot or cold seasonal variations and upgrading may be required. Nevertheless, the distribution of winterisation kits which usually consists of insulating floor mat, inner liner, floor protection for heater, and sleeve for heater pipe)can enable the occupants to upgrade their tents.

Therefore tents can be described as an emergency shelter solution - they can be distributed in quick time- due to their low cost and rapid construction ability which is suitable as a temporary solution that is a portable shelter that can be dismantled and reassembled with ease. That presents the active/responsive element of the tents,which is considered a lightweight structure that helps the occupants to overcome the land tenure issues for a while as constructing it while the land tenure discussion is going on which provides the FDP with the required time to proceed toward more adequate/durable solutions.

Also, tents could be suitable for an incremental process as tents covers can be reused in different ways such as transitional shelter cover or outdoor shading and/or privacy barriers. In addition to many possible innovative adaptation practices carried out by the occupants. Therefore, good quality covers and regular maintenance procedures could extend the life span of the tent covers which allow for multiple reuses of it, in the process of transition to adequate shelter. On the contrary, the long-term occupancy in tents without an incremental strategy causes repeated calls for sheltering assistance every one to two years due to the short life span of the tents, and the very basic means of adequacy that tents can provide, This results in inefficient HSR and insufficient sheltering solutions for FDP also the absence of incremental process results in vulnerable communities that will be in continuous risk, Tents as a sheltering solution are addressing low resilience against some types of natural hazards such as (fire, winds and flood). For instance, at the time of writing this chapter on the 4$^{th}$ of August 2021, an accident caused a massive fire that swept through Camp 004, one of Qub Elias refugee camps, Al-Beqaa, in Lebanon and fully burned 25 tents (*URDA*, 2021), this camp has been there for more than 10 years with the absence of an incremental process to address risk reduction and resilience improvement.

Also, tents as an emergency response are required to be distributed in time, so transportation and delivery of the items could be expensive and possibly causes the delay of the response. However, tent alternatives should always be assessed such as constructing temporary shelters from locally produced materials, after all, some kinds of tents are standardied and considered as a global design solution such as the following:

#### 4.1.1. UNHCR family tent

UNHCR family tent is a double fly tent of 23 sqm living space that has elevated walls and groundsheet with 2.2 m head height in the centre of the tent. The tent structure system consists of (double polyester cotton blend canvas, 3 upright poles, 1 horizontal pole, 10 side poles, 10 guy ropes on each side). Even though the tent living space is 23 square meters it does occupy a footprint of 61 square metres due to the space required for the assembly guy ropes. It is an emergency global shelter design with a lifespan of 1 year. However, a shade net can be added to the tent that is especially needed for hot climates, Also

this tent can be upgraded with a winterisation kit of a liner to improve the insulation against cold, in addition to the insulating mat, chimney sleeve, partition and floor protection under the stove.


**Figure 4.1-4.** Phot of family tent, by **(UNHCR, 2016)**

### 4.1.2. UNHCR framed tent

The framed tent is a self-standing frame that allows for easy setup and eliminating the lost space that is required for logs and ropes compared to the standard UNHCR family tent and also expanding the area of the living space which make the space suitable for a family of 5, with more sufficient headspace of 2.4 m height, however its heavier and more costly solution, with a 1-year life span.


**Figure 4.1-5.** Framed UNHCR tent, by **(UNHCR, 2016)**

The UNHCR framed tent also can be provided with a shade net and winterisation kit, also, the symmetric flaps allow for expansion by attaching two tents lengthwise to provide wider space.

### 4.1.3. Self-standing family tent

Research, development, and field testing carried out by UNHCR, IFRC, and ICRC from 2011 until2016 has resulted in a new improved self-standing family tent. This tent is a dome tent design with a self-supporting structure that is self-standing and self-tensioning with 4.3 m by 4.3m area with a head height of 1.8 metres and enhanced specifications due to the good protection against dust, wind, rain, snow, insects, and small fauna that is provided by the outer tent. In addition to the inner partition that divides the tent and provides the occupants with some degree of privacy.

The materials of the tent groundsheet follows the standards of plastic sheeting, and the outer tent is an HDPE and the inner tent is a polyester-cotton canvas which make it a fire retardant tent with a 1-year life span and moderate cost option.


**Figure 4.1-6.** Self-supporting tent with enhanced specs, By **(UNHCR, 2016)**

### 4.1.4. Tunnel structure Tents

Tunnel shaped tents can be made by using flexible tubes including MDPE water pipes that can be bent to create an array of arches and braced together with bars such as iron bars and plastic sheets can be used to cover the structure such as 4 metre by6 metre standard UNHCR tarp, also flysheets can be added.

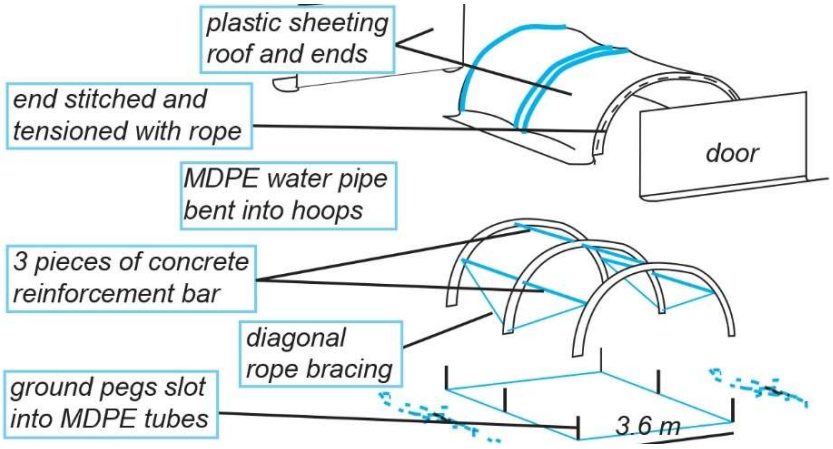



**Figure 4.1-7**. Exploded perspective of Tunel tents by **(United Nations, 2004).**

These types of construction are a good example of the potential use of already supplied materials on the camp such as distributed plastic sheets and water supply pipes that have been already supplied on the site for the construction of sanitation facilities Water pipes are difficult to source in sufficient quantities and qualities and alternatives are limited, which limits the vast response of sheltering due to this type of solution. But still, it is an emergency solution that can be constructed and fabricated on-site if the required materials are already available.

## 4.2. Materials distribution approach

Some other HSR approaches enables the people of concern to self-construct their emergency or transitional shelters by distributing materials and kits including construction tools that can empower them to erect their own relief shelters. Such as the following:

### 4.2.1. Distribution of plastic sheeting, poles, and ropes

IFRC (2009) clarifies that a persons capability of building and repair is highly related to the availability of the material, the volume of needed support materials are related to the volume of locally available materials, that contribute widely to enhancing the local economy. However, locally available natural materials should be assessed to ensure avoiding environmental impacts of overuse. Therefore, one of the common practices in the HSR is the distribution of plastic sheeting (Tarpaulin) together with

toolkit robs, frames and fixings which allow the FDP to erect their own emergency shelter, instead of whole ready-made tents as the first sheltering aid.

Plastic sheeting is also known as tarpaulin or polythene sheet (IFRC. and Oxfam., 2007) that has been developed and standardised by international organisations to meet some required specifications and to ensure better durability such as strong sheet, waterproof, and UV depredation stabilized. A standard sheet consists of a core black woven or braided Polyethylene which is laminated on both sides with Low-density Polyethylene sheets, for a minimum weight of 200g/m2. **Figure 4.2-1** shows the standard layers of tarpaulins for humanitarian relief.

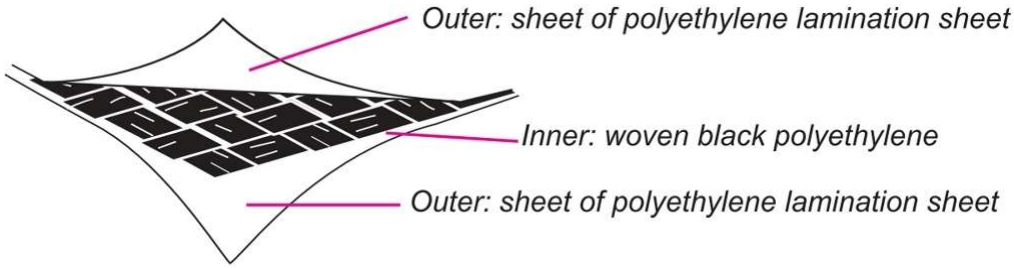



**Figure 4.2-1.** Illustration of plastic sheet layers, by **(IFRC. and Oxfam., 2007)**

Tarpaulins have different types that are following the requirements of different humanitarian agencies. Additionally, tarps are a versatile material that offers flexible usages of family emergency shelters, sanitation facilities, infrastructure in different proposition such as roofing, waterproofing damp, fencing, shading, and flooring. This flexible use and reuse of the plastic sheeting allows the FDP to construct their own emergency shelter that is customised to their needs and the potential contribution of the tarps in the incremental process of transition to adequate shelters. Furthermore, it is offering a more cost-effective option that can be vastly distributed to reach a wider range of the population in need of emergency shelter resulting in a very rapid sheltering response due to its lightweight and large production capacity.

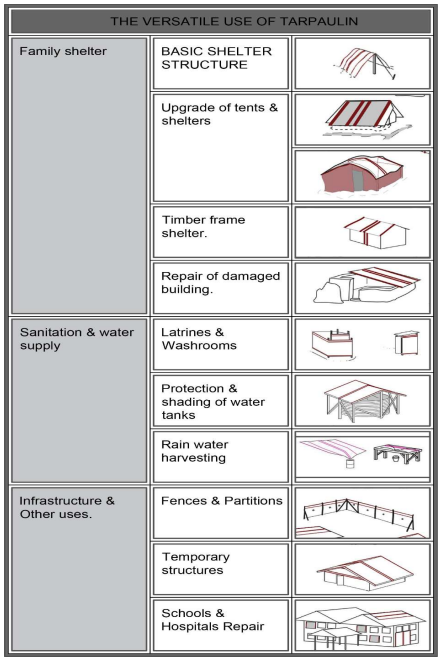



**Figure 4.2-2**. the potential use and reuse of the Plastic sheeting, reproduced by the Author from the the originally created **(IFRC. and Oxfam., 2007)** and **(Shelterprojects, 2018).**

PlasticsleMag (2014) in an article titled plastic in the heart of the action, declares that international organisations and NGOs distribute millions of metres of plastic sheeting every year, to FDPs. Shelter Center (2012) ransitional shelter guidelines highlight the flexibility of the use of plastic sheeting and link the durability of plastic sheeting with the extended potential of its versatile use and reuse.

Shelterprojects (2018) consider plastic sheets as the most practical and cost-effective material due to their functionality and its multi-purpose usage as a life-saving product with wide capability of reaching whos in emergency shelter need.

However, tarpaulin is not an ideal solution, tarpaulin has poor thermal performance, and a short life span of 6 to 12 months also sun rays can reduce the life span of the tarps. Therefore IFRC (2009) has recommended that shelters with Tarps or corrugated sheets should be shaded with (vegetation, flysheet, or shading device).

Even though plastic sheetings are more versatile than pre-fabricated tents and allow for wider rapid response for emergencies**, s**ome people with special concerns can't construct their own shelter, such as the elderly, and the disabled population, even though, ready-made tents are more costly, the proposal of the distribution of full tents may seem more appropriate for them. Another alternative and common material for humanitarian relief distribution are the corrugated galvanized iron sheets.

### 4.2.2. Corrugated galvanised iron (CGI/iron/zinc)

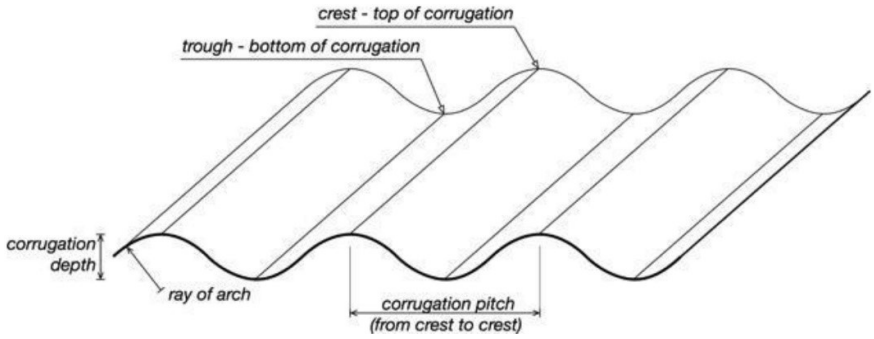



**Figure 4.2-3.** Terminology of CGI sheets, by (Shelter Cluster nepal, 2016)**.**

Corrugated galvanized iron sheets are made of thin sheets, that is corrugated in different shapes such as waves to increase the strength and stiffness of the thin lightweight sheets that is formed from mild

**Figure 4.2-4.** Humanitarian shelter in Philipene, by (IFRC, 2016)

**Figure 4.2-5.** Hardware store in Nepal, by (IFRC, 2016)

steel and galvanized to better withstand the weather and increase its durability. CGI sheets are common materials in HSR, due to their lightweight, considerably low-cost material, easily transportable and fast to build which allow for wide humanitarian response in different relief stages. But in comparison with tarps and asper (United Nations, 2004) metal sheets are a more costly alternative to plastic sheeting and require more skill to be used, nevertheless, they are more durable with an extended life span if used a proper specification.

However, metal sheets are a well-known example of poor performance construction material thermally and acoustically, which required additional protection layers, shading strategies and insulation to reduce the effect of such poor performance. Additionally, it could depreciate quickly due to corrosion issues, especially in humid or marine locations. Therefore a protection layer is required to protect from corrosion. Some types of corrugated sheets are made or coated with aluminium which means higher durability and corrosion resistance, others are aluminium corrugated sheets which are very lightweight with no corrosion issues, but these alternatives come with a higher cost. Another type is the bitumen corrugated sheets which have a lower cost than metallic sheets and do not rust with better thermal and acoustics properties, however, it is available in very few sizes and is not yet widely available and have low resistance to fire.

Other alternatives are plastic corrugated sheets which is a lightweight material and low cost but has poor resistance to wind and shocks, similarly, the fibreglass corrugated sheets which are transparent and good for windows but comewith higher cost.

However, IFRC (2016) declared that the galvanized corrugated sheets are still the more widely available material with fairly low cost, that is used universally as cladding and roofing materials in different types of shelters (low cost, self-built, and humanitarian shelters). The IFRC also highlights the potential raising of other alternatives such as the bituminous corrugated sheets. Additionally, the stability and the durability of the CGI sheets will vary due to different specs such as sheets thickness, dimensions, and type, corrugation size, also coating type and thickness.

The corrugation of the sheets which is the key to getting fairly strong sheets from a very thin material, cause further challenges in the ease of use, such as air leakage, and the difficulty in expanding due to the fact that not all corrugation shapes are identical so extensions of the same roof or wall may not be possible unless the added sheets have the exact same corrugation shape and size otherwise it will simply not overlap properly which will cause water and air leakage issues and will greatly affect the performance of the shelter by reducing the versatility of use for this material compared to tarps. Additionally, a lot of the guidelines recommend anchoring the CGI roof with nails which actually reduce the reuse capability of the material as it becomes perforated.

Finally, Both tarps and CGI required structural support of timber, lumber, coconut wood, bamboo, metal frames, or any other methods of support to be fixed properly. CGI requires more frames to allow for the sheets to be fastened stably, but tarp due to its good performance with tension can span longer distances if fixed tightly and requires fewer materials for structural support.

**Figure 4.2-6.** CGI roofing for transitional bamboo shelter in Nepal, **(IFRC, 2016)**

The figure above shows an example of the implementation of a CGI roof for a bamboo transitional shelter in Nepal.

### 4.3. Locally-built shelters

Local shelters are the shelters that are constructed using local materials, technologies, and/or traditions. United Nations (2004) declared that “local shelters solutions could vary from simple structures for emergencies to a more permanent durable structures solutions.” (Better shelter, 2021a) declared that “local solutions tend to be cost-effective, better stimulate the local economy and will more likely fit local culture and customs”.

The elimination or reduction in the cost of the transportation of the shelters (components/materials) is the major contributor to the cost reduction in local sheltering solutions, Additionally, familiar materials and familiar building solutions to the population enables self contribution in the process of materials extraction, production, and implementation .This also reduces the labour costs and makes it a cost-effective solution especially for long-term displacement.

Furthermore, localised design and build strategies are more likely to be socio-culturally appropriate as it has evolved over time in local manners, and enables the implementation of a self-built approach which could allow the FDP to customise, personalize, maintain, expand, and upgrade their shelters, that enhance the sense of pride and belonging. Furthermore, it is using local materials, manpower, and expertise so it tends to stimulate the local economy while responding to the emerging needs and economy of the FDP, this can increase the level of acceptance within the host community. However, it tends to use locally available natural materials, which need to be used at renewable rates to ensure the sustainability of the proposed solution especially in the case of the construction of full camps. Moreover, unsustainable use of local natural materials not only could cause environmental harm but also escalate the potential rejection of the host communities for the FDP, due to the unwelcome results of the rapid settlements on their environment, which could reduce the community resilience and delay the recovery of the FDP and eventually cause a conflict.

Locally available materials (LAM) could be any material that naturally exists or is manufactured, but is widely available locally, cost-effectively, suitable for construction, environmentally sustainable, and socio-culturally appropriate. such as timber, Bamboo, palm trunk, coconut wood, stones, sticks, straw, palm fronds, leaves, earth, adobe, available plastic sheeting, metal sheeting, concrete blocks and even steel frames, including materials for recycling, such as tyres, plastic or glass bottles, and so on.

#### 4.3.1. Framed shelters using LAM (Locally Available Materials)

It is possible to create a shelter by constructing a structural frame using locally available materials (LAM) such as wood poles, timber, limber, coconut wood, palm wood, Bamboo, bush wood, etc. This framed structure can establish the versatile use of the available materials for covering the erected frame to initiate the shelter envelope, starting with covering it with UNHCR tarps especially for roof and floor. Alternatively, corrugated sheets can be used for the roof, and possibly for walls, however, walls can be upgraded later on by (LAM) covering especially natural materials, such as thatch cladding, woven bamboo curtains, woven sticks panels, sliced bamboo panels, daub and wattle, lath and plaster, and so on. Additionally linear and shade net, dried grass or thatched roof, mud and earth cover, etc. can be added to the roof to improve its insulation, reduce the heat gain and enhance the envelope passive performance.

The appropriate solutions could be directed by the vernacular architecture of the local region, additionally, innovative upgrades can address better resilience, however, the population building skills and the locally available materials at the time of need could indicate suitable and cost-effective solutions that can allow the population to contribute, customize, personalise their shelters toward adequacy, nevertheless, training could enable the population to learn the essential skills for building with LAM.

Framed shelters shapes and systems can differ due to local practice, type of available materials and expertise. The next figure below show some of the different simple framed structure that has been used for humanitarian shelters in different regions as emergency-transitional-shelters.


**Figure 4.3-1.** Shelter frames covered by LAM, collected and represented by the author from UNHCR shelter design catalougue, **(UNHCR, 2016).**

### 4.3.1.1. The liability of the structural frames in humanitarian sheltering.

The structural frame should be stable and enhance the shelter resistance against the potential external loads especially wind and seismic loads, in addition to flood and fire risk, to ensure the safety of its occupants and enhance the resilience of the FDP, which lead to an effective response that avoids repeated calls for sheltering relief and initiation of early recovery. (IFRC, 2016)

The below figure shows the four effects of wind and seismic loads on shelters as the following: sliding, racking, overturning, and uplifting. Side by side figure represent an example of the racking effect on a shelter in thePhilippines in 2016.

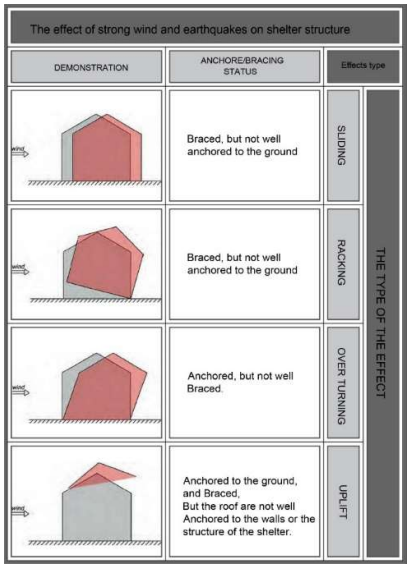



**Figure 4.3-2.** Sesmic and strong wind effect types on shelter, reproduced by the Author from **(IFRC, 2016)** .

**Figure 4.3-3.** Example of racking effect after Tayfoon Haima, 2016, Philippines, by **(IFRC, 2016)**.

After all, structural frame stability should be ensured not only through the proper selection of the available structural frame elements due to its availability, price resistants, strength, and implementation difficulty, which define the material durability, lifespan, and its ability to be reused within an incremental sheltering process. But also by proper bracing and anchoring techniques of the structural frame. Bracing is the process of adding diagonal supports for a rectangular structure in order for the frame to withstand horizontal forces or loads. A technical solution that is an effective technique for enhancing seismic and wind structural resistance of the humanitarian shelters, **Figure 4.3-4** explains the importance of bracing in rectangular structural frames.

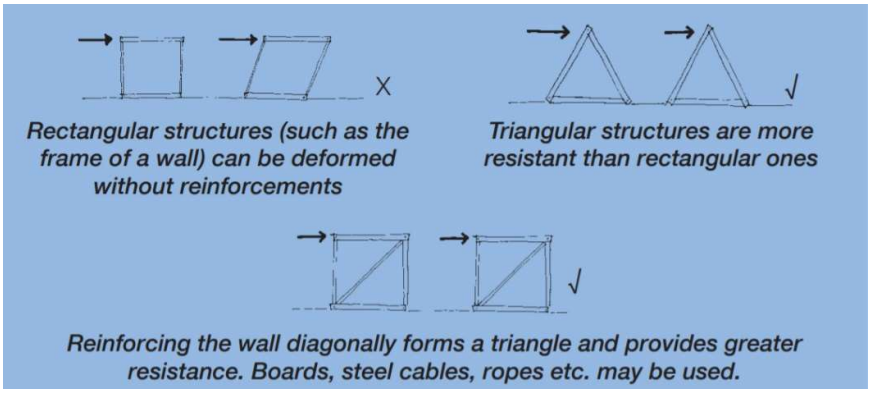



**Figure 4.3-4.** The importance of frames bracing, by **(IFRC, 2009).**

Anchoring is the process of securely fastening the connections between the frame elements, walls with the roof and/or the whole shelter with sufficient foundations that have different types of recommendations due to geolocation, soil investigation results, and the proposed shelter solution. Recommendations and guidance for proper connections details, fasteners and proper foundation system selection for common local and global building techniques has been discussed widely in many standards and guidelines such as the transitional shelter guideline that was published by the shelter centre in 2012 (Shelter Center, 2012).

Furthermore, the structural frame of the shelters should withstand the potential additional weight of the upgraded LAM, which could vary due to the type of added material. For instance, UNHCR standard tarps could weigh between 180 to 250 grams per square metre (NRSrelief, 2021) but thatched roofing with a thickness of 35 cm to 45 cm will weigh 45 to 75 kg per square metre (Thatching, 2018). So the structural frame elements strength in addition to its design can define the load-bearing capacity of the proposed structure, moreover the structure frames that are initially constructed in the emergency stage are more likely to have a very low bearing capacity. This is why upgrading these shelters tend to be with lightweight roofing that includes CGI roofing, lightweight additional LAM insulation or shading layers, such as woven mats). Enhancing the bearing capacity of a frame structure is quite challenging, that requires a new structure for a more durable solution which is more likely to be not available, costly, and/or are not compatible with an incremental approach which delays the initiating of population recovery. For that reason, upgradable structural frames solutions and designs could initiate the early shelter incremental envelope upgrades towards adequate shelters possibly using more durable materials.

To conclude, the adaptive capacity of the structure frame is not only related to its durability, stability, resilience, and load-bearing capacity but also related to its capability to be a responsive element that addresses one or more of the seven characteristics of the previously defined ADS (relocatable, upgradable, reusable, recyclable, sellable, and transformable) such as interlocking structural frames that could initiate for easy assembly and dismantle, or a structural frame that accepts additional support to enhance its load-bearing capacity. Here is where further research can be carried out to develop effective strategies for structural frames with high adaptable capacity.

To summarise**,** the characteristics of reliable structural frames that are compatible with the incremental process are:

Table 8. The characterestics of reliable structure for Adabtable shelters. By the Author (2021).

| |
|---|
| **Stable.** |
| **Hazard resilience.** |
| **Durable.** |
| **And responsive to ADS Characteristics** |

### 4.3.2. Bamboo framed shelter

Bamboo is a renewable fast-growing material that can grow to reach effective strength in a couple of years, with potential versatile use, such as (Bamboo frames, wall curtains, and weaved panels) which presents a low carbon and disaster-resilient alternative to conventional materials. It has a natural efficient structure due to the longitudinal hollowness and fibres which provide a lightweight tubular constructible element (HeritageFoundationPak, 2012). However, untreated bamboo is a non-durable material, preservation with safe, environment-friendly chemicals can increase its durability, and similar to wood the bamboo should be dry before being used as a building material. (IFRC, 2016).

**Case studies:**

#### 4.3.2.1. Nepal floods, 2017

In August 2017 heavy rain caused heavy flooding which resulted in massive damage to houses in Nepal. A sheltering project which aimed to enable early recovery to the affected population using bamboo as locally available materials was designed to include risk reduction features. The involvement of the affected communities, that lead to shelter upgrades by the beneficiaries, and paved the way for a long-term construction programme that aimed to address land tenure issues.

The shelter used an untreated bamboo frame, with CGI roofing and replaceable tarps. With risk reduction measures such as raised flooring to mitigate flood risk, plastic sheet wrapping to the poles underground to protect the frames from ground moisture and increase the shelter frames durability, tied down CGI roofing by bamboo with lashing connection to avoid the CGI nailing so as to not perforate the sheets which allows for further dismantling and reuse. Additionally, bamboo bracing, anchoring, and lashing connection were used to ensure a reliable framed structure.

**Figure 4.3-5.** Bamboo framed shelter, with bamboo mats for walls, Nepal floods, 2017, reference **(Global Shelter Cluster, 2019).**

The occupants have upgraded the shelters by, using the tarps as waterproofing layers, plastering the walls, and enhancing the flooring finishes. Also, the life span of the shelters have been expanded by changing the usage type of the shelters such as renting them as temporary accommodation for workers. Additionally, reuse of the shelter components in another construction. Local cultivators and business has benefited from the use of bamboo as locally available materials, and the local building culture has been inforced by adopting local building traditions, additionally, the improved population construction skills allow them to self-perform maintenance, repairs, expansions, and upgrades to their shelters.

#### 4.3.2.2. CG transitional shelter

This is a bamboo structure shelter constructed for FDP due to the 2015 earthquake in Nepal. CG Ashraya project built around 3000 transitional shelters between 2015 and 2016 with the aim to provide, innovative, affordable, home-made shelter, that using locally available materials, which can be reused or upgraded to a semi-permanent shelter. due to this project, people were able to move from their tents to their self-built transitional shelters, with an estimated life span of 3 to 5 years. However, some of the families who moved to permanent houses are still using the shelter to obtain additional income by renting them to other people, but, others still live in their transitional shelters as they cannot afford to build a permanent house. (Reliefweb, 2019).

**Figure 4.3-6.** CG Ashray Transitional shelter, collected from **(Reliefweb, 2019).**

The shelter is a bamboo frame structure with CGI roofing and sliced bamboo are used for walls to create a curtain, that provides privacy and allows for natural ventilation. The walls can be upgraded on-site by the implementation of mud plastering to the bamboo curtains similar to daub and wattle vernacular technique to create durability. This upgrade was especially done to the lower part of the curtains to protect from flood and rain, while the upper part remains a lightweight breathable bamboo curtains.

#### 4.3.2.3. T-shelter Pakistan 2010

The conceptual design of the previous case study is an upgraded version of a similar design of transitional shelter that has been used in northern areas of Pakistan in 2010 as a response to sheltering needs after a flooding disaster.


**Figure 4.3-7.** Bamboo framed Transitional shelter, Pakistan, 2010 **(IFRC, 2011).**

The shelter is a hybrid combination of materials, using a bamboo frame structure with a low brick wall 90 cm in height and tarps for the higher parts of the wall in addition to the CGI roofing. The low brick wall provides thermal quality and flood protection to the shelter and the tarps close the draughts which could allow for the winterisation of the shelter that is appropriate for cold climate regions. The frame can be provided in different alternatives such as wood poles and cut timber, also the thermal wall could be provided alternatively by using unfired earth brick such as SSBs (stabilized soil blocks).

Another example has been used as an emergency shelter for an immediate response that can be upgraded and extended that is culturally related due to the use of local building techniques, which enhance the solution appropriateness and population acceptance.

### 4.3.3. Thatching, weaving panels, and clay plastering techniques.

Thatching is the process of weaving and/or layering dried vegetation (botanical) materials such as sticks, straw, grasses, reeds, leaves, palm leaves, and bamboo strips to create screens, curtains or mats that can be applied to the roof and walls, see **Figure 4.3-8** and **Figure 4.3-9**, which protects the roof from water leaking if applied successfully with proper sloping. It also provides an insulation layer due to the trapped air within the thatch. Additionally, weaving thatch into screens or curtains could provide a lightweight wall that provides privacy but is still breathable which is usually suitable for the hot and humid climate that required proper ventilation. Furthermore, plastering the thatch walls with muds similar to the vernacular techniques of wattle and daub or lath and plaster is an effective method to upgrade the lightweight walls to be more durable, secure, with thermal mass properties. See **Figure 4.3-10** and **Figure 4.3-9**.

**Figure 4.3-8.** Woven Roof mat, in Pakistan , IOM **(Shelter Center, 2012).**

**Figure 4.3-10.** Plastering the Thatch walls with mud, By Architect Yasmeen Lari, **(Andreea, 2020)**


**Figure 4.3-9.** Temporary shelter in Srilanka 2009 of a returnee family next to their destroyed house in Srilanka 3 decade civil war. **(Global Shelter Cluster, 2019).**

**Figure 4.3-11**. Plastering woven thatch wall, Quincha mejorada, Peru, **(Shelter Center, 2012)**

Example case studies presented below:

### 4.3.3.1. South Sudan 2017-2018 conflict

Since 2013 an ongoing conflict resulted in a 1.9 million displaced population, an upgrade of the existing

**Figure 4.3-12.** Bamboo Thatching and grass roofing for existing shelter upgrade, in South Sudan, **(Global Shelter Cluster, 2019)**

shelters in western Bahr Alghazal state was conducted, in order to empower the occupant's self-sufficiency, expand the life span of the shelters, stimulate the local economic activity, and increase the beneficiaries satisfaction. The existing shelters are timber-framed shelters covered with tarpaulin, and the upgrade project added a layer of locally available dry grass to the top of the shelter roof to shade and ventilate the roof which will enhance the inside temperature of the shelter. Furthermore, bamboo thatched panels and doors were installed to the exterior of the shelters to enhance the privacy and the durability of the shelters. The project also involved skills training for the thatching of the bamboo curtains.

### 4.3.3.2. Congo 2018

A transitional shelter was designed in consultation with the FDP due to the escalated conflict in the Kasai region of the Congo. The shelter design used localised building strategies and techniques such

**Figure 4.3-13.** Cost effective shelter built with locally available materials, Congo 2018, **(Global Shelter Cluster, 2019)**

as wattle and daub or mud-blocks with thatched roof . The process allows for the involvement of the community and stimulates the local economy, however, a skill training programme was conducted to ensure the construction of safe shelters. Labour was provided by the affected population, women have led the process of local materials collecting such as sticks, palm leaves, ropes, reeds, soil, etc. and men prepare the materials before the construction. The design helped to mitigate the risk of tension in the host communities, as the solution was in harmony with the existing housing solutions in the area. A balcony was part of the proposed design which allows for an extended external shaded space for cooking and other activites.

### 4.3.4. Wooden framed shelters

A project in Ajuong Thok refugee camp, South Sudan in 2013 has been implemented to provide transitional adequate shelters to the occupants with a lifespan of 1 to5 years, by building a wooden gable frame from the locally available wood poles such as bushwood, timber, or bamboo then covering the frame with UNHCR standard tarps.

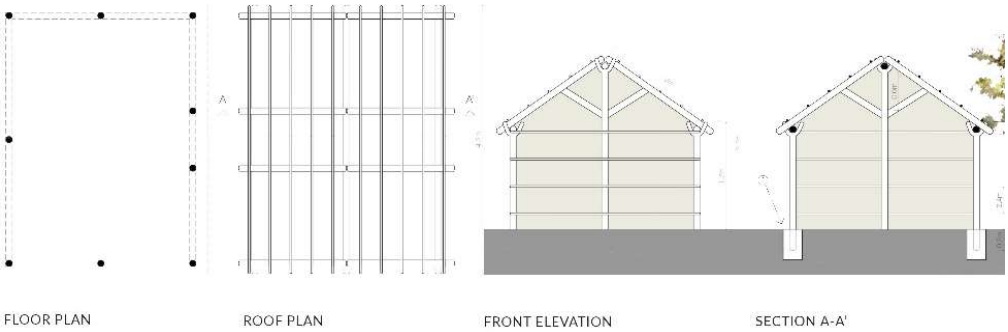



**Figure 4.3-14**, Wooden Gable frame shelter, in south sudan, (UNHCR, 2016)

Later on, the shelter envelope was upgraded using LAM such as thatch screens of straw or grass cladding that is rendered with earth plaster. The roof has also been replaced with a CGI sheet and

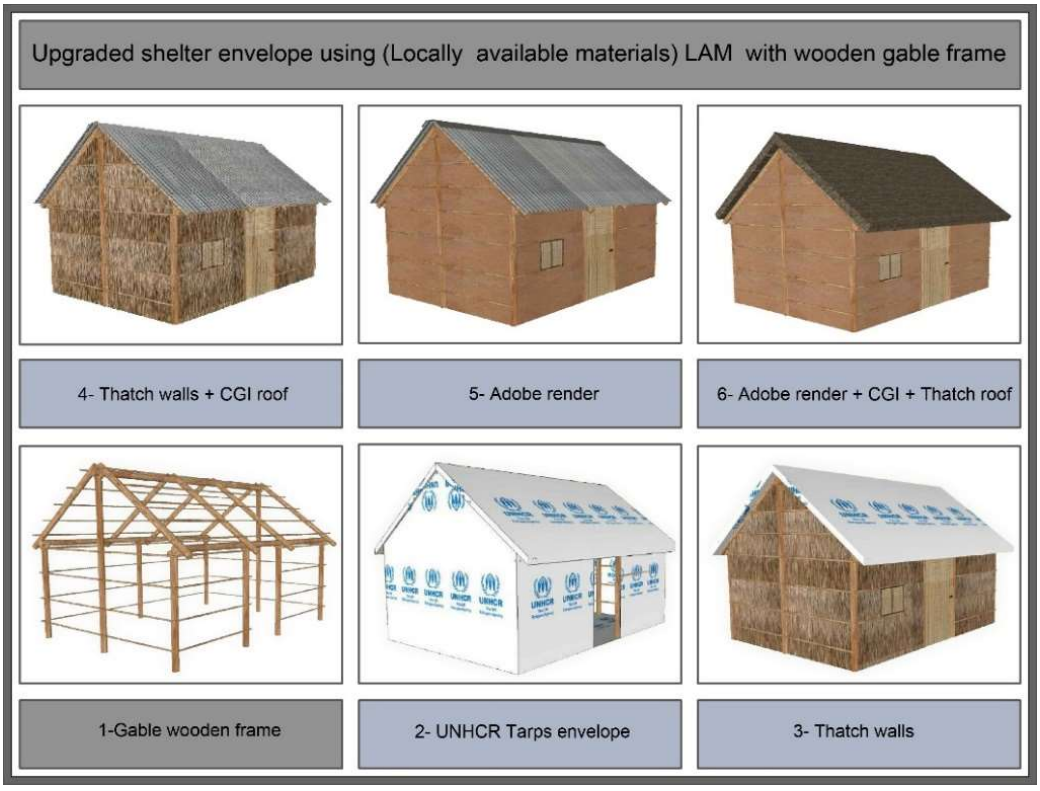



**Figure 4.3-15.** The potential use/upgrade of the LAM with Gable frame structure. By **(UNHCR, 2016).**

covered with thatched straw or dried grass **(UNHCR, 2016).** Figure 4.3-15 shows the upgrade options of the shelter envelope using LAM.

### 4.3.5. Durable Locally built shelters solutions.

When it is possible, locally built shelters could be directly built on semi-permanent means by using more durable materials such as adobe,brick, and concrete blocks with cement mortar, if available locally as a cost-effective option. The process of providing durable shelters are usually labour intensive and a time-consuming process that provides durable/ mass walls and longer shelter lifespans usually more than 5 years. See **Figure 4.3-16**

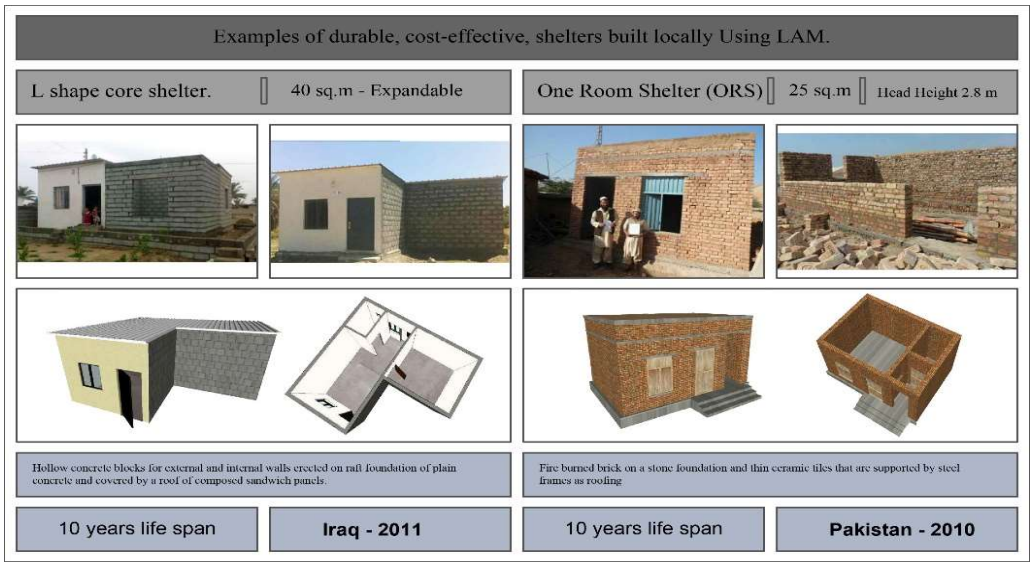



**Figure 4.3-16.** Examples of durable Locally built shelters with LAM, Collected by the Author from **(UNHCR, 2016)**

#### 4.3.5.1. ORS, Pakistan, 2010 - 2012

The one-room shelter program (ORS) was initiated in Pakistan after the 2010 flash flood as a response that aimed to help the vulnerable population to return to their location of origin by providing them with safe, durable, cost-effective and environmentally friendly shelter solutions.

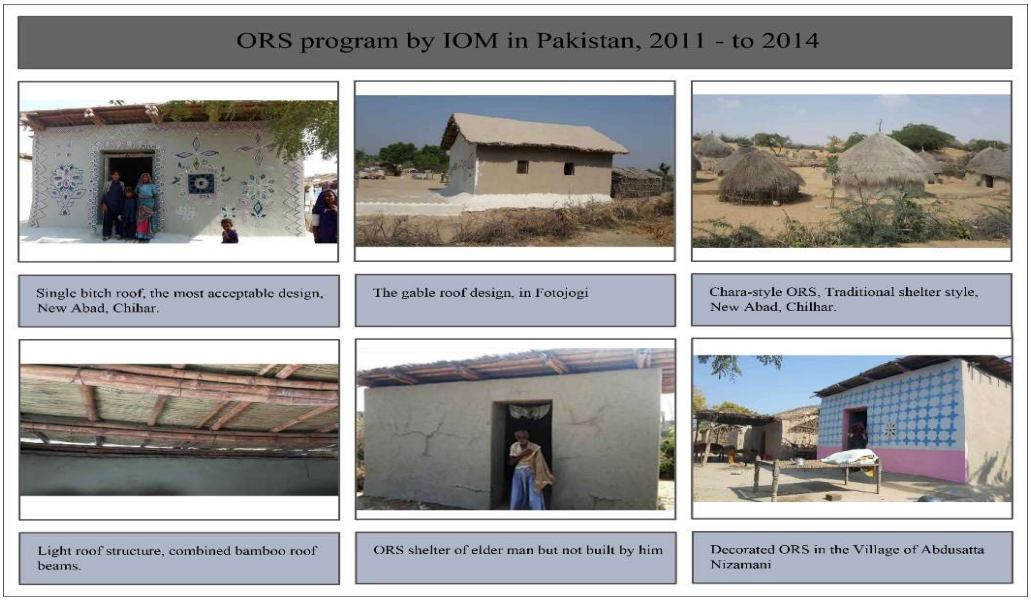



**Figure 4.3-17.** One room Shelter Program By IOM, Collected from **(Corsellis *et al.*, 2014).**

The core shelter comprised of one room combined with a private latrine and kitchen **(UNHCR, 2016).** These were erected using LAM such as fire burned brick, stabilized brick, and cob with a stone

foundation and lightweight roofs using thin ceramic tiles that are supported by steel frames or a bamboo framed roof with thatch and mud as roofing. The shelter of 25 sq.m, took a week to be built with a team of 4 people for an intended life span of 10 years. See **Figure 4.3-17**.

The initiated programme evolved over the next few years with the help of the The International Organization for Migration in Pakistan (IOM). The provision had been provided not only to support the FDP but also to enhance the resilience and reduce the community vulnerability to future disaster to become one of the lead projects to address DRR (disaster risk reduction) in flood response.

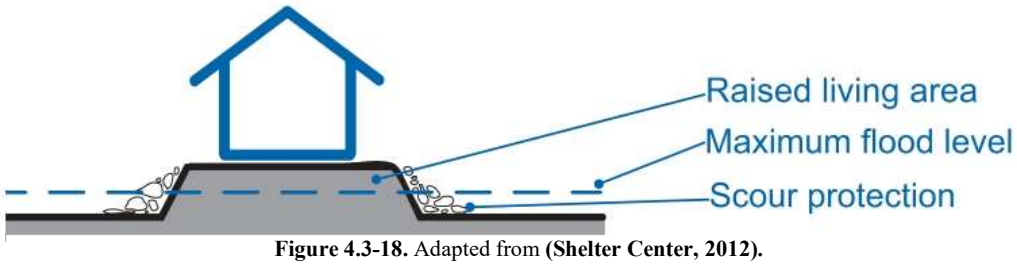



**Figure 4.3-18.** Adapted from **(Shelter Center, 2012).**

As a result,multiple provisions of enhanced traditional shelters using locally available natural materials that are enhanced flood resistance shelters has been promoted with the recommendations of lighter roofs, raised floors such as elevated plinth see **Figure 4.3-18** and thick walls (Corsellis *et al.*, 2014). These have been suggested to better address the socio-cultural appropriateness of the different communities living in the region. These traditional solutions aim to provide the FDP with a sense of pride and self-sufficiency. See **Figure 4.3-19**

**Figure 4.3-19.** ORS Flood resistance, and personalized shelter, in Pakistan 2012 **(Corsellis *et al.*, 2014).**

#### 4.3.5.2. Twin L shape shelter, Iraq, 2011

Similarly in Iraq in 2011 a project to construct core shelters was intended to be constructed to maintain a minimum living standard to support the re-integration of the returners and IDPs within their origin areas, and ensure sustainable return. Twin L shape core shelters, each consisting of two rooms, kitchen and toilet, with an area of 40 square metres was constructed using hollow concrete blocks for external and internal walls using cost-effective locally available materials. It was erected on raft foundation of plain concrete and covered by a roof of composed sandwich panels. The shelter required a 3 weeks construction period with a team of 5 but could be used for 10 years.

The L shape provision of the core shelter provides the occupants with the option of expanding by building an additional room in the inner corner of the L shape building to continue the building box shape See **Figure 4.3-16**. Such solutions with permanent means and durable materials when possible

can effectively deliver an early recovery response that could lead to sustainable community development.

In this method of shelter construction, the envelope durable materials become the load-bearing element which leads to eliminating the need for structural frames except for some types of roofing that required a support frame to secure the roofing. However structural specific recommendations should be considered to ensure safe and stabilised structures. Earthquake resilience measures should be considered with emphasis on load-bearing mass walls constructions. A recommendations in the Transitional shelters guideline **(IFRC, 2011)** is to have a simple layout for earthquake resilience design, and in the instance of an addition or expansion it is preferable to construct a structurally isolated addition.

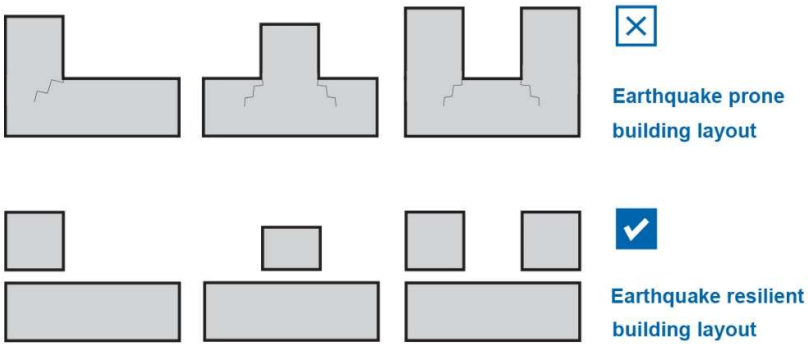



**Figure 4.3-20.** Recommendations of Earthquacke resilient layout **(IFRC, 2011).**

Additionally, this kind of solution requires intensive labour-power which can be achieved by the community involvement and the implementation of a self-reliance approach including women, especially for communities with a culture of self-building. However proper support and training programmes can enhance the shelters quality through the self-building approach.

### 4.3.6. Earth shelters.

Transitional shelter guidelines refer to many traditional/vernacular building techniques, that use mud, clay, soil, and dirt especially in the construction of walls. Other materials include, compressed earth blocks (CEB), or also called stabilized soil blocks (SSBs) in addition tointerlocking stabilised soil blocks (ISSBs), adobe, supper adobe, cob, rammed earth, wattle and daub, and lath and plaster. The CEB or SSB is a mixture of soil and stabilising agent (cement or lime) that is compressed in blocks shapes. Adobe blocks usually use a mixture of clay and straw, additionally, the ISSBs is a variation in the shape of the blocks to allow for block interlocking with each other, on the other hand, cob does not blocks but uses a the mixture to directly moulded into a free form of walls and roofs. Rammed earth uses temporary moulds to create formed walls, whilst wattle and daub involved wooden frames that is filled with the earth mixture. Similarly lath and plaster use wooden screens that are plastered with the earth mixture. (UN-Habitat, 2009). It can be seen that each type has its own building technique and/or a variation in composition, therefore in this research earth shelter will refer to the shelters that are using soil as a major construction material.

**Figure 4.3-21.** Visualization of different Earth buildings methods, By the Author from the original photos of **(UN-Habitat, 2009)**

Earth shelters are more likely to be cost effective than modern alternatives such as cement blocks, and or fired blocks. Additionally, it is less environmentally harmful and can deliver climate-responsive shelters that are mainly using soil as a widely available material that can be reversed to nature. However, Earth shelters construction tends to be a time-consuming building method, and labour

intensive, therefore it could be not suitable as emergency shelters when required to be erected fast and in great numbers. Also mud and bricks require water availability for mixing, additionally, rainwater could cause erosion damage, so cement or lime can be added to make it more durable, and a layer of lime plastering or painting could serve as a protective layer. Finally overhangs can reduce the wall's exposure to rain slashes. Furthermore, earth walls are commonly used to deliver durable sheltering solutions or to upgrade a transitional shelter envelope due to their properties of being fire-rated walls that are secure, thermally massive, simple to construct, widely available and cost-effective..

#### 4.3.6.1. Air-dried stabilised adobe brick shelter - Kigoma Region, Tanzania, 2015

Air-dried bricks have been used to erect 18 square metres of living space adobe shelters in the Kigoma Region, Western Tanzania in2015. This was a national strategy to ensure the apid upgrading to durable shelters to accommodate arrivals from Burundi and Democratic Republic of Congo due to the civil unrest in Burundi and the vulnerable FDP living in temporary tents. Therefore 20 by15 metre plots have been allocated for each family to allow for the family to stay in the temporary shelter or tent while the construction of the durable house in the same plot is still in progress. The plot size was sufficient to provide enough space for a kitchen, an individual latrine addition and a garden.

**Figure 4.3-22.** Air dried Lime stabilized adobe Transitional shelter next to the Tent tshelter that the family was living in, Nduta refugee camp, **(Shelterprojects, 2017)**

The shelter design was compatible with the local climate (hot day and cold night) as the bricks provide good thermal insulation properties. Nevertheless, the low tech shelters provide the occupants with the ability to self-maintain and upgrade due to the technical ease, of dividing, extending and adding to the shelter. Locally available materials (lime and clay) allow the population to be integrated in the process of brick making and construction, which leads to an enhanced sense of pride and ownership (Shelterprojects, 2017). Additionally, in this project air-dried stabilised adobe brick shelter was defined

**Figure 4.3-23.** Air dried adobe, Lime stabilized, in Nyaragusu refugee camp, Tanzania, **(Shelterprojects, 2017)**

as the most environmentally harmless due to the elimination of the brick firing process, and a socio-cultural acceptable sheltering solution that stimulates the local economy and provides the ability of self-construction approach. Additionally, a strategy for the restoration of soil extraction was adopted as a parallel project including planting banana trees in the pit as part of the restoration strategy. However, drying the bricks was a problematic during wetter months.

#### 4.3.6.2. SSBs walls (Stabilized Soil Blocks), Sakkali, Sudan, 2010.

**Figure 4.3-24.** House built by SSBs in Sakali settlement, South Darfur State, Sudan. for IDPs vulnerable families, **(UN-Habitat, 2012)**

Another example in Sudan, Khartoum and Darfour states UN Habitat and the government have developed a programme to support the return, the integration, and the recovery of the IDPs due to war, drought, and poverty in a sustainable manner using alternative construction methods. The UN Habitat in the National Conference of Sustainable Urbanisation in 2010, demonstrate SSBs technology as an affordable, good quality reconstruction material, and effective in deforestation prevention by eliminating the burning process of the fire burned brick (UN-Habitat, 2012). The figure above represents an example of an IDPs vulnerable family house built by SSBs, in Sakkali, South Darfour, Sudan in 2010. The option of using SSBs technology allows for temporary settlements of the returners to be upgraded from tents to upgradable permanent shelters which integrate early recovery approach successfully into the response. See **Figure 4.3-25**.

**Figure 4.3-25.** Upgrading settelments from tents to houses using (SSBs). **(UN-Habitat, 2012)**

#### 4.3.6.3. Super adobe shelters

Super adobe shelters are shelters that are constructed using long sandbags filled with earth and stacked in layers to form the dommed living spaces. The technology was developed by the Iranian architect Nader Khalili, who is the founder of Kal Earth Institute and has been sponsored by the UNDP/UNHCR to build these an emergency sheltering solutions for FDP due to the ease of converting to more permanent structure due to proper finishes applications.

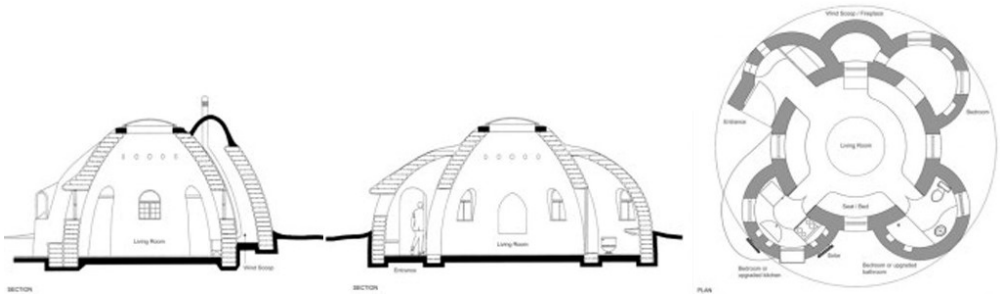


**Figure 4.3-26.** Construction drawings of the super adobe shelters in Ahwaz region, Iran **(Khalili, 2004)**

The prototypes that were designed and implemented in 1992 in the Ahwaz region, Khuzestan province, Iran by Kal Earth Institute consisted of arch-shaped sandbag walls plastered and painted with ime mortar, and asphalt that is burned to provide a ceramic finish that is waterproof., This project has been awarded the Agha Khan award in architecture for the cycle of 2002 to 2004 **(Khalili, 2004).**

**Figure 4.3-27.** The buildings erection of the Aga khan awarded project **(Khalili, 2004).**

The project has be marked for wider implementation all over the world as it is a simple alternative, affordable, seismic, flood, and fire-resistant, sheltering technology that provides temporary sheltering with a thermal mass envelope using mainly a widely available material which is sand.

#### 4.3.6.4. Super adobe community-building - Zaatari Camp, 2018

A super adobe community building has been erected in 2018 at the Zaatari camp, in Jordan. This was funded by Oxfam International as a pilot temporary building to dignify the future of Syrian refugees that are unable to return home and still living inside caravans after 10 years of displacement. (CalEarth, 2018).

**Figure 4.3-28.** Community building in Zaatari camp, Jordan, pilot project. **(Albarada *et al.*, 2018)**

#### 4.3.6.5. Thin tile vaulting


**Figure 4.3-29.** Single curved low rise thin tile vaulting slab supported by load bearing walls, **(Ball *et al.*, 2014)**

Thin tile vaulting is an affordable but labour-intensive technology, and allows for multi-storey construction. It was developed on the Mediterranian shores as a popular low-cost building technique, using local building materials. It is a thin layer of interlocking tiles that form self-supporting arches which allow for wide spans by using local materials without the need for steel reinforcement or form work during the construction. This makes it a low-cost building method that provides durable sheltering solutions. Different types of geometrical slabs can be produced such as: single curved thin-tile vaulting slab, low rise vaulting and high rise vaulting, in addition to, free form vaulting.

These vaults are versatile as they can be used as flooring, roofing and as a free form building material.

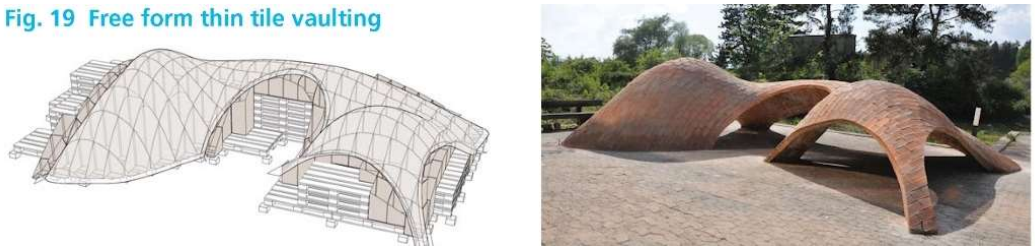



**Figure 4.3-31.** Example of the free form thin tile vaulting, , **(Ball *et al.*, 2014)**

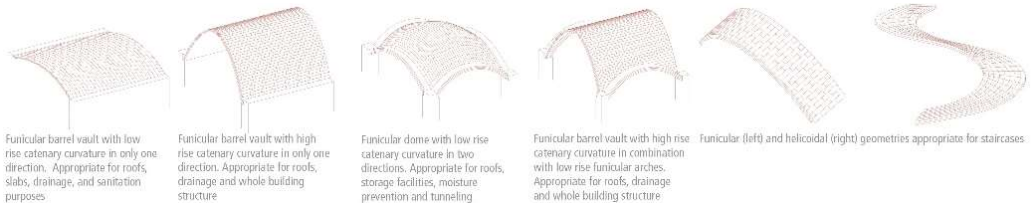



**Figure 4.3-30.** Thin tiles slabs common geometries that serve defferent purposes, **(Ball *et al.*, 2014).**

Additionally they can be used for different types of structures like shelters, communal buildings and sanitation facilities, and for infrastructures such as water tanks, drainage and underground trenches.

The thin tiles are produced from raw materials such as clay, lime and sand which are widely available materials and usually can be locally provided in a process that does not require any electric machinery, which reduces the embodied energy that resulted from the process of extraction, transportation, production, and implementation. Additionally in small spans the construction in thin tiles vaulting do not require form work during the construction, however for longer spans it does require temporary support. The manufacture of tiles can be produced using stabilised soil techniques by adding a small proportion of cement.

However, training and technical advice are required to ensure its safe and successful implementation. Also for thermal purposes, the vaults are more efficient surfaces regarding heat gain and loss than other geometrical surfaces, so the shape factor helps regulate temperature fluctuations, as rounded roofs generate their own shaded areas throughout the day therefore, thin-tile vaulting reduces the need for

active heating and cooling. When combined with additional layers such as earth it provides a thermal mass for the envelope.

The thin tile vaults can be built using three building materials - the tiles which are fired or stabilised soil, the fast setting mortar that binds the first tiles course which is commonly gypsum or fast setting cement mortar, and the cement mortar that binds the tiles between courses or stabilised earth mortar. The fast setting mortar is the basis of this building technology as it is the material that allows the tiles to be set without the need for form work. The tiles can be provided from the local market or can be produced in the site however it requires a curing time of 3 days to set. This needs to be donein a shaded area to avoid humidity and to gain strength before it goes to the drying process for 28 days where rain should be avoided. This process could be challenging especially in wetter times of the year (Ball *et al.*, 2014).

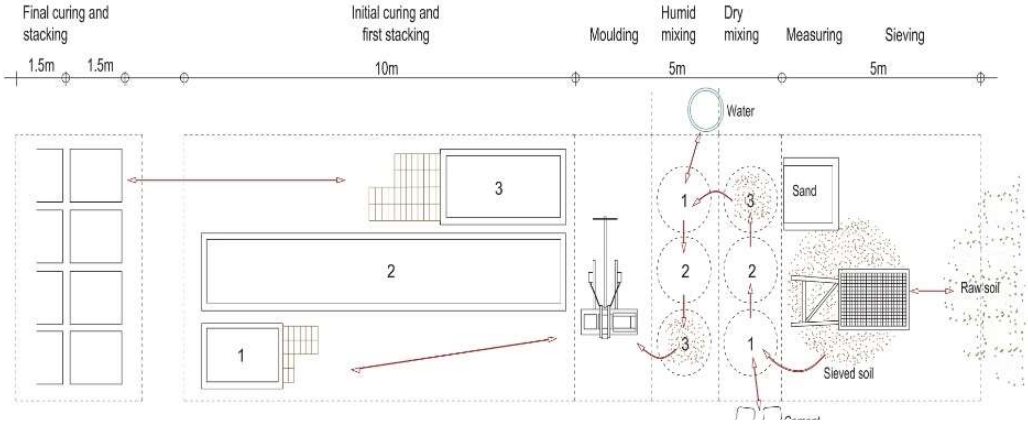



**Figure 4.3-32.** the linear organization of tile production. , **(Ball *et al.*, 2014)**

### 4.3.6.6. Alazraq camp refugee school, Jordan, 2018.

In 2018 EAHR (Emergency architecture and humanitarian right) launched a programme to train the Syrian refugees and Jordanian workers on thin tiles vaulting techniques using stabilised sand and lime mortar in order to enable a cost-effective process of building schools in Jordan for refugees. and These techniques have also been used to build the roofs of the classrooms in Al-Azaraq village.

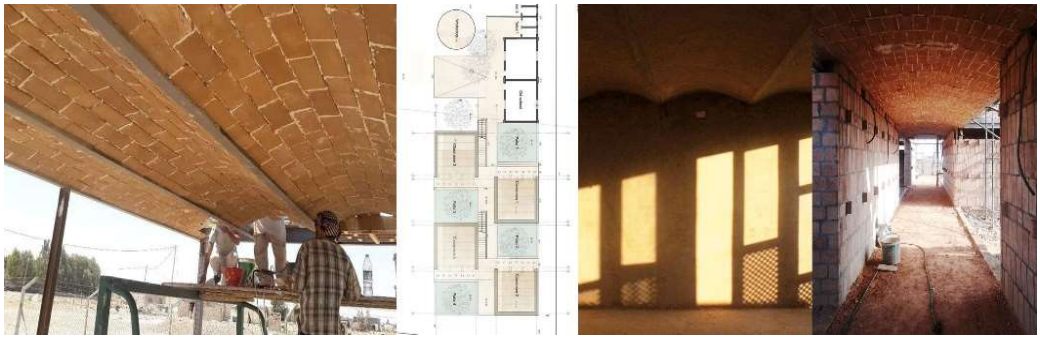


**Figure 4.3-33.** Alazraq camp refugee school **(CERCCA, 2018)**

### 4.3.7. Yasmeen Lari integrated (Earth-Bamboo framed) shelters

A frame structure of bamboo can be assembled in as little as 3 daysMud and lime roofs and walls can provide a thermal mass envelope with better performance and insulation properties. So the earth-bamboo) integration system combined the benefit of these two methods that use widely available materials to provide cost-effective and more convenient shelter solutions for disaster affected populations.


**Figure 4.3-34.** The Green Karavan Ghar, 2010 Pakistan flood. **(HeretageFoundationPak, 2011)**

#### 4.3.7.1. The Green Caravan Ghar, Pakistan, 2010

The Heritage Foundation in Pakistan developed the Green Caravan Ghar ,which are bamboo constructions, through continuous research and experimentation. These were used after the 2010

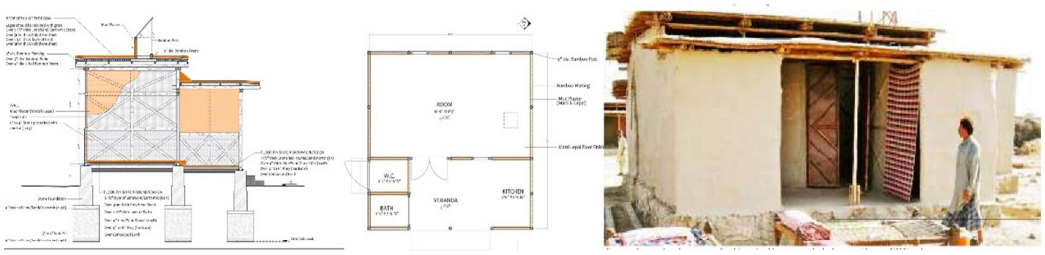



**Figure 4.3-35.** Demonstration Unit, at Koray, Matta, Pakistan. **(HeretageFoundationPak, 2011)**

Pakistan flood (HeretageFoundationPak, 2011). The unit consists of one living space, kitchen, veranda, WC (Water closet), and bathroom. The project has used a bamboo structure frame and fills the gaps with stone and lime as a mortar then plastered with a mud-lime mixture. A more advanced structure has been developed consisting of a two storey floating bamboo structure.

**Figure 4.3-36.** Raised on stilts bamboo structure combined with mud, Health centerand primary school, Village Darya khan Sheikh, (Shaikh and Uthero., 2011)

#### 4.3.7.2. Health centres and primary schools, Darya Khan Sheikh, Pakistan 2010

The above described bamboo structures served as community buildings such as women centres, schools, and health facilities. As a flood resilient measure in low lands, in 2018 more green shelter projects were adopted to target several villages in Pakistan.

#### 4.3.7.3. The Lari Octa Green (LOG) shelter, Sindh province, Pakistan, 2018

These types of shelters are easy and fast to assemble as they are an integrated system of bamboo, mud-lime, and thatched roofs. they use a prefabricated bamboo structure ease of quick assembly and transportation.

**Figure 4.3-39.** LOG shelter using prefabricated bamboo structure. **(Jaimini, 2021).**

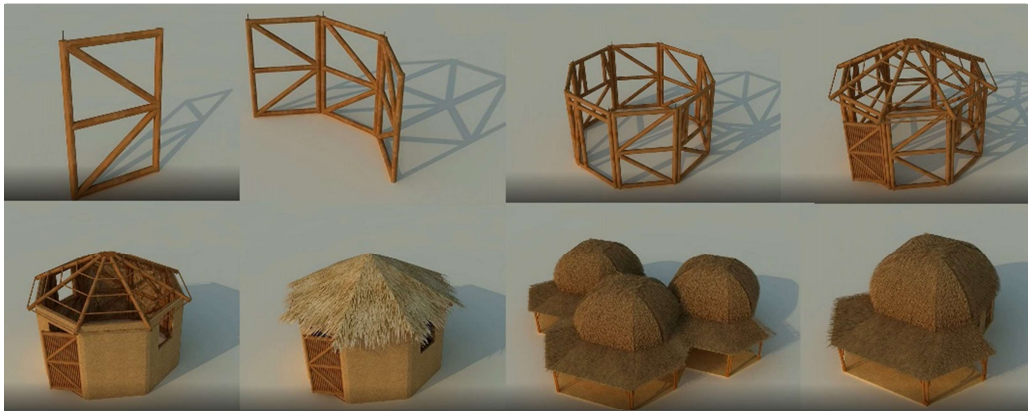


**Figure 4.3-38.** Lari Octa Green, the assembly methodology of the prefabricated bamboo frames, **(Shah, 2020).**

**Figure 4.3-40.** Lari Octa Green cottages (LOG),2019 **(Shah, 2020).**

A combination of these shelters can provide an efficient cluster for one, two or four families, and the integration of renewable energy is possible within the cluster.

### 4.3.8. Mozambique 2021

This project aimed to respond to the humanitarian crisis in the north of Mozambique between 2019-2020. It was carried out by Shelter Cluster Partners who provide material distribution for the IDPs to self-build their shelters. It must be noted that the self-build approach is not suitable for people with special cases such as the elderly and disabled who need further support. Many different shelter designs have been implemented in the response process and reviewed by the aforementioned organisation. One of the implemented designs has been built repeatedly but with different materials.

#### 4.3.8.1. Semi-permanent, Caraco, Pemba, Mozambique, 2020

The shelter is a 26 square metre shelter that is intended to be semi-permanent with a lifespan of 5 to10 years. In Memba Sede, Memba and Bairro Cariaco, Pemba Josina bamboo, local wooden poles "estacas", and "barrotes", and CGI roof sheet have been used to erect the shelter, however, it has been upgraded with mud plastering for the external walls.


**Figure 4.3-42.** Fast solution for permenant shelter in Bairro Caraco, Pemba **(Shelter Cluster, 2021).**

In Mazuane Memba the same shelter design has been built using cement blocks for walls and wood poles and CGI for the roof, which provided strong walls and foundation that enhanced the shelter resilience and security.


**Figure 4.3-43.** Cement Blocks walls permenant shelter in Mazuane, Memba. **(Shelter Cluster, 2021).**

In the same region, a CSEB block has been used with wooden poles and corrugated sheets for roofing, the provision also provided strong foundations and walls for better security, stability and durability with an extended life span of 15 to30 years. However, the CSEB is considered to be a sustainable alternative that is cheaper than cement blocks.


**Figure 4.3-44.** CSEB interlocking blocks Permenant shelter in Mazuane, Memba **(Shelter Cluster, 2021).**

#### 4.3.8.2. The extended shelter in Cujupane, Mozambique 2021

This shelter is a16 square metres with half of the space as an external shaded space for cooking and extended living activity. The proposal used wooden poles, bamboo and tarps as an initial emergency shelter. The use of tarps reduced the shelter life span that required regular replacement or upgraded roofing solutions. The shelter can be upgraded by daubing the walls with mud and the external space can be enclosed later on to extend the shelter size. The use of available natural materials should be at a sustainable rate to reduce the potential environmental impact of uncontrolled collecting (Global Shelter Cluster, 2021).

**Figure 4.3-45.** Addaptive Localizd emergency shelter solution in Cujupane, Ancuabe. **(Shelter Cluster, 2021).**

#### 4.3.9. Core houses with lightweight extension in the Philippines 2015

The project aims to provide a long-term core shelter that is earthquake and typhoon resistant. The houses consist of parts that are made of timber and another parts built using interlocking compressed earth blocks (ICEB) which consist of 90% lime and 10% cement, that is locally supplied. ICEB was selected due to its durability and structural safety. The project population training to ensure safety and disaster risk reduction measures. The design is simple, culturally rooted, and a cost-effective hybrid

**Figure 4.3-47.** the hybrid core houses with lightweight extension, Philipen, 2015 to 2017 **(Global Shelter Cluster, 2019).**

system of ICEB and timber. The window and door arrangement and the design itself which is similar to the common rural house which joins rooms into one that is communal and the other is more private, allow for future expansion, which tends convert it into a permanent house with a life span of 20 years. The programme has initiated a parallel project to solve land tenure issues, and relocation was considered for the families with no permanent agreement, however it must be noted that the adjoining room was made from light-weight material, such as treated coco-lumber which has a shorter life span of 10 years.

This design is an adaptive solution for expanding, upgrading, and customisation, similar to the well-known examples of social housing in Villa Verde Housing in Chile, 2010. See **Figure 4.3-48**.

**Figure 4.3-48,** Example of addition considerations **(Andreea, 2020)**

It allows for for the expansion in the incremental process of the community but in a pre-planned growth scenario. This allows the occupants to adapt and personalise their units to their needs which increase the sense of ownership and belonging.

### 4.3.10. Two storey transitional shelter, Haiti, 2010.

After the Haiti earthquake in 2010, clearing the lands from ruble was essential to initiate the recovery however it required time, funds and effort of removing the destroyed buildings and rubles decreased the available land for temporarily sheltering and the land tenure issue was a struggle. Therefore a neighbourhood approach was adopted by the coordinating organisation to integrate multi-sector planning. This allows for the provision of humanitarian assistance and a platform for the reconstruction process. A project entailing the construction of two storey transitional shelters took place in the Ravine Pintade neighbourhood of Port-au-Prince.after the Haitian earthquake by USAID in an attempt to think outside of tent solutions.

The provision aims to provide appropriate covered living space as an adequate shelter for the displaced population. This provision allows for the more efficient use of space and enhances the occupant's privacy, However, it requires a stronger structure to withstand the load of two levels and additionally required stairs which add more cost and effort to the provision (IOM, 2020).


**Figure 4.3-49.** Tow story transitional shelter for the affected population of Haiti 2010 Earthquick, **(Cluster, 2020)**

## 4.4. Shelters and reclaimed materials.

The possible reuse of materials, in shelter construction, should be a question of its appropriateness, availability, and affordability. The use of reclaimed materials are more likely to be affordable but not always available, or appropriate, however, it is a cost-effective approach to use the constructible reclaimed materials, components, or even full shelters. Additionally, it is environmentally rewarding to upcycle the available pre-used materials instead of disposing or recycling them.

### 4.4.1. Plastic bottles filled with sand

A project in the Sahrawi refugee camps in Algeria demonstrates how innovative use of locally-available materials could enhance the living condition in the camps. Tateh Lehbib self-built a house for his grandmother using plastic bottles filled with sand as a strategy to use locally available pre-used

**Figure 4.4-1.** Filling the collected bottle bags with sand, converting the bottles to a construction material, **(World-habitat, 2018).**

materials to build a flood resilience shelter, community-led project caught the attention of the UNHCR local office and obtained funding to build more durable shelters using similar methods. Similar projects required materials that can be obtained locally and by the community itself so as to reduce the dependency on required external body funding and material distribution which initiates a self-supportive approach to environmentally friendly better sheltering solutions (Lehbib, 2018).

**Figure 4.4-2.** Plastic bottle house, Sahrawi refugee camp, Algeria **(World-habitat, 2018).**

This project which uses plastic bottles reduces the sheltering process impacts on the environment, and reduces the dependency on new materials supply. It has a similar effect to the reuse of salvaged materials after destruction areas due to conflicts.

### 4.4.2. Earth ship using tyres

Similarly, earth ship buildings are using mainly alternating automobile used tyres backed with earth for bear-loading walls. Also used are glass bottles and cans for the filling and cladding of non-bearing walls, additionally, the earth ship houses are implementing some of the passive design strategies especially the temperature stabilising effect of the earth mass and the harvesting of passive solar heating.

**Figure 4.4-3.** Earthship home and outdoor shelter in Adelaide, Australia **(Goodshomedesign, 2018).**

**Figure 4.4-4.** The building process using (earth, old tyres, and used Glass and cans. **(Reynolds, 2021).**

Furthermore, earth ship principles aim to provide an off-grid sheltering solution so it is seeking renewable energy integration such as solar and wind power, also harvesting and filtering rain water, using the greywater for irrigation, and encouraging food production outdoor and indoor. See example

project in **Figure 4.4-3**, also, **Figure 4.4-4** shows the upcycle use of tyres, glass, and cans with earth to erect the walls.

### 4.4.3. Scaffolding structure

**Figure 4.4-5**. construction Methodology of the transitional school in Zaatari refugee camp, **(Franco, 2015).**

In the Zaatari refugee camp a school has been built using construction scaffolding and gravel, this structure was developed by the Pilosio Building Peace organisation, along with architects Pouya Khazaeli and Cameron Sinclairas as an innovative constructible method that uses scaffolding to build a temporary but durable, safe, and comfortable structure that can be dismantled later on. The design uses the scaffolding bars as a frame to hold the grids that stabilise a thick wall of gravel which promotes a well-insulated envelope by using temporary low-cost materials. However scaffolding elements are not necessarily cheap and available but in some cases, it could be available from construction sites and can be reused in humanitarian sheltering response, furthermore, the project presents another effective method to develop the shelters envelope by filling the wall cavity with sand, earth, or gravel to provide the required insulation. The sides (double wall, double grid or double panels) of the envelope should be able to hold the weight of the proposed filling material.

**Figure 4.4-6.** School in Zaatari refugee camb in Jordan, using scaffolding, grids, and gravel. **(Franco, 2015)**.

## 4.5. Prefabricated shelters

Prefabricated shelters, flat-packed, and containers generally come with a high unit cost and required long production and transportation time and is inflexible (United Nations, 2004).

Prefabricated shelters, even though they can present semipermanent long-lasting structures, it is a costly solution that requires a long time and a lot of effort for fabrication, transportation and assembly. Also it is usually presenting an inflexible solution that is more likely to disregard the social and cultural norms and does not contribute in the local economy (UNHCR, 2019a).

### 4.5.1. Life shelter

Life shelter aims to provide a low-cost alternative for durable sheltering that is stable, secure, and provide better thermal performance. This design uses prefabricated bent rockwool panels, where every two panels will form an arched frame and by attaching an array of frames the shelter roof will be erected. The concept provides a stable structure with ease of construction. Plastering and paint are required for panel protection. Gabs are required to be enclosed after being erected, which requires two persons for three to five days. This type of shelter has a life span of 15 years so it does not require as much time as earth buildings and provide good thermal performance with lighter and simpler construction due to its insulated panels. Even though this presents an affordable durable sheltering solution, the bent panels are not providing enough headspace especially in the sides which is not exactly suitable for attaching furniture to the walls and makes it more difficult to divide the internal space due to the arched roof.

**Figure 4.5-1.** Bending rock wool light weight panels, performing Humanitarian shelter, **(Life-shelter, 2013).**

The linear expansion of the shelter is possible with further distribution of the panels to shelters but cannot be easily attached to the long side of the shelter. Additionally, these panels, especially after plastering, are not easy to dismantle so their materials are difficult to be reused, and recycling required an energy-intensive process.

### 4.5.2. Azraq T - shelter


**Figure 4.5-2.** Azraq T shelter perspective with optional additional porch, **(AL Abweh, 2016).**

The shelter has been designed by UNHCR to host Syrian FDPs in the Jordan-Azraq camp. It can withstand the harsh desert weather, dust and a vast variation in climate which is hot in the summer and cold in the winter. It has a 24 square metre living space with a minimumheight of 2 metres.

**Figure 4.5-3.** The inside of Alazraq T shelter **(AL Abweh, 2016).**

The shelter consists of an interlocking steel frame see **Figure 4.5-4**, that is covered by triple layers starting with UNHCR tarps as water and moisture proofing layer then thermal foam insulation to protect from extreme heat and cold weather and IBR cladding (Inverted Box Rib) which provide strength and enhance the protection properties of the shelter. The shelter was designed for a life span of 2 to 4 years.

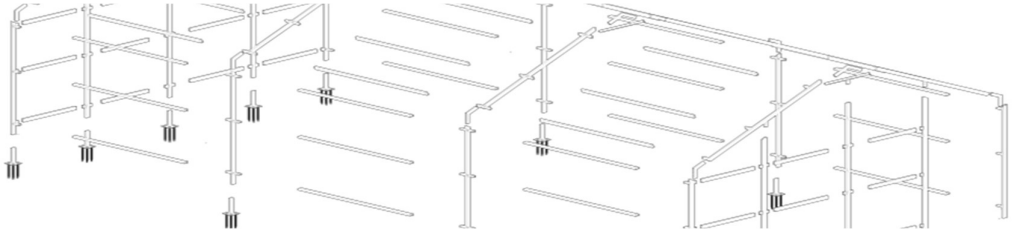


**Figure 4.5-4.** Azraq T-shelter a perspective of the interlocking steel frames, **(UNHCR, 2016)**

On-site pour raised concrete flooring are provided after the erection of the shelter. An optional side porch addition for enhanced privacy was developed due to FDP feedback see **Figure 4.5-2** in order to deliver a more socio-cultural appropriate sheltering solution. All the shelter components were provided in the form of a kit, which makes it easier for transportation, storage, and further supply. Also, it is a dismantable structure that can be relocated and reused. The shelter has provided adjustable footing that has leg extenders to allow the structure to be erected on uneven land. See **Figure 4.5-5**.

**Figure 4.5-6.** Example of design alteration, **(AL Abweh, 2016).**

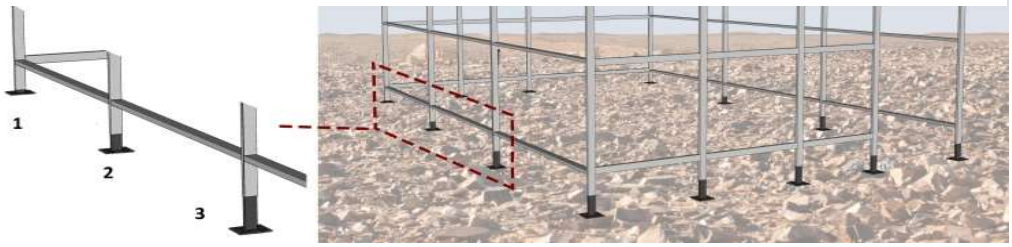



**Figure 4.5-5.** Adjustable footing of the Azraq T shelter, **(AL Abweh, 2016).**

The alteration and customisation of the shelter is possible due to its modular design, **Figure 4.5-6** show an example of the shelter design alteration in a marketplace in Al Azraq camp.

### 4.5.3. The Refugee Housing Unit (RHU) (flat-packed).

**Figure 4.5-7.** RHU Flat Packed, Exploded perspective showing the unit components, **(UNHCR and IKEA, 2016)**

Research, development, and field testing that is carried out by UNHCR, and Bettershelter, with support of the Ikea Foundation, has resulted in an innovative shelter solution with a floor area of 17.5 square metres and minimumheight of 1.8 m that uses a lightweight steel tube frame with plastic panels that compose of overlapping 5mm thick polyolefin panels for walls and roof, and lockable door. Additionally, a protective screen that reflects sunlight during the day as well as a solar panel for lighting up the tent during the night, and ventilation opening with a sliding-open hatch and mosquito net. An innovative anchoring system anchors the tent to the ground. The innovative ground anchoring system does not require digging but only a driver to lock the anchor in its position, also it is a height adjustable to enable fixing it on uneven land up to 7 degrees, and it suits a different types of soil (grabble, sand, and clay). See **Figure 4.5-8**

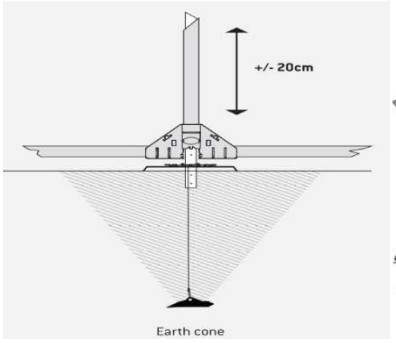



**Figure 4.5-8.** The ground anchoring system, **(UNHCR and IKEA, 2016)**

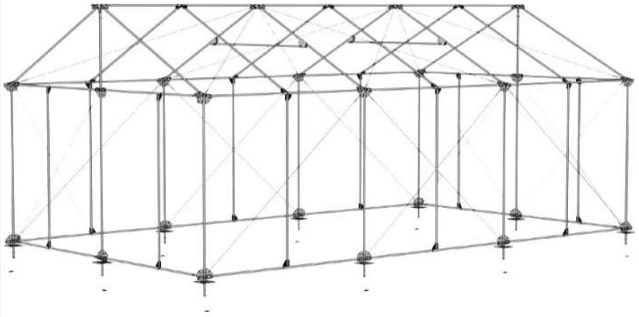


**Figure 4.5-9.** The modular light weight frame and the ground anchoring system, **(UNHCR and IKEA, 2016)**

This solution is designed for a 1.5-year lifespan that can be extended to 3-years by the implementation of proper maintenance (UNHCR, 2016) as an opportunity to solve the issue of the need for transitional housing. The possibility of a winterisation kit, wind kit, and shade net kit is available.

This solution has been promoted as a stable durable and safe solution that is cost-effective and provides more protection to the occupants, also offering a sense of dignity. These have been increasingly implemented all over the world.

However it is a global solution that requires transportation and does not simulate the local economy. Additionally, it does not necessarily represent a socio-cultural appropriate solution, however, the modular design and the dividers allow for some level of customisation and privacy.

**Figure 4.5-10**. Working mother and her children living inside the RHU **(UNHCR and IKEA, 2016).**

The modular frame of the RHU (The Refugee Housing Unit) allows for the upgrading from the emergency shelter that is covered with standard tarps sheets to a more adequate shelter by covering the frame with locally available materials. See **Figure 4.5-11**

**Figure 4.5-11.** The upgrade possibility by using LAM, **(Better shelter, 2021b)**.

Further investigation for novel solutions has been discussed in the appendix.

# 5. Chapter 5: Results and discussions

## 5.1. Linking humanitarian relief to sustainable development

The interest in connecting humanitarian response with long-term sustainable development is not a new concept, LRRD model (linking relief, rehabilitation and development) originated in the 1980s to fill the identified gap between humanitarian assistance and long-term development post crises. This model is adopted by the international agencies for decades, but the implementation of the model on the ground remains difficult as specified by Ramet (2012) due to relatively uncoordinated responses to crises. Also Wagemann and Moris (2018) identifies the gap between the international aim and the reality as the interest of connecting emergency response with long-term sustainable development, in reality, tends to be divided into separate stages.

### 5.1.1. LRRD model

LRRD model is a process that aims to link short term relief measures with long term development through rehabilitation in order to create a sustainable response to crises. It aims to support the ease of transition from emergency response to recovery and long-term development of sustainable livelihoods, in order to ensure a more efficient humanitarian response including the implementation of conflict prevention and risk reduction measures (Ramet, 2012).

This process is initially a linear continuum approach that starts with relief then rehabilitation as a bridge to development, as shown in **Figure 5.1-1**

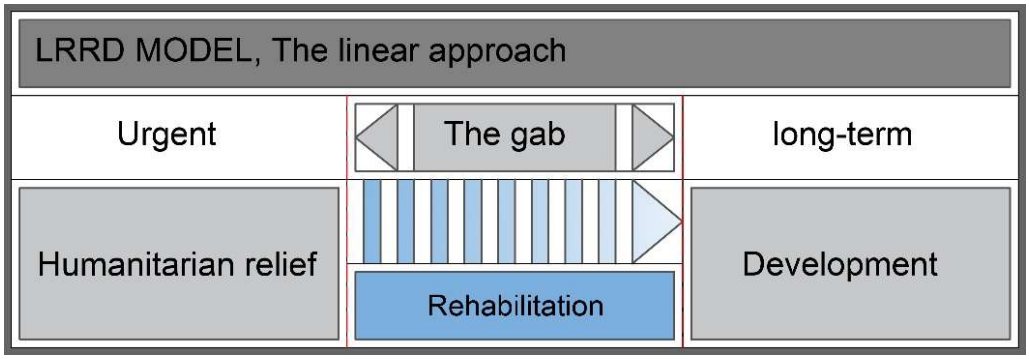



**Figure 5.1-1.** The linear approach of LRRD model, visualized by the Author (2021).

But the separation between these three processes lead the humanitarian response to fail due to the changing nature of the operations that requires the use of different processes and tools at the same time. Therefore this division causes a delay in response and increases the vulnerability of the affected population. However, this model has evolved over time to a more flexible approach that allows for all stages of PDPC response to operating together in an overlapping juxtapositioned approach,

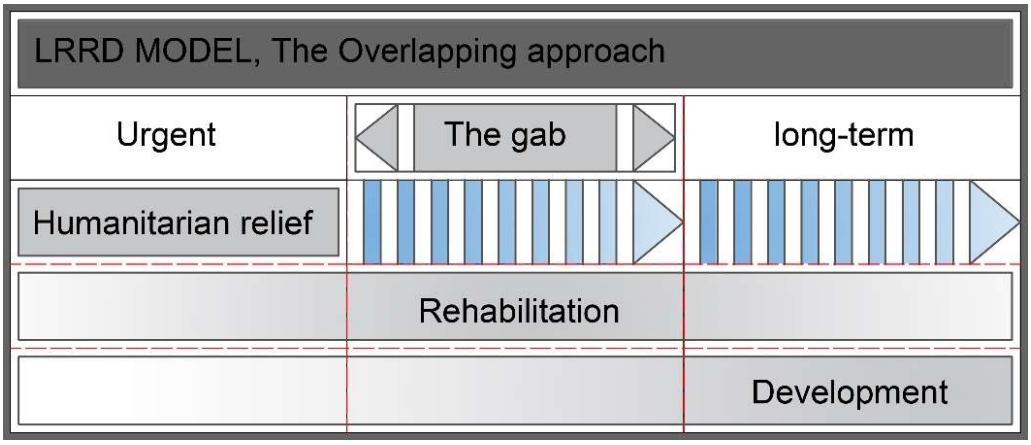



**Figure 5.1-2**. The overlapping LRRD model, visualised by the Author (2021)

**(Wagemann and Moris, 2018)** that requires early comprehensive coordination between humanitarian actors with the aim of a smooth transition to recovery and development, as shown in **Figure 5.1-2**

The LRRD model remains difficult to implement because of the difficulty in filling the gap between immediate urgent response and sustainable development due to the different objectives, tools and bodies that each process has. The humanitarian aid is designed with the aim of ensuring speedy response that is usually done by international and non-governmental organizations, but on the contrary, sustainable development requires careful programming in correlation with governments plans and its development strategies which is usually a time-consuming process. Shelter Center (2012) clarifies that sustainable reconstruction after major crises require community involvement, secure land tenure and agreed standards before the commencement of design and construction of permanent houses. These procedures required time and if rushed it could result in unwelcomed results such as inequality, poor sustainability, and increased vulnerability within the community. So this is why the LRRD model tends to be separated as shown in **Figure 5.1-3**, instead of interconnected stages that could allow for incremental development.

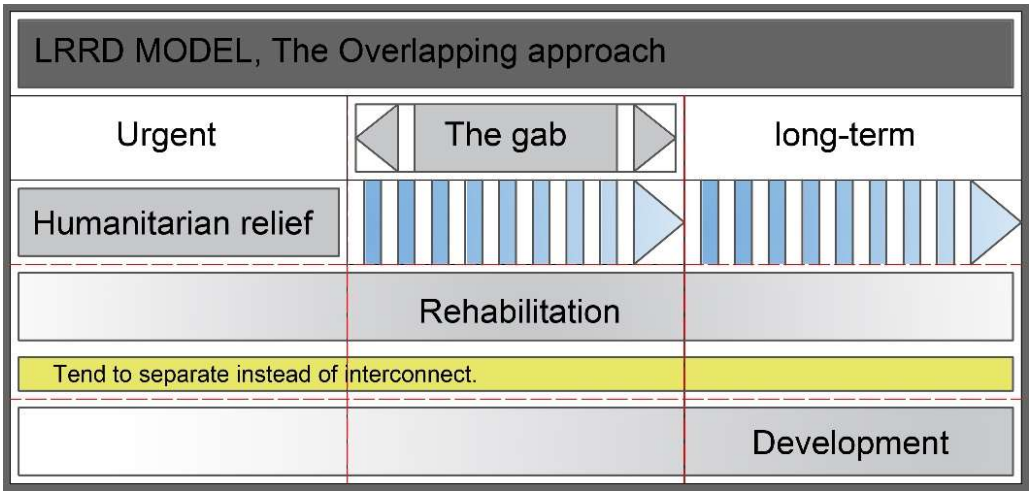



**Figure 5.1-3.** The tendancy of separation of the LRRD overlapping approach, visualized by the Author (2021).

However, climate change and its corresponding potential to increase natural crises and emerging conflicts, have increased the importance of the efficient implementation of the humanitarian response. The Sendai framework (2015-2030) for disaster risk reduction which has been adopted at the UN World Conference for Disaster Risk Reduction in Sendai, Japan in 2015 has promoted the enhancement of effective response in recovery, and to build back better in reconstruction, and tried to link disaster risk reduction with sustainable development. Also, UNDP, (2012a) UNDP (United Nations Development Program) aims to address an effective humanitarian response approach by defining the Early Recovery (ER) concept. Early recovery (ER) is a multidimensional process of recovery that starts from the early –stages of the humanitarian response, and UNDP(2012a) considers it as a vital element to effective humanitarian response. It is considered early on because it is promoting the need to look beyond relief immediately, and its recovery due to the fact it prepares the ground for long-term recovery.

Emergency response and providing the initial human needs are very critical for life-saving, but also the integration of the Early recovery (ER) concept into the humanitarian response approach is crucial for communities to recover and build resilience. Early Recovery has been defined by (UNDP (2012b) as "a set of specific programmatic actions to help people to move from humanitarian relief towards self-sustaining development.". In asddition to this, Sphere (2018) one of the most recognised standards for humanitarian relief in its lastest edition in 2018 has required recovery measures to be considered in the early stage of the settlement planning and sheltering, which commences with a sense of community social cohesion and a feeling of safety.

Furthermore, Wagemann and Moris (2018) promotes the adoption of an integrated approach in Chile to enable resource optimization, and used a transitional term to define the period that extends directly

after the crises till adequate housing has been achieved. This period covers overlapping processes of transformation to ensure long-term recovery from the early stages, that ensure continued transition to a less vulnerable situation. However**,** Shelter Center (2012) through their adopted definition of transitional shelter has emphasised the importance of the adoption of anintegrated approach which includes the call for an integrated, comprehensive strategy of shelter, settlement and reconstruction. It also, considers the incremental process as the main character of the provision. So, there is an international call for an efficient humanitarian relief response through an integrated approach that adopted the early recovery concept to facilitate the transition of the FDP toward building community resilience and self-sustainable development.

### 5.1.2. The presented IRRD model

Based on the LRRD model, **Figure 5.1-4** represents a new model that aims to integrate relief, early recovery, and sustainable development through a transitional process that defines the targets of vulnerability reduction and self-reliance strengthen , as well as, considers the potential of alteration in the process due to varied people and circumstances. The produced (IRRD) (Integrated relief, recovery, and sustainable development) model is visualized as the following:

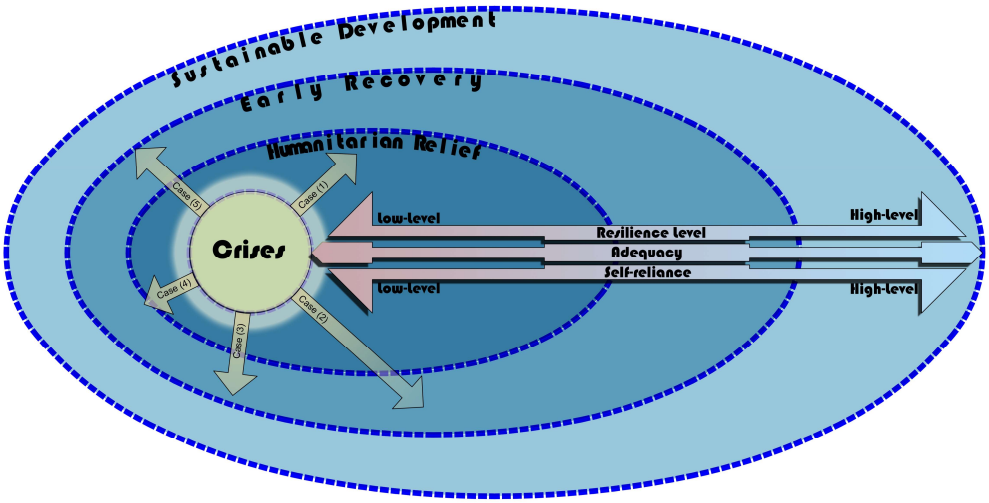



**Figure 5.1-4**. The produced (IRRD) Model, The Integrated Aim of (Relief, Early recovery, and sustainable development), produced by the Author(2021).

The model above allows for the understanding that each stage of response is part of other stages, so while focusing on the purpose of each stage it is also preparing the ground work for the purpose of other stages. Also, it shows that all stages are contained into each other, for instance, the provided solutions in the relief stage should provide a life-saving measure but also should not be an obstacle that could delay the recovery. Also the recovery of the population should initiate the continued transition of the community to the sustainable livelihood. In addition to that, the model above can indicate the differentials for different scenarios and cases for the varied aspects of the population such as women, elderly, disabled, ethnic groups, and special cases families. This allows for the addressing of different responses due to each case and scenario. It is also reflecting the transitional situation of the displaced population toward building resilience and reducing dependency. Finally, it is a proposed model that aims to ensure an efficient humanitarian response that allows for resource optimization through transitional sustainable development. Furthermore, the transition of the FDP needs both a target and a path to be followed. The FDP will naturally seek a less vulnerable situation as an aim, however, guidance and support are required. In addition, the ease of this transition requires more adaptable solutions that allow for the transformation and evolvement to provide the smooth transition and empower the population to guide their own transition process toward the most suitable recovery and sustainable development for them and their environment. Therefore, the research will aim to address the potential existing and novel solutions that could facilitate the transition of the FDP to recovery and sustainable development.

## 5.2. Adaptable Design strategies (ADS)

Adaptable design strategies in this research will refer to the architectural design and building strategies, practices, and techniques that allow effective shelters transition, transformation, and evolvement to more adequate shelters. The adaptability of these design strategies means that the design should be responsive to the continuous transition that aims to continue improvements in living conditions by providing wider options and solutions to its occupants throughout the lifespan of the shelter.
So a shelter with ADS measures/characteristics is an adaptable shelter to the state of transition to adequate shelter. This type of shelter is most commonly known as a transitional or progressive shelter.

### 5.2.1. ADS Characteristics

Shelter Center (2012) guidelines for transitional shelter specified five design characteristics for transitional shelters to maximize the available options for occupants by allowing them, to relocate, upgrade, reuse, recycle, and resell. Within this method of assistance the process starts with the first material distribution to FDP and continues until the achievement of durable solutions. These design characteristics can maximize the adaptability of the shelter to different circumstances and reduces the limitations of the solutions also enhancing shelter transition capability by maximizing the available options that help the FDP to overcome the constraints, As the following:

#### 5.2.1.1. Relocatable

Relocatable shelters allow the shelter to be relocated from its temporary settlement which could be vulnerable to land tenure issues, natural hazards, or security issues to a less vulnerable location. Also it could be relocated to a reconstruction site while reconstruction is ongoing. Relocatable shelters have the potential to allow for livelihood enhancements by moving to a better location with access to work opportunities. As addressed by Ssphere (2018) the minimum standards that shelter location should provide is access to work opportunities near the shelter. This kind of flexibility is responsive to the risk reduction needs and allow for community resilience improvements and reduced the dependency of the FDP.

#### 5.2.1.2. Upgradable

Upgradable shelters allow for the continuous improvement of shelter performance with time (incremental progress), which means the longer the displacement time is the more adequate means could be addressed.

Shelter upgrade means upgrading its components including both its structural elements and its envelope. Upgrading the structure of the shelter will enhance the building stability and its resilience to natural hazards such as earthquakes, floods, and wind uplift.

Shelter Center (2012) also highlights that it is not only the envelope that should be developed but also the structure frames. Promoting the use of shelter frames that can be upgraded in order to be used to provide resilience against hazards and provide a stronger structure that could stabilise a more durable envelope including upgrading with local materials and avoiding replacing the structure which reduces wastage of resources and allows for more efficient sheltering response. So it is also paving the way to upgrade the building envelope which allows for mass walls that provide better security means and better protection against the weather.

Sphere (2018) minimum standards mentioned that the displaced family should feel safe and secure from the outside world, and get the privacy needed in their home as they have a door to close. In addition to this the standards vocalise better protection from the weather that makes people less likely to get ill., Adaptable design solutions therefore provide the occupants with the ability to upgrade the envelope of the shelter in accordance with local climate and available resources into a more durable envelope to maintain the occupant's security and safety through the provision of a door that can be closed to maintain their privacy and dignity. This also provides comfort, safety and a private place for family members to dwell and engage with each other. So it can be said , that upgradable shelters are responsive to the need for shelter performance improvement to achievesafety, comfort, and health.

#### 5.2.1.3. Reusable

Reusable characteristics allow for the changing of the use in the shelter into different spaces. This includes changing the internal space use between day and night which has been highlighted in the

minimum standards of Sphere (2018). The total change of the space use, to different occupancy types such as office, shop, canopy, barn or even the reuse of it as a core or an extension of an adequate or permanent house. For instance Aceh Indonesia tsunami, 2004 show that many affected populations still use their transitional shelter after changing the use of it to a business space and some are using it as additional space to their permanent house.

Also, this feature allows for the reuse of its components and elements for another construction such as the reuse of the tent frames and fabric for shading of the external space of an upgradable shelter.
This reusable design feature is responsive to the need for efficient humanitarian response and enhances the linkage to sustainable practice and development. Also it empowers the FDP by providing them with the option of changing the use to specifically meet their needs and reusing the already distributed materials as an initial resource to proceed with the transition process. However, materials reusing required innovative practices, guidance and knowledge transfer.

#### 5.2.1.4. Recyclable

Furthermore, transitional shelter guidelines also promote recyclable shelters that encouraged the use of recycled shelter materials and allow for the recycling of the already used shelter materials so they can be used later on for another construction such as the reconstruction of apermanent house.
However, recycling the shelter components and their materials requires a process of reproducing before they can be reused and that usually needs skill, energy and time. It however still expands the provided options to the FDP and allows for a more sustainable response to the needs of disposal, regenerate the resources and the reuse of it, which reduces the need for raw materials.

#### 5.2.1.5. Resell

Finally, the fifth design characteristic that is specified by the transitional shelter guideline (Shelter Center, 2012) is a dismantled shelter that enables the FDP to resell their shelters and transform it into a fund resource in the instance of the finishing of the reconstruction process.

These specified five design characteristics of transitional shelters are adaptable design strategies (ADS) that maximize the options, reduce the dependency and enhance the resilience of the FDP.

This can be presented in a table as shown below:

**Table 9.** reproduced (ADS) characteristics in reference to (Shelter Center, 2012).

| The Characteristics of ADS from (Shelter Center, 2012) | (ADS) Characteristics | The Modified Element |
|---|---|---|
| | Relocate-able | Location |
| | | Micro-location |
| | | Orientation |
| | Upgrade-able | Skeleton |
| | | Envelope |
| | Reuse-able | Space |
| | | Shelter |
| | | Shelter components |
| | Recycle-able | Materials |
| | Sell-able | Shelter |
| | | Shelter components |

However, it must be noted that theTransitional Shelter Guideline (Shelter Center, 2012) did not specify other design features that are also adaptable and responsive to the transition needs. Further research extends the list of ADS characteristics and features as the following:

#### 5.2.1.6. Transformable

Sphere (2018) minimum standards required shelters to ensure privacy, andseparation between sexes, different age groups and families within a given household according to cultural and social norms. Culture, privacy, and safety should be considered especially for the internal division and the allowance for extended families or more than one family.

Family structure or occupant numbers and age will change or grow with time. As a result, the dividing needs inside the shelter may differ in accordance with the cultural appropriateness and safety needs, therefore, the feature of a flexible dividable shelter design is an adaptive solution that responds to the privacy and safety needs that could change with time and with the changes to family andoccupant structure.

Sphere (2018) standards also encourage building a shelter with a smaller floor area and then following with an increased floor area. The indicated minimum space could be applicable in the emergency phase. when the duration of stay extends, the habitable space calculations must be revisited in order to meet the acceptable local standards. This practice highlights the importance of expandable design strategies to shelters and this adaptability feature is responsive to the needs of extended space for addressing occupants dignity and comfort.

Furthermore, it is not only (dividable and expandable) shelters that are responsive to the needs of space change but also the solutions that allow for the additions of other spaces such as outdoor shaded space that extend the useable living space for activities and enhanced the community interactions. In addition to this, it helps to reduce direct sunlight and protect from rain. This is a responsive design strategy needed for livability enhancement that promotes the health, comfort and social interaction of the shelter occupants. Another example is the addition of a private sanitation facility within the shelter instead of communal sanitation, in order to promote healthier practices and ensure the privacy and dignity of the occupants. This addition can enhance the living conditions within the shelter and the settlement, however, this enhancement requires organisations to ensure the healthy and environmentally friendly disposal/treatment of both grey and black water which requires funding, manpower, support and guidance.

Furthermore, UNHCR (2019a) in its emergency standards requires shelter designs to allow for modifications to enable the occupants to meet their specific needs. This encourages the adopting of more flexible designs that give the population the power of customization and modification in order to specifically respond to their needs. This measure of flexibility can address successful sheltering solutions reducing the risk of community rejection of the proposed solutions and empowering the population with the opportunity of self-decision making which enhances the sense of belonging and ownership and allow for a more appropriate responses to the various needs within the community.

These four adaptive design features ,dividable, expandable, addition-able, and customize-able, are all transforming the shape of the shelter to another shape that is more likely to better respond to the needs of the occupants. This is why transformable design characteristics should be added to the list of ADS. Also UNHCR ( 2019a) has differentiated the humanitarian response standards for shelters due to different response stages which highlights the importance of adaptable solutions such as upgradablility and transformability which can respond and allow the implemtation of different acceptable standards due to the extension of occupancy time.

#### 5.2.1.7. Integratable

Furthermore, Shelter Center (2012) has promoted the implementation of passive design strategies in order to respond to the local climate ensuring the comfort of the occupants and reducing the required energy needed for heating and cooling which enhance the performance of the shelters with less environmental impacts and overcome the common problem of poor performance humanitarian shelters.

Passive design strategies have different recommendations to different climates and microclimates also it is using a wide and well known architectural tools to ensure passively responsive shelter design to the climate such as optimal orientation, optimal height, appropriate insulation level, thermal mass strategies, and proper ventilation strategies that differ due to geolocation, micro climate conditions and available resources. However, the local practices usually indicate some of the successful strategies that have been examined over time, furthermore, innovative practices can help in enhancing the climate-responsive shelter design.

ADS measures have the potential to facilitate the transition of the shelters to more climate-responsive shelters. For instance, relocatable shelters which can be dismantled and reassembled allow the occupants to accommodate reoriented shelters in order to match with the recommended optimal

orientation that enhances the shelter performance response to climate. This response can be addressed as early as possible with proper planning of sheltering and settlement to ensure sufficient spatial organisation of the settlement. Another example is that upgradable shelters which allow for incrementally achieving proper thermal massing and proper insulation for shelters. Therefore HSR should allow for the integration of passive design strategies in incremental process toward more adequate shelters.

Another important integration is the renewable energy integration in shelter and settlement planning which provides power for off-grid locations which is a common case for temporary and emergency settlements. Also, it can build a more resilient community and promote sustainable, environmentally friendly energy consumption practices (lighting, heating, cooking, and cooling). For instance, the need for energy in lighting is essential to allow for night time activity such as reading and studying. Also artificial night lighting can contribute to safety measures and reduce the risk of theft. Therefore the integration of renewable energy can respond to the need for lighting network connection and power supply for internet connection, in order to enhance the living standards of the FDP during the extended occupancy. However, this integration can be done incrementally with the upgrades of the shelters and settlements. Therefore, integratable shelter designs that allow for the integration of both (passive design, and renewable energy) represent another ADS characteristics that should be included in the ADS characteristics panel.

The ADS panel as shown in Table (10) present the seven characteristics of the adaptable design strategies that have the potential forenhancing the status of shelter transition to adequacy.

**Table 10**. ADS panel, represent the seven characteristics of ADS, By the Author (2021).

| **The Seven Characteristics of ADS** (Adaptable design strategies) | **(ADS)** Characteristics | The active/response **Element** |
|---|---|---|
| | Relocate-able | Dismantled & reassembled |
| | | Fold-able |
| | | Transport-able |
| | Upgrade-able | Skeleton |
| | | Envelope |
| | Reuse-able | Space |
| | | Shelter |
| | | Shelter components |
| | Recycle-able | Materials |
| | Sell-able | Shelter |
| | | Shelter components |
| | Transform-able | Divide-able space |
| | | Expand-able space |
| | | Addition-able space |
| | | Customize-able space & shape |
| | Integrate-able | Passive strategies |
| | | Renewable energy |

However this panel also represents the active/responsive element in the shelter. For instance, for a shelter to be upgradable it should have at least one of its components (skeleton or envelope) to be compatible with upgrade needs, and this compatible component is the active/responsive element in the shelter. Another example is when shelter design could be used as an emergency shelter but also it could be re-used as a retail shelter within the settlement or a workspace shelter for making a living. This is a reusable shelter and the active/responsive element of it is the space of the shelter, more examples, the responsive element of recyclable shelters is its recyclable materials.

Shelters could have one or more active/responsive elements that can increase the level of adaptability of the shelter design. These are detailed in following chapter.

### 5.2.2. The principles panel of Adaptable design strategies (ADS)

ADS by definition should facilitate the transition to adequacy, and should not contradict that aim. Therefore, one of the essential principles of ADS is to support the aim to deliver adequate shelters by addressing adequacy means that is described in Table 1. Section 2.4

ADS principles, present the general strategies that are non– architectural shelter design and go in correlation with the ADS to help the transition to adequacy. For instance, chapter 5 which discussed linking relief to sustainable development, clarifies that HSR should continuously transit to a less vulnerable situation and increase self-reliance. Nevertheless, Sphere (2018) adopt self-sufficient and self-management of the FDP through the implementation of localised strategies.

Also, UNHCR (2019a) in the UNHCR emergency handbook promotes self-reliance strategies and actions that create a sense of ownership which empower the displaced population to build their own appropriate shelters. Furthermore, transitional shelter guidelines (Shelter Center, 2012) have supported sustainable self-reliant construction of shelters.

However, vulnerability reduction and resilience is part of the adequacy means of adequate shelters. That ADS helps to address the principles of self-reliance, management and localised strategies, helping the displaced population to meet their particular needs that are socio-culturally appropriate and enhance the sense of ownership that initiate the early recovery process which also reduces the cost and time of the construction and help in achieving effective and efficient (HSR) humanitarian sheltering response that transport the population to a more resilient community. Further important principles that ADS should comply with can be identified by digging more into the well-known standards of humanitarian relief. These include the UNHCR Emergency Handbook, Transitional Shelter Guideline, and The Sphere Handbook.

Sphere (2018) emphasises the importance of construction techniques and materials that are culturally and socially acceptable and environmentally sustainable. Shelter Center( 2012) also promote the construction of culturally appropriate shelters which also agreed with UNHCR, (2019a) which encourages the FDP to self-build shelters that are specifically appropriate for them.

Socio-cultural appropriateness is one of the essential principles that is repeatedly emphasised in these standards and its one of the identified adequacy means that ADS should not contradict.

Additionally, UNHCR (2019a) emphasize that the used materials should be environmentally friendly. This principle was highlighted by Shelter Center (2012) who supported the sustainable construction of shelters and agreed with by Spheer (2018) who call for environmentally sustainable construction techniques and materials.

However, Shelter Center (2012) went on further to promote the implementation of locally produced materials that will help the local economy create livelihood opportunities and reduce dependency on external assistance. In addition to this the use of locally produced materials allows for massive production and wider response. It also highlights the importance of local building techniques and materials that will enhance the shelter appropriateness, construction (cost and speed) efficiency, and durability. It also helps in adopting sustainable development and risk reduction strategies including preserve hazards and vulnerability. It considers Local building techniques are indicators of the evolving strategies over a long period of time of adaptation to the local culture, environmental challenges and correlated response, that adapt to different factors such as climate, topography, community lifestyle, and culture factors, such as social interaction patterns. However, more recent building techniques and materials are still valuable as they maybe use to improve the traditional techniques in order to build back better (Shelter Center, 2012). These three factors: local strategies, locally produced materials and the adoption of local building techniques can be described as the localisation of the sheltering solutions that have the potential of shelter performance enhancement and shelter appropriateness which cannot be ignored in the established ADS principles panel.

However, technical support and quality insurance are essential to empower the FDP to build back better. The importance of this kind of support is emphasised in (Spheer, 2018). and also considered is technical support which addresses hazard resilience techniques that reduce the risk and the vulnerability of the affected population.

Nevertheless, Shelter Center (2012) claims that standards should be agreed upon in consultation with the affected population upon the crises and these agreed standards should address the different needs for different groups, and consider factors such as local climate, hazards, available labour, materials and skills, cultural and social requirements. Religious beliefs, culture, and tradition which will be reflected in the activity of daily life of the affected population should be reflected in the design of their transitional shelter, which cannot be achieved without the involvement of the FDP in the design process, therefore committee, workshops, and consultation are key factors to establish a proper design. This discussion highlights the balance between providing support and the self-reliance approach, as the self-reliance approach without quality insurance could result in poor outcomes. On the contrary, providing support without the involvement or the consultation of the FDP could risk the appropriateness of the shelter solution. Therefore, technical support and quality insurance companies in consultation and involvement of the FDP are part of the ADS principles panel.

Finally, Shelter Center (2012) has adopted the incremental approach and the implementation of the early recovery concept in the transitional shelter which is part of the suggested IRRD model in **Figure 5.1-4** and considering that the first distributed materials can be part of the transitional shelter design which allow for an incremental upgrade instead of phases approach, and that reducing the cost and adopt early recovery approach.

Moreover, Shelter Center(2012) has specified ten principles for transitional shelters as the following: assess the situation, involve communities, develop strategy, reduce vulnerability, agreed standards, maximise choice, bye time, incremental process, plan site and reconstruction. These 10 principles are not only specified TRansitional-shelter principles but are more likely to describe suggested processes for transitional shelter implementation while ensuring the quality of response through assessment, planning, strategy development, and standardisation. Also by ensuring the appropriateness of the response through the involvement of the targeted communities, additionally adopting the incremental process and using the time factor to transit to the less vulnerable situations and maximizing the choices of the FDP. This again emphasises the importance of the identified ADS and its principles that have the potential to maximise the available solutions to the FDP.

To summarize the discussed principles above, a panel of principles is presented in the following table:

**Table 11.** The ADS Correlated Principles Panel, By the Author (2021).

| ADS corresponding Principles panel | |
|---|---|
| **Adequacy means** | Protection, security, and resilience |
| | Health, and comfort |
| | Adequate space |
| | privacy, and dignity |
| | Socio-cultural appropriateness |
| **Self-sufficiency** | Self- reliance |
| | Self-management |
| **Standardization** | FDP involvement in decision making |
| | Consultation with FDP |
| **Interfere & Support** | Technical support |
| | Hazard resilience techniques |
| | Quality insurance |
| | Assessment & planning the development |
| **The localization of the solutions** | Locally produced materials |
| | Local building techniques |
| | Local strategies |
| **Sustainable & environmentally friendly** | Construction technique |
| | Materials |
| | Locations |
| | Disposal |
| | Energy production and consumption |
| **The adoption of the (IRRD) model** | Incremental approach |
| | Early recovery |
| | Sustainable development |

The end of the table

### 5.3. The categorisation of the sheltering solutions.

A wide review of existing and novel projects involving humanitarian sheltering solutions worldwide has been carried out in order to initiate a general understanding of the currently available solutions and the potential novel solutions to categorise and evaluate the existing sheltering solutions and most importantly to investigate and extract the potential transition enablers for adaptable shelter solutions. The review has covered 36 main case studies of existing projects/solutions and 7 novel solutions with a total of 43 case studies, from a variety of trusted resources such as theUNHCR & IFRC reports, Global shelter cluster (shelter projects), and shelter centre. The reviewed projects represent different climate conditions, response stages, vulnerability levels and crises types.


**Figure 5.3-1.** The reviewd case studies, projects/solutions, by the Author.

Each case study has been discussed individually and extensively in the thesis case studies chapter, however, the reviewed projects have been categorized into **10** different categories that mainly represent different types of shelters or solutions, namely tents, materials distribution, prefabricated shelters, framed shelters, durable shelters, earth shelters, hybrid (Framed-Earth) shelters, integrated (Framed-Earth) shelters, reclaimed materials (infill tech) and novel solutions.. Also included are the two main categories global and Local solutions. Then the diverse humanitarian sheltering solutions (E-sh, Esh+, T-sh, Tr-sh, Pr-sh, C-sh.) has been assigned to each project depending on the criteria that are specified previously in the table of DHSS (Diverse humanitarian sheltering solutions) -vulnerebility, land tenure, and the approach which can be seen in Table 7. This was to ensure that the reviewed projects covering the different stages of the sheltering solutions (urgent, midterm, and long-term) provide a more balanced database and help to avoid the risk of biased information in the evaluation process and the extraction of the potential transition enablers.

**Table 12.** The categorized solutions by the Author (2021).

| The categorization of the 43 research case studies. | | | | |
|---|---|---|---|---|
| | **Type of shelter** | | **Case studies** | **Shelter solution category** |
| Global solutions | Tents | | UNHCR family tent | E-SH |
| | | | UNHCR formal tent | E-SH |
| | | | Self-standing family tent | E-SH |
| | | | Tunnel structure tents | E-SH |
| | Materials distribution Traps & CGI sheets | | Traps+ kits | E-SH |
| | | | CGI sheets + kits | E-SH |
| | Prefabricated shelters | | Life shelter | T-SH |
| | | | Azraq T shelter. Jordan,2016 | T-SH |
| | | | The Refugee Housing Unit (RHU) | T-SH |
| Local solutions | Framed Locally-built shelters | Wooden-framed Locally-built shelters | Gable frame. South Sudan,2016 | TR-SH |
| | | | Tuareq shelter, 2012 | T-SH |
| | | | Tukul shelter, South Sudan, 2012 | TR-SH |
| | | | Com Pact bamboo shelter, Ethiopia, 2013 | TR-SH |
| | | | Twin elevated shelter Maynamar,2014 | PR-SH |
| | | Bamboo-framed Locally-built shelters | Bamboo shelter. Nepal,2017 | PR-SH |
| | | | Tent shelter. Afghanistan, 2009 | TR-SH |
| | Durable Locally-built shelters | | ORS in Pakistan, 2010-2014 | C-SH |
| | | | L Shape core shelter. Iraq,2011 | C-SH |
| | Earth shelters | | Air dried adobe shelter. Tanzania ,2015 | A-SH |
| | | | Stabilized soil blocks shelter. Sudan, 2010 | C-SH |
| | | | Super adobe shelter. Ahwaz, Iran, 1992 | A-SH |
| | | | Super adobe community center. Zaatari, Jordan, 2018 | A-SH |
| | | | Thin tile Valut school. Al Azraq camp, Jordan,2018 | A-SH |
| | Hybrid (Framed-earth) shelters | | T shelter. Pakistan, 2010 | TR-SH |
| | | | Core house + light weight extension. Philippines 2015 | C-SH |
| | | | CG Transitional shelter. Nepal 2015-2016 | PR-SH |
| | Integrated (Framed-earth) shelters | | Upgrade (Bamboo Panels). South Sudan,2017-2018 | E-SH+ |
| | | | LAM shelter. Congo, 2018 | A-SH |
| | | | The Green Karavan Ghar. Pakistan flood, 2010 | PR-SH |
| | | | Flood resilient Health center. Pakistan flood, 2010 | PR-SH |
| | | | Lari Octa Green (LOG) shelter. Sind, Pakistan, 2018 | PR-SH |
| | | | Fast permanent shelter. Mozambique, 2021 | A-SH |
| | | | The extended shelter. Mozambique, 2021 | E-SH+ |
| | Reclaimed materials & infill Slef- built shelters | | Lahib shelter, Recycled plastic bottles. Sahrawi camp, Algeria, 2018 | A-SH |
| | | | Earth ship house reused tires. Adelaide, Australia | C-SH |
| | | | Scaffolding structure school. Zaatari camp, Jordan, 2015 | TR-SH |
| Global | Novel Shelters Solutions | | Two stories , Transitional shelter. Haiti, 2010 | E-SH |
| | | | Liina Transitional shelter. Aalto University, 2011 | TR-SH |
| | | | Just add water. Cutwork studio, 2019 | C-SH |
| | | | The expandable structure. Abeer Seikaly, 2018 | TR-SH |
| Local | | | Weave your home. Abeer Seikaly, 2018 | E-SH |
| | | | Grow your home. Fab tree Hab,2005 | PR-SH |
| | | | Grow your home. Al Biqaa, Lebanon, 2021 | TR-SH |

| LEGEND | |
|---|---|
| E-SH | Emergency shelter |
| E-SH+ | Emergency shelter plus |
| T-SH | Temporary shelter |
| TR-SH | Transitional shelter |
| PR-SH | Progressive shelter |
| C-SH | Core shelter |
| A-SH | Adequate shelter |
| | Global Solutions |
| | Local Solutions |

### 5.4. Pros & Cons of the each category of the reviewed case studies/solutions.

To enable the evaluation of the specified categories for sheltering solutions, an explanation and a list of pros and cons have been established for each category due to the reported data in the reviewed projects as the following:

#### 5.4.1. The Tents

Tents are portable and temporary shelters that are being used as an emergency sheltering solution due to their low cost and rapid construction ability, and consist of lightweight structures with a cover that provides its occupants with at least the protection against the external loads at an acceptable level as a life-saving measure. Also, different climates required different tent designs and seasonal variations, such as winterised tents. However, tents are standardised and considered as a global design solution such as the UNHCR family tent, the UNHCR Framed Tent, and the self-standing tent). Furthermore, the comparison table below shows the strengths and weaknesses of each of these categories of solution.

**Table 13.** Pros and Cons for Tents as HSR.

| Pros | Cons |
|---|---|
| - Provide time for solving land tenure issues.<br>- Rapid construction for relief.<br>- Possible in-time urgent response.<br>- Self-standing shelters. | - Poorly addressing adequacy such as (Low-security level, Low sound Proof and Privacy level, Poor thermal performance).<br>- Low hazard resilience.<br>- Short life span.<br>- Could cause response delay due to possible transportation and distribution time. |

The end of the table.

#### 5.4.2. Materials distribution (Tarps and/or CGI sheets).

One of the common practices in the HSR is the distribution of plastic sheeting (tarpaulin) together with a toolkit, which allows the FDP to erect their own emergency shelter, instead of whole ready-made tents as the first sheltering aid. Plastic sheeting has been developed and standardised by international organisations to meet some required specifications and to ensure better durability such as strong sheet, waterproof, and ones which are UV depredation stabilised. Tarps are a versatile material that offers flexible usages such as roofing, waterproofing damp, fencing, shading, and flooring. Also, it is a cost-effective option that can be vastly distributed to reach a wider range of the population in need of emergency shelter which results in a very rapid sheltering response due to its lightweight and large production capacity. However, tarpaulin has poor thermal performance and a short life span.

Another commonly distributed material for relief purposes is CGI sheets (corrugated galvanised iron) which are common materials in HSR, due to their lightweight, considerably low-cost, easily transportable and fast to build which allows for wide humanitarian response in different response stages. However, metal sheets are a more costly alternative to plastic sheeting and require more skill to be used. Nevertheless, it is more durable with an extended life span if in the proper manner. The

comparison table below shows the extracted pros and cons of the distribution of the material as a sheltering solution.

**Table 14.** the Pros and Cons for Materials distribution as HSR.

| Pros | Cons |
|---|---|
| - Allow for Fast and Vast Response.<br>- High Versatile solution.<br>- Lightweight Materials<br>- Large production capacity.<br>- Tend to be a Cost-effective solution for relief.<br>- Help to avoid the overuse of natural materials during the response.<br>- Support Self-build approach. | - Short life span, causes repeated calls for distribution.<br>- Poorly addressing adequacy.<br>- Low hazard resilience. |

The end of the table.

### 5.4.3. Prefabricated shelters

Prefabricated shelters, flatbacks, and containers even though they can present semi-permanent to long-lasting structures is a costly solution that requires a long time and a lot of effort for fabrication transportation and assembly. Also it is usually presenting an inflexible solution that is more likely to disregard the social and cultural norms and does not contribute in the local economy (UNHCR, 2019a).

Many case studies (Life shelter, Azraq T shelter, and the refugee housing unit(RHU)) have been reviewed and discussed in the case studies chapter and the table below shows the extracted pros and cons.

**Table 15.** The Pros and Cons for Prefabricated shelters as HSR.

| Pros | Cons |
|---|---|
| - Standardized solutions.<br>- Good level of quality control Measures.<br>- Relatively more adequate than tents.<br>- Modularity, allow for expansion and addition.<br>- Ease of assembling & dismantling.<br>- Lightweight components.<br>- Transportable.<br>- Suitable for temporary lands.<br>- Longer life span<br>- Reusable.<br>- Resellable. | - High unit cost.<br>- The limited scale of response.<br>- Long production time and transportation.<br>- Generally, inflexible and Rigid solutions, do not allow for further transformation & Upgrade.<br>- Poorly addressing Socio-culture appropriateness.<br>- The absence of community engagement.<br>- Doesn't contribute to the local economy. |

The end of the table.

### 5.4.4. Locally built shelters

Local shelters are shelters that are constructed using local materials, technologies, and/or traditions. United Nations (2004) declared that “local shelters solutions could vary from simple structures for emergencies to a more permanent durable structures solutions”. Better shelter (2021a) declared that “Local solutions tend to be cost-effective, better stimulate the local economy and will more likely fit local culture and customs”. However, locally built shelters include a variety of subcategories including framed local shelters, durable locally built shelters, earth shelters, hybrid or integrated (Framed-earth) shelters, and finally the use of reclaimed materials and infill techniques. The table below shows the general pros and cons of localised solutions as the following:

**Table 16.** The Pros and Cons for Locally built shelters as HSR.

| Pros | Cons |
|---|---|
| - Cost-effective solution for recovery of the FDP.<br>- Reduce or eliminate the cost and time of transportation.<br>- Enable a self-built approach.<br>- Allow for community engagement.<br>- Can address Socio culture appropriateness.<br>- Enhance the sense of pride and belonging.<br>- Enhance the host community acceptance of the FDP.<br>- Enforce local culture.<br>- Stimulate the local economy.<br>- Can use natural materials at sustainable rates which the self-reliance of the community in sustainable manners. | - Risk of Slums and increased Hazards due to the possible absence of (quality insurance, Training programs, and/or Expertise support).<br>- Risk of unsustainable use of natural materials. Which cause:<br>- NM (Natural Materials) degradation<br>- & increase the level of rejection by the host community. |

The end of the table.

### 5.4.5. Framed locally built shelters.

It is possible to create a shelter by constructing a structural frame using locally available materials (LAM) such as wood poles, timber, limber, coconut wood, palm wood, Bamboo, bush wood, etc.. Locally available materials (LAMs) could be any material that naturally exists or is manufactured, but is widely available locally, cost-effective, suitable for construction, environmentally sustainable, and socio-culturally appropriate. These could include timber, bamboo, palm trunk, coconut wood, stones, sticks, straw, palm fronds, leaves, earth, adobe, available plastic sheeting, and metal sheeting, concrete blocks and even steel frames, including materials for recycling, such as tyres, plastic or glass bottles, and so on. These framed structures can establish the versatile use of the available materials for covering the erected frame to initiate the shelter envelope. Framed shelters shapes and systems can differ due to local practice, type of available materials and expertise. However, it should be a reliable structure that is stable, hazard resilient, durable, and responsive to the occupant's needs. The table below summarizes the pros and cons of the reviewed projects in this category as the following:

**Table 17.** The Pros and Cons for framed locally built shelters as HSR.

| Pros | Cons |
|---|---|
| - Relatively, Faster erection of the shelter.<br>- Establish the Versatile use of LAMs for envelope build and upgrade.<br>- Possible, relocatable structure frames.<br>- Could be designed to include Risk reduction measures that reduce the Vulnerability level of the community.<br>- With a durable structure frame, the reuse of the shelter elements and space is possible. | - Risk of hazard structure due to the weak or absence of proper (bracing & anchoring).<br>- Limited load-bearing capacity especially for the roofing. |

The end of the table.

### 5.4.6. Durable shelters

Locally built shelters could be built through semi-permanent means by using more durable materials such as (adobe/brick/concrete blocks with cement mortar, if available locally as a cost-effective option. It does provide durable/ mass walls and a lifespan of more than 5 years and is usually suitable for use on permanent lands for the construction of resilient shelters for returnees. The pros and cons are shown in the below table.

**Table 18.** The Pros and Cons for Durable shelters as HSR.

| Pros | Cons |
|---|---|
| - Long life span<br>- Provide Mass walls with better shelter envelope performance.<br>- Provide durable and secure envelopes.<br>- Reduce or Eliminate the need for frames.<br>- Enable Early recovery. | - Are not applicable for Temporary lands.<br>- Could be Costly for a large scale response.<br>- Time-consuming.<br>- Labour intensive. |

End of the table

### 5.4.7. Earth shelters

Earth shelter referto shelters that use soil as a major construction material. It does cover many traditional and vernacular building techniques, as well as, innovative ones, that use mud, clay, soil, and dirt) in construction such as compressed earth blocks (CEB), or also called stabilized soil blocks (SSBs). Additionally, interlocking stabilized soil blocks (ISSBs), adobe, supper adobe, cob, rammed earth, wattle and daub, and tath & plaster are considered in this catergory each with its own variation in composition.

Earth shelters are considered to be a localised solution that is uses locally available materials so in addition to the main pros and cons of locally built shelters, the below table emphasises the pros and cons that are related to the earth shelters in specific in addition to the general ones.

**Table 19.** The Pros and Cons for Earth shelters as HSR.

| Pros | Cons |
|---|---|
| - Use widely available material(Earth).<br>- Provide thermal mass walls<br>- Secure envelope<br>- Fire-resistant envelope.<br>- Allow the upgrade to durable shelters.<br>- Require a high level of community involvement.<br>- Enable early recovery.<br>- Use Low tech and Vernacular techniques. So it is a simple and familiar building method to the locals.<br>- Reduce the cost of skilled workers.<br>- Soil is a reversible material.<br>- Allow for the vast adoption by the FDP.<br>- Flexible solution for personalizing, Customization, addition, expansion, and division.<br>- Less harmful to the environment than another modern alternative.<br>- Contribute to deforestation prevention.<br>- Can address a climate-responsive sheltering solution. | - Water intensive.<br>- Required a sunny open space for drying the blocks, and shaded storing area.<br>- Difficult to dry in wet seasons.<br>- Labour intensive.<br>- Time-consuming.<br>- Risk of soil erosion.<br>- Soil extraction could be environmentally harmful.<br>- Required additive (Cement, or Lime) to enhance the durability. |

End of the table.

### 5.4.8. Hybrid (Framed-Earth) shelters

Hybrid (Framed-earth) shelters are erected using a combination of the two different shelter systems, earth and frames in order to gain the combined benefits of these two systems. However, in hybrid shelters the combination will be used in the shelter but not in its components, as only one system is used for one shelter component such as walls and another system for different shelter components such as the roof. For instance, bamboo frames for the roof with a brick wall and earth flooring.

**Table 20.** The Pros and Cons for Hybrid (Framed-Earth) shelters as HSR.

| Pros | Cons |
|---|---|
| - Could combine the benefits of both systems such as providing Mass walls and bracing systems for natural hazards reduction.<br>- Could reduce the overuse of natural materials due to the use of a wider range of materials.<br>- Relatively, shorter construction time compared to earth shelters.<br>- Can address higher adequate than framed shelters especially in cold climates/seasons.<br>- Some materials are transportable and others are reversible | - Required multiple sources of materials.<br>- Required further training and support for proper construction.<br>- Only partial dismantling and transporting. |

End of the table.

### 5.4.9. Integrated (Framed-Earth) shelters

Integrated shelters are erected shelters that use a combination of systems integrated into one component of the shelter, such as a framed wall with bricks infill or wattle and daub walls. The procs and cons of these are shown below:

**Table 21.** The Pros and Cons for Integrated (Framed-Earth) shelters as HSR.

| Pros | Cons |
|---|---|
| - Provide more durable shelter than framed shelters<br>- With enhanced adequacy and security.<br>- Required less soil than earth shelters so contributes to reducing the environmental effects of soil degradation.<br>- Better addressing risk reduction measures than earth shelters, with fewer materials.<br>- Allow for the integrated use of prefabricated frames, which allows for faster response.<br>- Compatible with an incremental approach.<br>- Allow for shelter upgrade of the lightweight envelope to the mass envelope.<br>- Could be suitable for temporary lands, while solving the land tenure issues. | - Required multiple sources of materials.<br>- Required further training and support for proper construction.<br>- Once upgraded to mass walls it becomes more difficult than the hybrid system to be dismantled and transported. |

End of the table.

### 5.4.10. Reclaimed materials.

The possible use of reclaimed materials is subject to its appropriateness for construction use, and availability in addition to the possible innovative reuses and community initiatives and involvement. However, it is a possible cost-effective approach that is environmentally rewarding due to the upcycle process of the concept of using it as a building material. The following table represents the possible pros and cons extracted from the reviewed reclaimed materials case studies.

**Table 22.** The Pros and Cons for Reclaimed shelters as HSR.

| Pros | Cons |
|---|---|
| - Environmentally rewarding due to the upcycling of disposal materials.<br>- Contribute to the avoidance of the overuse of natural materials.<br>- enhance community resilience.<br>- Affordable approach<br>- Cost-effective approach.<br>- required community involvement especially For materials collection and preparation. | - Not always available.<br>- Not all disposal materials are constructible materials.<br>- Subject to social appropriateness. |

End of the table.

Innovative practices are excluded from the evaluation process due to the absence of reliable information and the lack of credible feedback.

### 5.5. The Evaluation of different sheltering solutions based on the specified creteria .

#### 5.5.1. The evaluation criteria.

In order to enable a practical comparison between the different types of existing solutions, an evaluation table has been established with specified criteria. Firstly, the criteria themes are a list of ADS characteristics with a corresponding principles panel which in total cover eight main categories as follows: The scale of the response, The solution durability, Self-reliance, Adequacy, the solution sustainability, Adaptable capacity, Localisation, and Compatibility with IRRD model.

**Table 23.** The Evaluation Criteria of the categorized sheltering solutions.

| The evaluation criteria of the comparison table | |
|---|---|
| Scale of response | Fast relief response |
| | Vast relief response |
| | Cost-effectiveness |
| Durability | The durability of the solution |
| | Life span |
| | Standardization &quality insurance |
| Self-reliance | Community engagement |
| | Ease of Self-built |
| | Less manpower |
| Adequacy means | Protection, security, and safety |
| | Health and comfort |
| | Adequate space |
| | Privacy, and dignity |
| | Socio-cultural appropriateness |
| | Resilience |
| Sustainability | Climate responsive |

| | |
|---|---|
| | Materials overuse prevention |
| | environmentally friendly |
| Adaptable capacity-ADS Characteristics | Upgrade-able |
| | Transform-able |
| | Reuse-able |
| | Sell-able |
| | Recycle-able |
| | Integrate-able |
| | Relocate-able |
| | Addressing land tenure issue |
| Localization | Locally produced materials |
| | Local building techniques |
| | Local strategies |
| | Local economy stimulation |
| (IRDD) model | Incremental approach |
| | Early recovery |
| | Sustainable development |

End of table.

Secondly, the evaluation aim is to specify the level of strength and weakness for each type of solution in the specified theme, therefore three different tags have been used to specify the status of each solution as shown by the following table:

**Table 24.** The evaluation method and the Tags meaning.

| | |
|---|---|
|  | The Pross & Cons list reported a Strength(s) in the evaluated theme. |
|  | The Pross & Cons list reported both a Weakness(es)and a Strength(s) in the evaluated theme or did Not report any. |
|  | The Pross & Cons list reported a Weakness(es) in the evaluated theme. |

### 5.5.2. The evaluation table

After investigating the reported strength and weakness of each solution type the evaluation table can be presented as the following:

**Table 25.** Strength and weakness of the different types of shelter solutions. By the Author.

| Table of Strength and Weakness by theme of the Different types of shelters solutions | The evaluation criteria of the comparison table | | Global Solution | | | Local Solution | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tents | Materials distribution Tarps & coir sheets | Prefabricated shelters | Framed Locally-built | Durable Locally-built | Earth shelters | Hybrid | Integrated | Reclaimed materials & infill |
| | Scale of response | Fast relief response | S | S | sw | sw | W | W | sw | sw | W |
| | | Vast relief response | S | S | sw | sw | W | W | sw | sw | W |
| | | Cost-effectiveness | sw | sw | W | S | W | S | S | S | S |
| | Durability | The durability of the solution | W | W | sw | W | S | S | S | sw | S |
| | | Life span | W | W | sw | W | S | S | S | sw | S |
| | | Standardization &quality insurance | S | S | S | sw | sw | sw | sw | sw | sw |
| | Self-reliance | Community engagement | W | sw | W | S | sw | S | S | S | S |
| | | Ease of Self-built | S | S | S | S | sw | sw | S | sw | sw |
| | | Less manpower | S | S | S | S | W | W | sw | sw | W |
| | Adequacy means | Protection, security, and safety | W | W | sw | sw | S | S | sw | S | S |
| | | Health and comfort | W | W | sw | sw | S | S | sw | S | S |
| | | Adequate spare | sw | sw | sw | sw | sw | sw | sw | sw | sw |
| | | Privacy, and dignity | W | W | sw | sw | S | S | sw | S | S |
| | | Socio-cultural appropriateness | W | W | W | sw | sw | S | sw | S | sw |
| | | Resilience | W | W | sw | sw | S | S | S | S | sw |
| | Sustainability | Climate responsive | sw | sw | sw | sw | S | S | sw | S | sw |
| | | Materials overuse prevention | S | S | S | W | W | W | S | S | sw |
| | | Environmentally friendly | W | W | W | sw | sw | sw | S | S | S |
| | Adaptable capacity-ADS Characteristics | Upgrade-able | W | sw | sw | S | sw | S | sw | S | sw |
| | | Transform-able | W | sw | sw | S | sw | S | S | S | sw |
| | | Reuse-able | sw | W | S | S | sw | sw | S | sw | S |
| | | Sell-able | sw | W | S | sw | W | W | sw | W | sw |
| | | Recycle-able | sw | sw | sw | sw | sw | S | sw | sw | sw |
| | | Integrate-able | W | W | sw | sw | sw | S | S | S | sw |
| | | Relocate-able | S | S | S | S | W | W | S | sw | sw |
| | | Addressing land tenure issue | S | S | S | S | W | sw | S | sw | sw |
| | Localization | Locally produced materials | W | W | W | S | sw | S | S | S | S |
| | | Local building techniques | W | W | W | S | sw | S | S | S | S |
| | | Local strategies | W | W | W | S | sw | S | S | S | S |
| | | Local economy stimulation | W | W | W | S | sw | S | S | S | S |
| | (IRDD) model | Incremental approach | sw | sw | sw | S | W | S | W | S | W |
| | | Early recovery | W | W | sw | sw | S | S | sw | S | S |
| | | Sustainable development | W | W | W | sw | S | S | sw | sw | S |

End of table.

In order to simplify the schedule above, another version of the schedule has been presented that shows only the strengths in light blue and weaknesses in yellow and the other areas which are left blank. The colour coded table below was easy to read and shows some important key findings.:

**Table 26.** Colored Strenght and weakness of different types of shelter solutions.

| Table of strength and weakness by theme of the Different types of shelter solutions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evaluation Themes / Type of shelter solution | | Scale of response | | | Durability | | | Self-reliance | | | Adequacy Means | | | | | Sustainability | | | Adaptable Capacity -ADS Characteristics | | | | | | | | Localization | | | | | (IRRD) model | | |
| | | Fast Relief Response | Vast Relief Response | Cost-Effectiveness | Durability of the solution | Life span | Standardization | Community Engagement | Ease of Self-built | Less man power | Protection, security, and safety. | Health, and comfort. | Adequate space. | Privacy, and dignity. | Socio-cultural Appropriateness. | Resilience | Climate responsive | Materials Overuse Prevention | Environmentally friendly | Upgrade-able | Transforme-able | Reuse-able | Sell-able | Recycle-able | Integrate-able | Relocate-able | Addressing Land tenure Issue | Locally produced Materials | Local Building Techniques | Local Strategies | Local Economy Stimulation | Transitional Approach | Early Recovery | Sustainable Development |
| GLOBAL SOLUTIONS | TENTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Materials Distribution Tarps and CGI sheets | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Prefabricated shelters | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LOCAL SOLUTIONS | Framed Locally-built shelters | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Durable Locally-built shelters | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Earth Locally-built shelters | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Hybrid (Framed-Earth shelters) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Integrated (Framed-Earth shelters) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Reclaimed materials & Infill | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Table 27.** Legend of Table of Strength and Weakness.

| **Legend of Table of Strength and Weakness.** | |
|---|---|
| | Weak in its related theme. |
| | Strong in its related theme. |
| | Neutral or Multisided in its related theme. |

### 5.5.3. The comparison and discussion

To understand the table above a discussion for each theme has been conducted in order to identify the final remarks.

#### 5.5.3.1. The scale of response:

Tents and materials distribution presents a vast and fast humanitarian response solution which could be critical, especially in the relief stage. Moreover, it does not necessarily present a cost-effective solution due to its short life span which usually causes a repeated call for further distribution, unless it was a part of an incremental process of response. Additionally, prefabricated shelters could serve for a long time but are not addressing fast and vast solution due to the time required for fabrication and transportation and its considerable additional costs. So it is not usually a cheap solution, However, locally built shelters which present more durable solutions and make more sense in cases such as response for returnee and cases with solved land tenure, it is clear that these solutions tend to be time-consuming and required greater funds in addition to the availability of the construction materials locally in order to be vastly adopted. Therefore it is usually more suitable for long term displacement situations.

#### 5.5.3.2. Durability and lifespan

Global solutions such as tents, materials distribution, and prefabricated shelters do not represent a durable solution as it tends to be designed for the minimum possible cost in order to ensure the possibility of a vast response As a result its life span could vary from a 1 year to 5 years which means it could serve short to mid-term displacement, even though it is a standardised solution that tends to ensure proper manufacturing, distribution, and standardised implementation so to ensure that it does serve the goal that it has designed for it. However, locally built shelters such as durable, earth, hybrid, and integrated.) are all present more durable solutions with an extended life span that are more suitable for mid to long term displacement. However these solutions could not be standardized as the global solutions therefore support and training are required to avoid the risk of slums and the possible unwelcome results, due to the low-quality insurance.

#### 5.5.3.3. Self-reliance

In terms of self-reliance, the localised solutions such as framed shelters, earth shelters, hybrid, and integrated are addressing better community engagement in the design and construction process of the humanitarian shelters, which allow for addressing more successful response in the mid and long term Global solutions tend to skip the community involvement and address more rigid standardised solutions, however, the global solutions could address the ease of self-built and additionally could require less manpower to be erected compare to localized solutions, which again, indicate the potential success of global solutions in the relief response, but not in long term displacement.

#### 5.5.3.4. Adequacy means

Even though global solutions are more successful in terms of fast response it tends to address poor or very little adequacy means as it is usually designed for emergencies. Even a good performance global shelter which tends to be prefabricated still do not properly address a socio-cultural appropriate solutions due to the rigid approach in the global solutions and the absence of the community role. On the other hand, localised solutions have greater potential to address adequate shelters for the displaced population including, dignity, a sense of belonging, enhanced community resilience and provide socio-culturally appropriate solutions through a self/supported build approach. but where it is not an emergency situation due to the time, manpower, and materials availability.

#### 5.5.3.5. The Sustainability

In terms of climate-responsive shelters, localised solutions can better address different climate conditions, than globalised solutions. It must however be noted that localised solutions could cause local materials overuse with its potentially harmful environmental effects. Global solutions could reduce such effects, however, the potential use of natural materials that is available locally in renewable rates, can address environmentally friendly sheltering solutions that can reduce or eliminate the environmental harmful effects related to long-distance transportation and provide a more healthy and sustainable sheltering solution and development.

#### 5.5.3.6. Adaptable capacity

Global solutions usually are a temporary structure that is more likely to be relocatable and more suitable for temporary lands that give time to solve the land tenure issue and in that sense it could be more adaptable to urgent and temporary situations. However, these solutions are more rigid in terms of upgrade and shelter transformations compared to other localised solutions, which allow for more adaptable solutions to the population differences and the shelters transformation to meet the future changes in their needs and requirements. Solutions such as prefabricated shelters are more likely to be sellable and reusable due to the ease of dismantling and reassemble of existing sheltering solutions, but not necessarily integratable, even though it is more likely to integrate hitech solutions such as solar lighting in a prefabricated shelter. But maybe not renewable resources that are more likely to depend on overseas materials. Therefore the integration of locally available renewable resources is more possible with localised sheltering solutions which are more likely to be reusable and/or invertible materials and shelter elements.

#### 5.5.3.7. Localization

Localised strategies such as locally produced materials, local building techniques and strategies which is previously specified as one of the ADS corresponding principles are establishing early recovery response and tends to stimulate the local economy, create work opportunities, ensure better community involvement but enhance the sense of belonging, dignity, and the appropriateness of the proposed solutions. Moreover, global solutions are not adaptable to the local needs and requirements, therefore local solutions could be preferable especially in the advanced stages in the displacement solutions.

#### 5.5.3.8. IRRD compatibility

As mentioned, localised solutions are more likely to establish an early recovery response with a possible sustainable sheltering approach and development. This could initiate a successful integrated linkage among relief, recovery, and sustainable development, that is compatible with the proposed IRRD model. The absence of an incremental approach, proposed by localised solutions such as the direct implementation of durable solutions, and some hybrid systems (Framed- earth shelters), which propose a rigid and/or a single-stage solution increase the risk of disconnectivity and the separation between the stages of the approaches which ending up with more costly solutions and risking the failure

of response, especially in long term displacement. However, earth shelters, local vernacular techniques, and the integrated systems of framed – earth shelters show a high potential of multi-stages solutions with high compatibility with an incremental approach of upgrade and transformation.

### 5.5.4. Final remarks of the evaluation.

To conclude, there is no single sheltering solution that can be considered appropriate for the whole life span of the displacement global and/or local. Each solution tends to have strengths in some aspects of the evaluation criteria and weaknesses in other aspects. However, there is a clear difference in the strength and weakness of the response between global and local solutions as global solutions tends to show strength in terms of scale of response, standardisation and quality insurance, ease of self-built with less manpower, help to avoid the possible overuse of local materials, and most importantly provide a transportable shelter as a temporary solution for temporary land that provides the occupants and the organisations with some time for solving land tenure issues. Local solutions show greater strength in terms of durability, adequacy, climate response, community engagement, early recovery, and some higher levels of compatibility with an incremental approach. Moreover, localized solutions seems to be more cost-effective due to their longer life span. Cost-effectiveness cannot be considered for a specific solution's life span, but it should be considered for the whole life span of the displacement situation, so what could be considered as a cost-effective solution could be not that effective in the long term of the displacement especially with the absence of a holistic overview of a transitional approach.

Generally, global solutions are more likely to be suitable for the relief aim of response and local solutions are more likely to be suitable to the aim of early recovery and sustainable development.This result could highlight another practical reason for the possible gap between these two different aims, relief and sustainable development. It does show the potential of maximising the strength of the sheltering response through a more holistic approach due to the potential connections between the solutions by increasing their adaptable capacity through the implementation of ADS characteristics and the transition enablers that could initiate an integrated linking between relief, recovery, and sustainable developmentand, and its correlated adequacy enhancement for the FDP.

The next chapter will aim to specify the potential transition enablers and their role in the transitional approach.

## 5.6. The transition enablers identification.

United Nations (2004) has visualised an example of the shelter self-upgrade presenting an incremental process using initial sheltering assistance of tarps, poles and ropes and upgraded it by using locally available materials. This shown in the below example where wood poles, and soil are used in order to transit to a more adequate shelter.

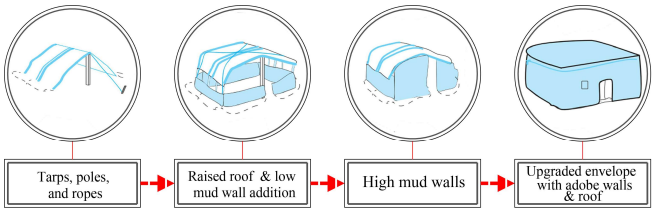



**Figure 5.6-1.** Humanitarian shelter self upgrade visualized by **(United Nations, 2004)** , represented by the author.

The figure above has been represented by the author as a logical hierarchy of shelter stages. Another example of a transitional process of sheltering upgrade is the wooden gable frame shelter in South Sudan (UNHCR, 2016). The diagram below represents a tow stage of envelope upgrade that is also using an initial shelter of wooden frames and UNHCR tarps that has been upgraded using locally available materials (LAMs) for the first stage. In this example (Thatch cladding covers for walls, woven curtain covers for doors and windows, and CGI sheets is used for the roof ). The first envelope upgrade

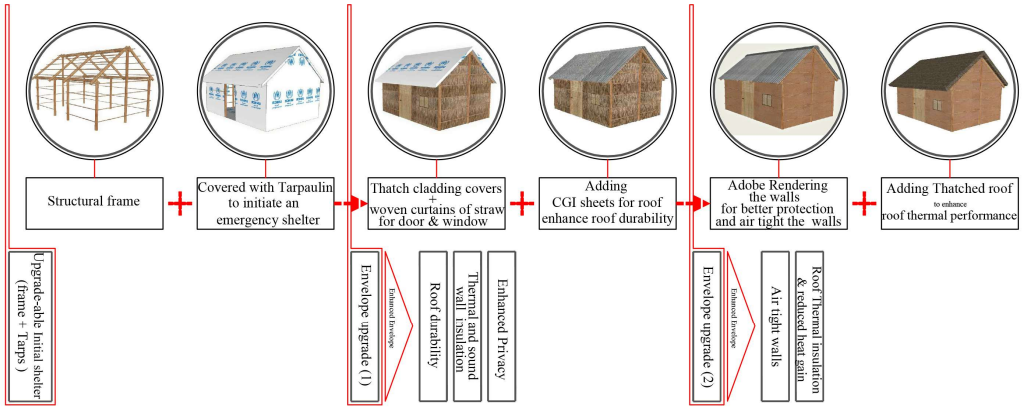



**Figure 5.6-2.** Incremental process of gable frame shelter in South Sudan 2013, **(UNHCR, 2016)**

has increased the roof durability and enhance thermal and sound insulation and privacy. The second envelope upgrade thatched walls have been rendered with mud and the CGI roof has been covered with thatch so the second upgrade has enhanced the strength and durability of the walls providing the occupants with better protection and increased the envelope airtightness reducing the roof heat gain and enhancing its thermal insulation properties. The key factor to be noticed in this example is that all these improvements were enabled by three main enablers self/supported build, LAMs, and liable structure.

So similar to this discussion and in order to specify the possible enablers (technique, practice, approach, and, material) that could be extracted from the reviewed existing and innovative case studies in this thesis and to specify its role and place in the process, an entity-relationship diagram (ERD) has been visualized. This specifies the enabler with its related examples and its possible contribution in maximising the shelter solution adaptive capability to transition and connecting it with the related ADS characteristics of the adaptable shelters. This has been established partially for each enabler and then combined together in one diagram that is summarised later on in the transition enablers general table.

### 5.6.1. Liable structure & LAMs

Liable structures as identified in the reviewed case studies is a structure which is stable, resilient to hazards, and durable. Additionally it should be responsive to future needs such as withstanding the weight of additional materials and/or the need for dismantling and reassembling.

LAMs (Locally Available Materials) also has been previously defined as any material that is widely available locally, cost-effective, suitable for construction, environmentally sustainable, and socio-culture appropriate, however, LAMs could be originally available and/or previously distributed so the key factor is its availability at the time of the need, in addition to its durability. So when both liable structure frames and LAMs are available the self/supported build) approach will become more possible. When people can self-build their shelters they can also self-repair and self-upgrade the shelters, which present the self/supported (build, repair, and upgrade) approach as a key enabler for upgradable shelters. The relationship between these enablers can be visualized through an entity relation diagram (ERD) shown below:

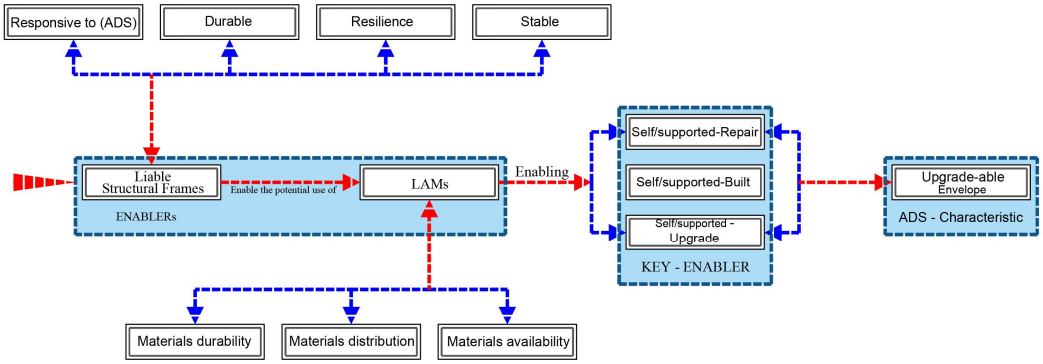



**Figure 5.6-3.** ERD-01, Liable structure, LAMs, and Self/supported built as an enablers for upgradable shelter envelope, By the Author (2021).

### 5.6.2. Liable structures as a key for extended shelter life span.

Liable structures are not only an enabler for the self-build approach but also could enhance the effectiveness of the sheltering response and its long-run cost by enabling the possible reuse of the shelter as the liable structure should be resilient and stable and withstand the potential hazards such as (Flood, Earthquake, Snow load, hurricanes, fire, etc. This enhances the FDP community resilience and when combined with quality insurance and regular maintenance the life span of the shelter will be extended. This will enable the potential reuse of the shelter which provide the FDP with further options for the future changes. The below ERD presents this situation:

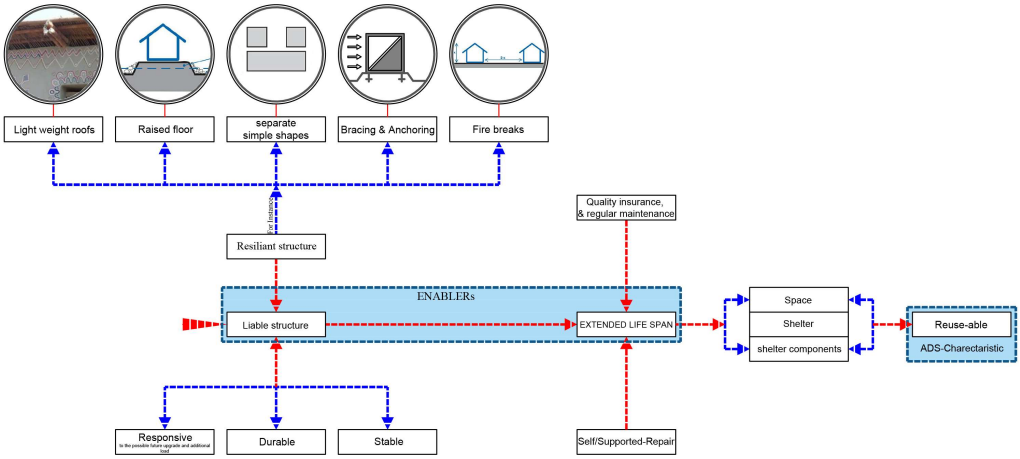



**Figure 5.6-4.** ERD-02, Resiliant structure and the potential reuse of the shelters, by the author (2021)

### 5.6.3. Technical ease & materials availability

When looking at LAMs and their availability, there is another factor that is also important for the population to be able to reach a successful Self/supported build approach which is the technical ease of construction, which should be simple in order to be learned and to be copied multiple times between

the population, for an effective and scaled response, so to present this enabler an (ERD 03) has been visualized as the following:

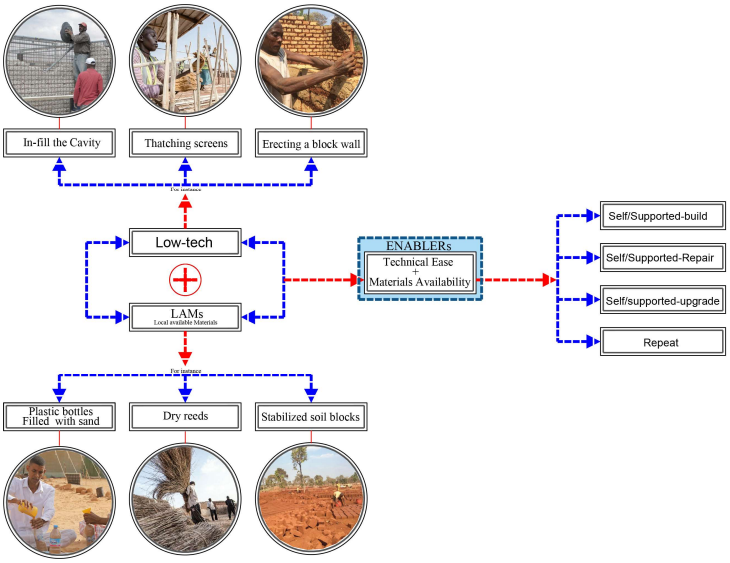



**Figure 5.6-5.** ERD-03, Technical ease as an enabler for Self/supported (Build, repair, upgrade, and repeat) approach, By the Author.

### 5.6.4. FDP capability of self/supported (build, Upgrade, Repair, & repeat).

Technical ease means that the building techniques are not complicated which is defined as low-tech. Also it consists of lightweight materials or components so it does not require heavy machinery or a lot of people to carry, move, or erect the components. Additionally, the local vernacular techniques which usually represent a familiar building technology for the FDP that is more likely to be suitable culturally and environmentally. Furthermore, it is important to identify the FDP's local building skills and their need for training and support. It is also important to identify the FDP's capability of self supported BUR (Build, Upgrade, Repair, and Repeat), through the identification of three major enablers LAMs, local building skills and training, and technical ease. This relationship is presented in the following ERD-04:

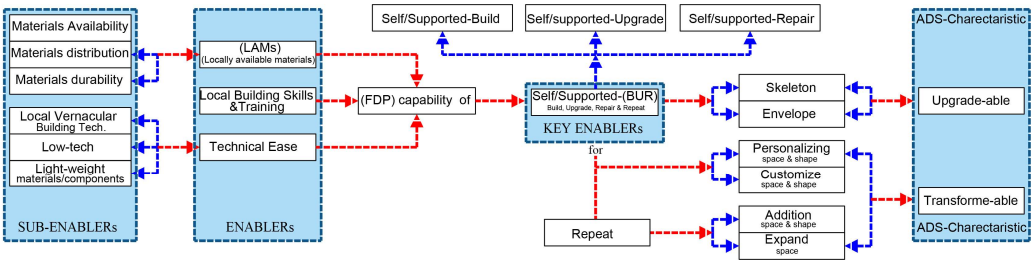



**Figure 5.6-6.** ERD-04, FDP capability of Self/Supported (BUR), By the Author

A Self-supported (BUR) approach does not only enable the upgradeable characteristics of ADS but also allow the FDP to successfully personalize and customise their own shelters to meet their specific requirement and increase the sense of pride, ownership, dignity and belonging. Furthermore, the population can repeat the process for the possible need of adding and expanding the shelters due to the occupant's special needs and requirements. The self-supported (BUR) is defined as a key enabler for the characteristics of both upgradable and transformable.

### 5.6.5. Expandable designs

Expandable and additional solutions for shelters could be enhanced by the adoption of expandable designs as an enabler for this kind of transformation. Many types of expandable designs have been observed in the reviewed case studies such as shapes that allow for the addition, predesigned addition

spaces, modularity, extended living spaces, and innovative expandable structures. This sub-enabler and examples of it has been presented in the following ERD:

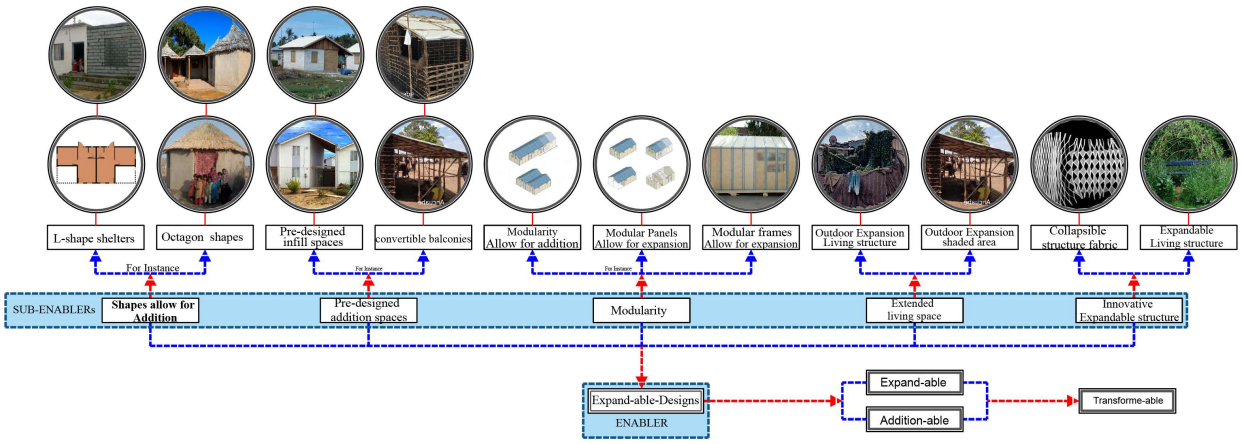



**Figure 5.6-7.** ERD-05, Expandable designs as an enabler for Transformable ADS Character.

### 5.6.6. Ease of dismantling and transportation.

Furthermore, one of the defined ADS characteristics was relocatability. For this characteristic, two major enablers should be considered which is the ease of dismantling and assembling of the shelter and its components. For this aim many techniques and solutions which are localised or global solutions are extracted from the reviewed projects and considered to be a sub enabler for the aim of easy dismantled and re-assembly such as lashing connections, interlocking shelter elements, prefabricated shelter components, modularity, and self-standing systems. On the other hand flatbacks, lightweight (shelters,

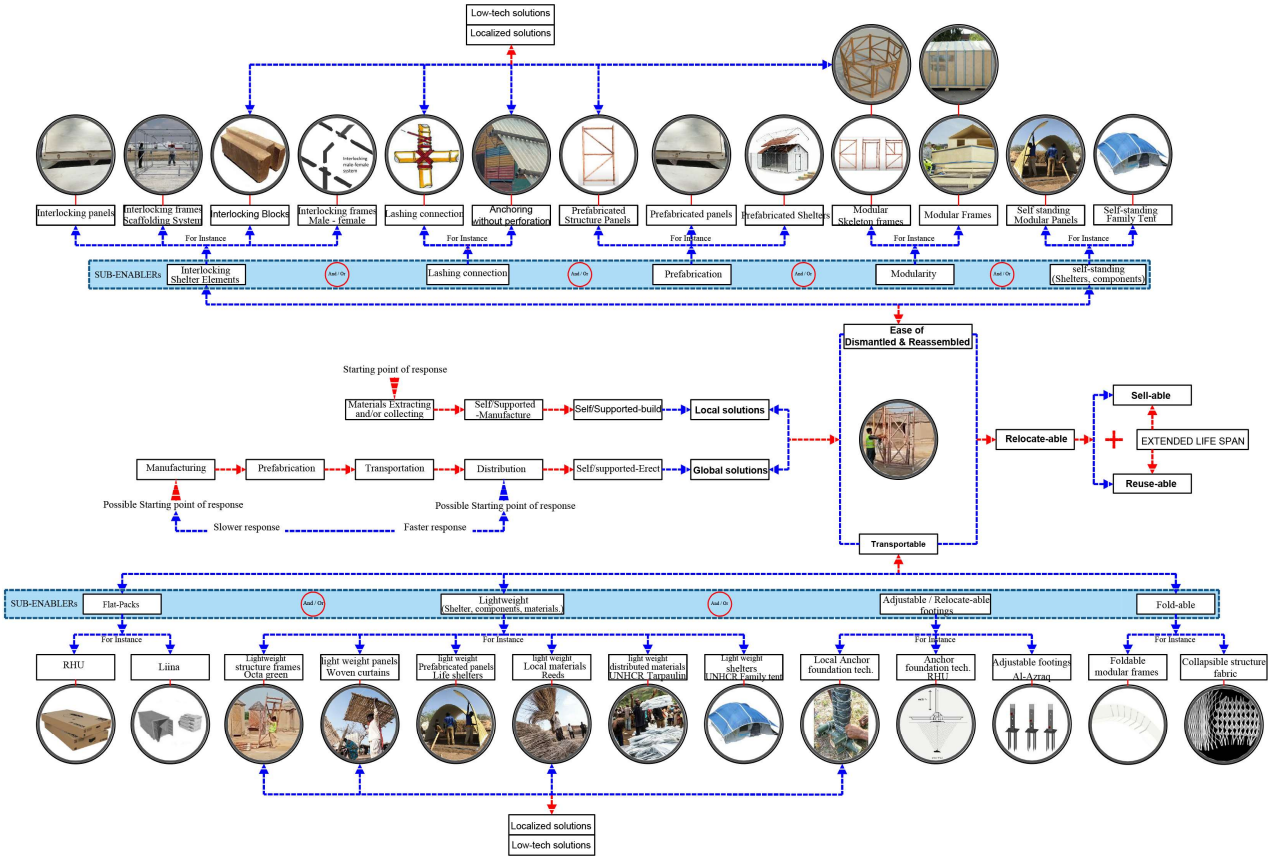



**Figure 5.6-8.** ERD-06, the enablers and sub-enablers of Relocat-able characteristic of ADS, By the Author (2021)

components, and materials), adjustable and relocatable footings, and foldable (shelters, and/or components)) represent a list of sub-enablers for transportable shelters and shelters components. Together ease of dismantling , reassembly and transportability will enable relocatable shelters. ERD-06 presents this relationship and visualises examples of the implementations. Additionally, relocatable shelters with an extended life span are more likely to be reusable and sellable.

### 5.6.7. Reversible, recyclable, and the Upcyclable materials

Moreover, locally available materials could be naturally available materials such as reeds, poles, bamboo, sand, mud, rock etc. or locally manufactured materials, such as CGI sheets. It could also be materials for disposal that could be reclaimed innovatively as construction material such as, Tyres, bottles, water tanks, etc. After the end of the use, natural materials are biodegrable materials , locally manufactured materials could be recycled, and the disposal materials could be upcycled through the concept of the reusing it before the disposal. Therefore the use of LAMs are enabling the recyclable characteristics of the ADS. This is present in ERD-07 below:

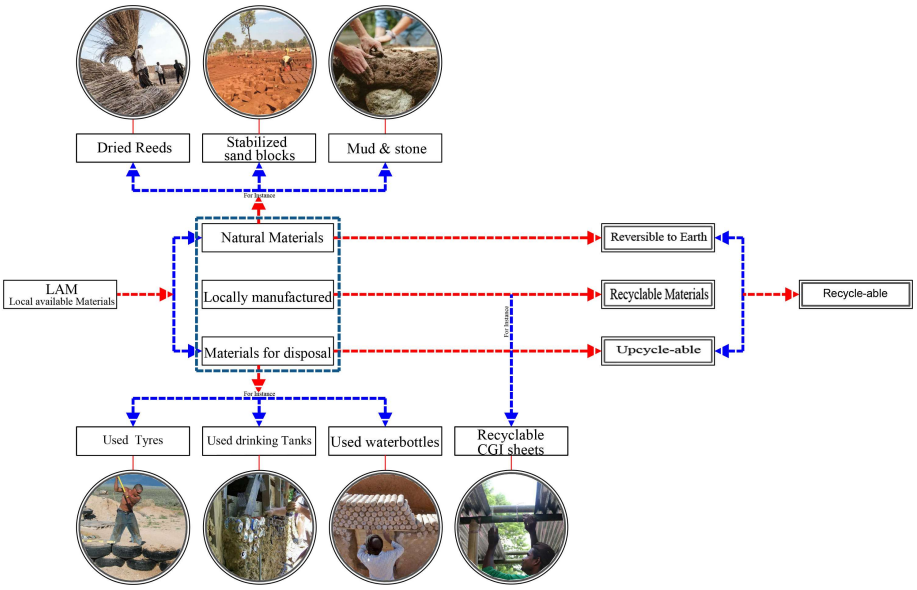



**Figure 5.6-9.** ERD-07, LAMs as an enabler for the characteristic of (Recyclable). By the Author (2021)

### 5.6.8. Sellable shelters & (RRR) Reusable, Relocatable, &Recyclable.

Additionally, the RRR which represent the three characteristics reusable, relocatable, and recyclable combined together will facilitate the sellable characteristics as the shelter solution can be relocated, reused, and as a last option, it could be resold by the beneficiary to recycling bodies. As shown in ERD-08 below:

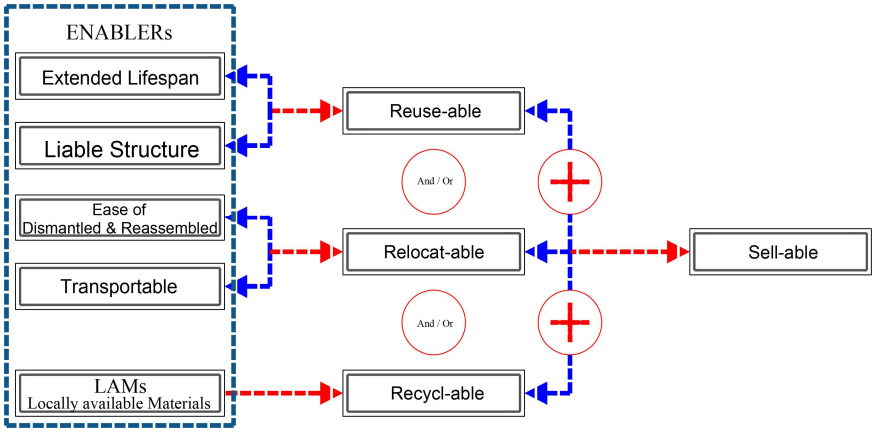



**Figure 5.6-10.** ERD-08, the RRR relation for sell-able shelters. By the Author (2021)

### 5.6.9. The integration of passive strategies

As shown previously the self-supported BRU (Build, Repair, and Upgrade) can be the key enabler for self shelter upgrade. In parallel to this process this approach can also integrate the passive design strategies as a targeted upgrade, so it represents a passive-upgrade for humanitarian shelters. therefore

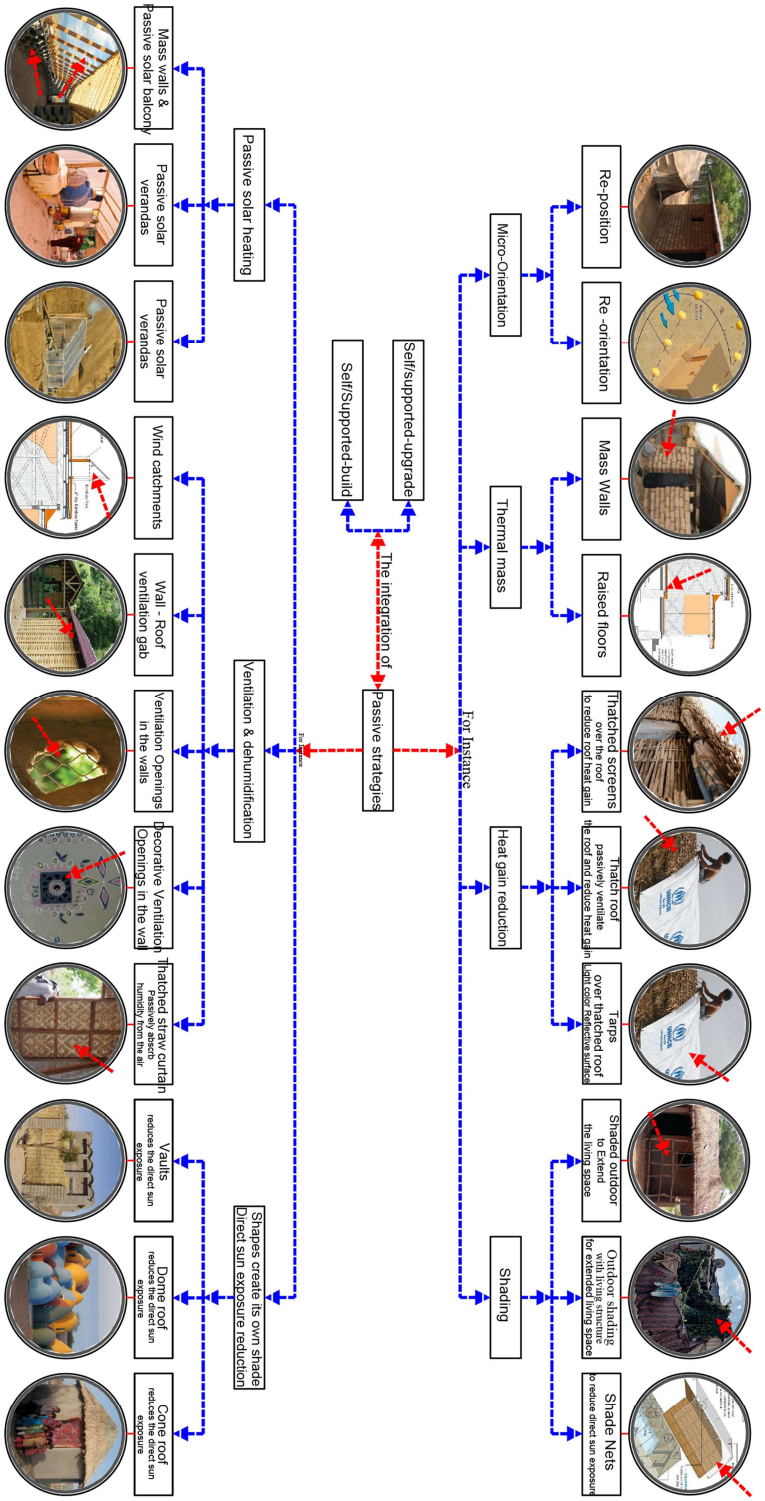



**Figure 5.6-11.** ERD-09, The integration of passive strategies in the Self/supported (BRU) process.

pPassive design strategies such as micro orientation, thermal mass, heat gain reduction, and shading in addition to solar heating, ventilation, dehumidification, direct sun exposure reduction etc are strategies to be integrated within the process of self -supported BRU. Examples of the real-life humanitarian sheltering implementations are represented in **ERD-09.**

### 5.6.10. The integration of renewables.

The integration of renewables in the humanitarian sheltering response, such as the adoption of reversible and/or renewable materials as a construction material for the humanitarian shelters , in addition to strategies such as rain water catchments and the potential use of the advanced technology when it is available and affordable such as solar lighting, solar heaters, and solar panels. This integration of the renewables are part of the ADS characteristic of integratable shelters. This relationship is represented in ERD-10 with examples of real implementations of the possible integration Self-supported BRU is still a key enabler for such integration of both passive strategies and renewables for integratable shelters. As shown in ERD-11.

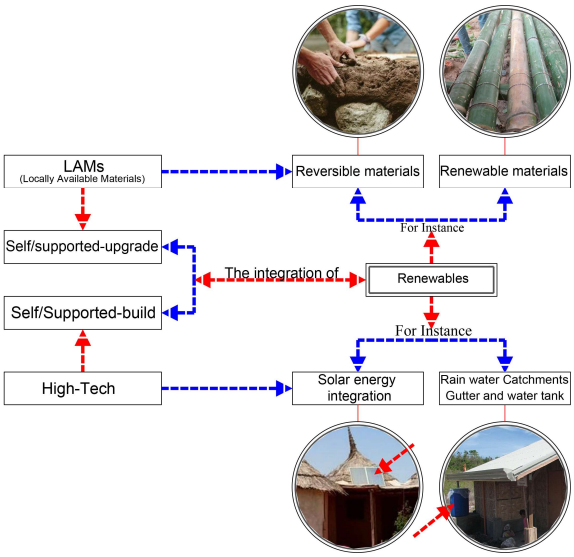



**Figure 5.6-13**. ERD-10, The integration of renewables, by the Author.

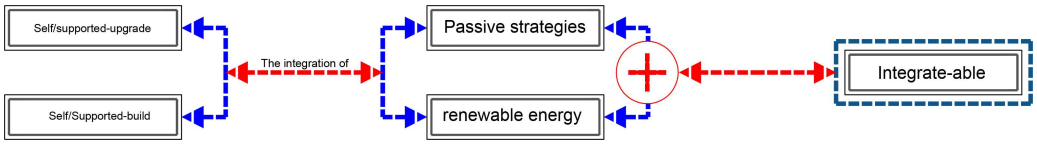



**Figure 5.6-12.** ERD-11, Self supported (BRU) the key enabler for the Integratable ADS character.

### 5.6.11. Types of transition.

Two different types of transition can be identified in the reviewed cases, which are hybrid transition and integrated transition. These are explained in the following sections.

#### 5.6.11.1. Hybrid transition.

Hybrid shelter transition refers to shelter transition to the adequacy and resilient shelters depending on the benefit of self –standing envelopes such as superadobe, thin tile vaulting, earth shelters etc which allow the FDP to erect a more adequate shelter without the need for the integration of the initial emergency shelter and/or its components into the new envelope construction. So the new shelter envelope can be erected structurally separated from the initial shelter eitherbesides, contained or as an addition to the initial shelter. This allows for transition while the FDP is still living within the initial shelter. This type of hybrid transition even though it does possibly require further materials is able to provide and address further adequacy means as it does allow for the use of more durable

materials and mass walls. It also, provides the occupants with free use of the initial shelter by

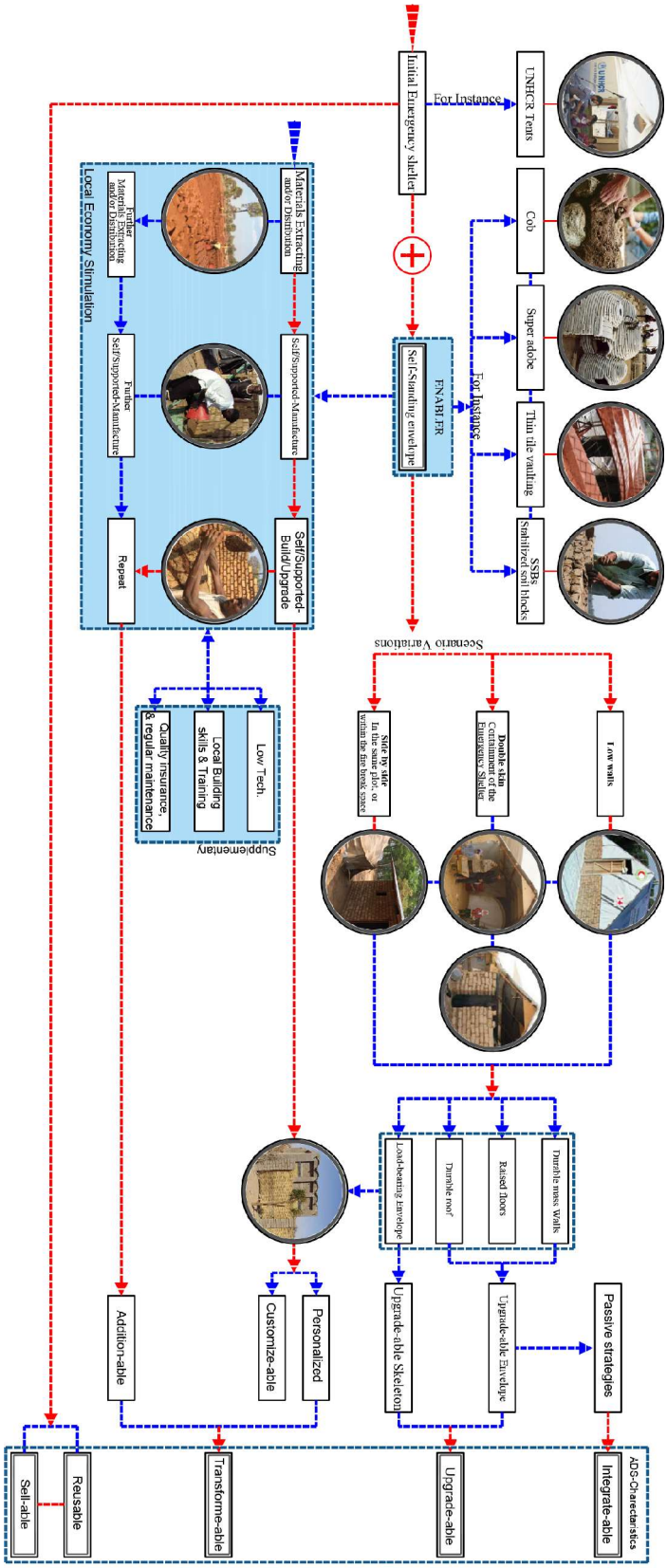



**Figure 5.6-14**. ERD-12, Hybrid type of transition. By the Author.

reusing, selling, and or recycling. However, this type of transition can be implemented effectively by the adoption of the self-supported BRU approach, including materials extraction, distribution and manufacturing, which also stimulate the local economy and provide work opportunities to the FDP, allowing for the FDP to recover as early as possible. ERD-12 represents and explains the process and also provide examples of hybrid transitions.

### 5.6.11.2. Integrated Transition.

Integrated shelter transition refers to the shelter transition process that integrates the initial shelter and/or its components within the process of the shelter envelope upgrade using innovative uses of vernacular localised architectural techniques that allow for the initial structure and envelope materials to be part of further development and upgrade. This approach of transition tends to be a lightweight structure yet can address better adequacy with multiple upgrade stages, this approach seems to be more suitable for temporary situations with land tenure issues but still, provides the occupants with the option of transition to adequacy while still compatible with the self-supported BRU approaches.

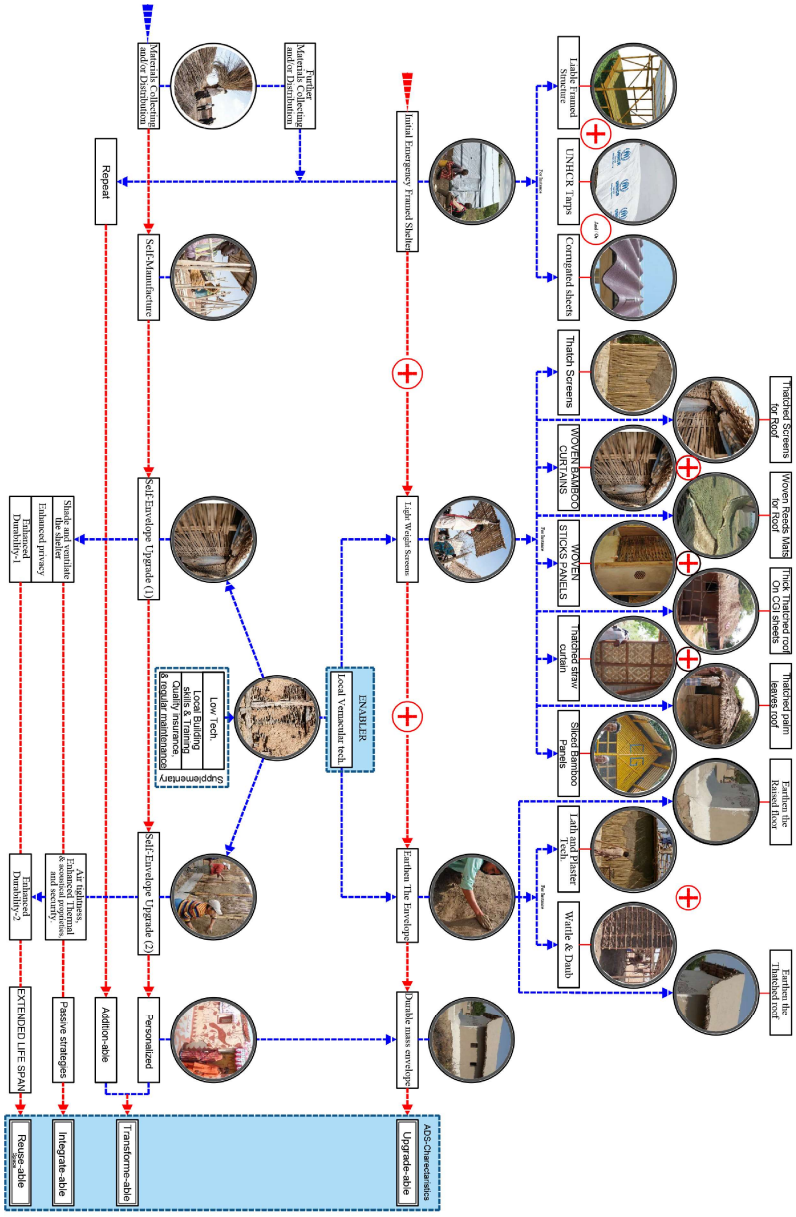



**Figure 5.6-15** ERD-13, The Inttegrated Transition, By the Author (2021)

### 5.6.12. Summary

To summarise the above-discussed enablers a more comprehensive ERD has been mapped that summarises the enablers and their relations to adaptable shelters while categorising it into three main categories (enablers, sub-enablers, and key enablers.). This is diagrammatically shown below.

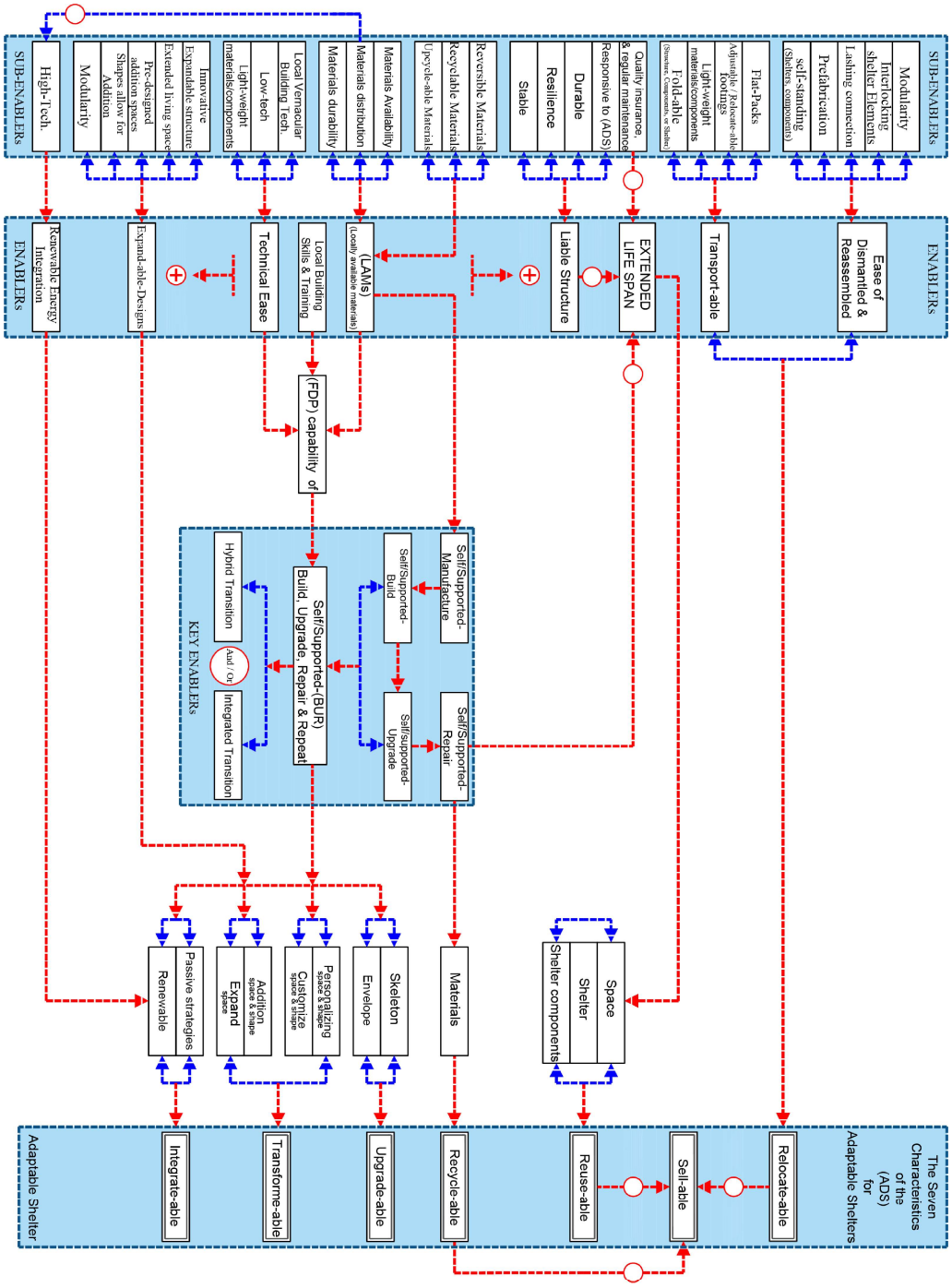
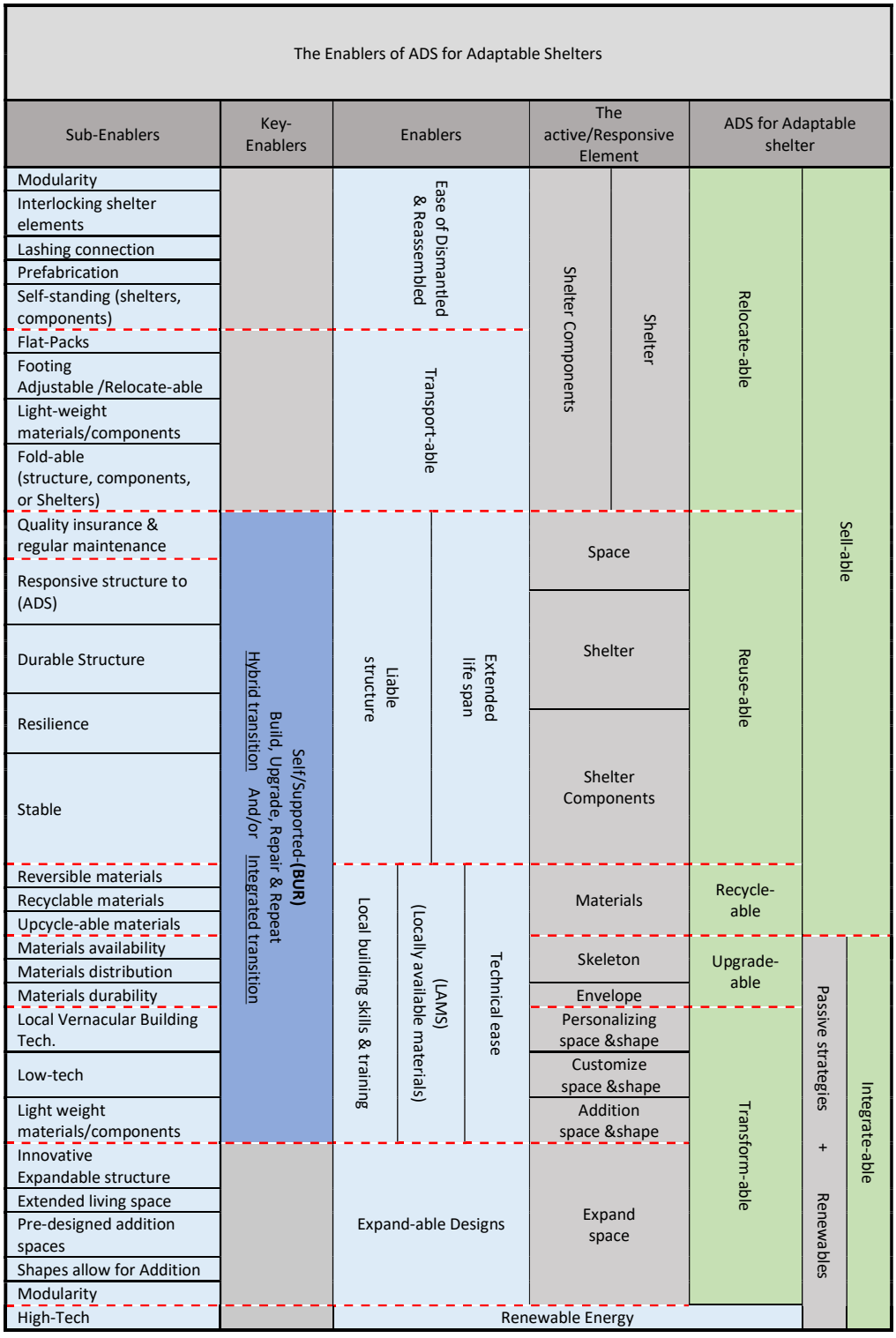



**Figure 5.6-16.** ERD-14, the Enablers of the ADS charachtaristics for Adabtable shelters.

And the next table represent self/supported BUR as a key enabler of ADS for adaptable shelters to the status of transition and nine enablers with five of them as core enablers (Extended lifespan, Liable structure, Technical ease, LAMs, and Local building skills & training) and four additional enablers that help to expand the adaptable capacity of the shelters (ease of dismantled and reassemble, transportable, expandable designs, and the integration of the renewables). These ten enablers can facilitate the seven

ADS characteristics of adaptable shelters and reduce the possible disconnectivity in the aim of transition to adequacy and resilience. This helps in the aim of the adoption of the previously specified IRRD model for the linkage of relief, recovery, and sustainable development. In addition to 27 sub-enablers that present more specified potential enablers of the transition. And all enablers are presented in the following table:

**Table 28.** The enablers of ADS characteristics for adaptable shelters. By the Author.



# Chapter 6: Conclusions and Recommendations

## 5.7. Conclusion

- The absence of durable solutions (reconstruction, resettlement, and reintegration) for the FDP, should not disable the aim of HSR to address the adequacy, build community resilience and the self-reliance of the FDP. Instead, a transitional approach should be adopted.
- For efficient humanitarian response and to support the transition from emergency response to recovery and long-term sustainable development, the HSR should adopt an integrated aim of (relief, recovery, and sustainable development in the early stages of response, which is presented in the proposed IRRD model. **Figure 5.1-4**
- The adoption of an integrated aim (IRRD) requires a holistic transitional approach, (Hybrid and/or Integrated) -**Figure 5.6-14 and Figure 5.6-15** - with adaptable sheltering solutions.
- ADS characteristics -**Table 10-** can maximize the adaptable capacity of the proposed sheltering solutions to the status of transition (Hybrid and/or Integrated).
- And transition enablers, especially the (self/supported build, Upgrade and maintenance (BUR)) as a key enabler and other enablers such as (LAMs, Local building skills and training, technical ease, Extended life span, liable structure, ease of dismantling and reassemble, transportability, Expandable designs and the integration of passive design and the renewables.) **-Table 28 -** can facilitate the smooth transition of the adaptable shelter solutions through the holistic transitional approach (Hybrid and/or integrated transition.) that is seeking the integrated aim of (Relief, Recovery, and Sustainable development), and altogether represent a holistic approach that can be visualized as the following:

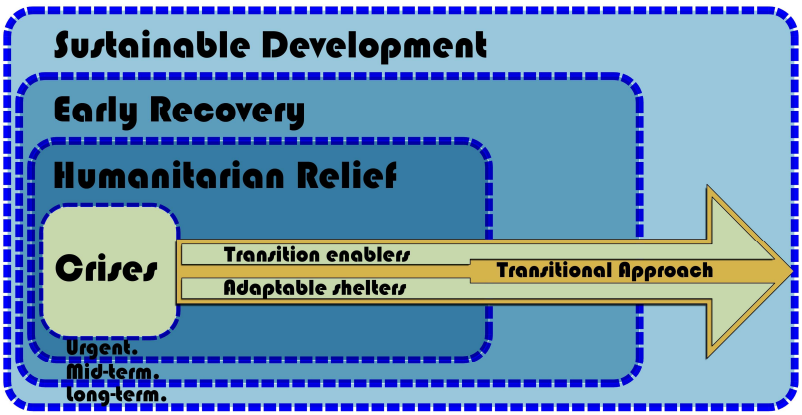



**Figure 5.7-1.** The Holistic Approach Diagram of HSR. By the Author (2022).

However, the validation of the effectiveness of the hybrid/integrated transitional approach required further field adoption and assessment. And the adoption of the IRRD model in HSR with a continuous assessment for future rectifications is recommended.

## 5.8. Recommendations for Future Studies

Further research can be conducted in order to validate the transition in real HSR implementations and to gain feedback on the implementation. Additionally, multiple scenarios of the transition approach can be determined and evaluated for a specific case study with possible visualisation and digital simulation. Further research could investigate the potential change of the future design proposals for sheltering solutions driven by both ADS characteristics and transition enablers. That could provide solutions with higher adaptable capacity.

Moreover, alternative innovative practices can be discussed, simulated, and evaluated such as the discussion of the living structure and its possible contribution in HSR.

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# Appendix

## 5.9. Novel solutions

### 5.9.1. Liina shelter

Is a prototype transitional shelter that has been designed by the students of the wood program at Aalto University, in Finland which is designed for the cold climate of the Ararat region in Turkey, with a

**Figure 5.9-2.** The prototype of liina Transitional shelter, **(Meinhold, 2011)**

planned life span of 5 years covering a living space of 18 sq.m for a family of (4-5) members. The project is using prefabricated thermally insulated wooden sandwich panels. Every 5 modular panels can be assembled on-site to create a frame that includes the flooring, the frames can be tilted up and stacked to the other frames to create the shelter envelope, a process that only required 6 hours and 2 persons to assemble the shelter.

**Figure 5.9-1.** The internal divisions and the addition loft space, **(Meinhold, 2011)**

The modular frames allow for the implementation of different shelter lengths to make the implementation of different shelter sizes is possible, and further supply of the prefabricated panels allows for future expansion of the interior space and the addition of exterior shaded living spaces. Which allow for better acceptance of the shelter and the interrelation with the outside which could enhance the occupant's health and feeling of belonging.

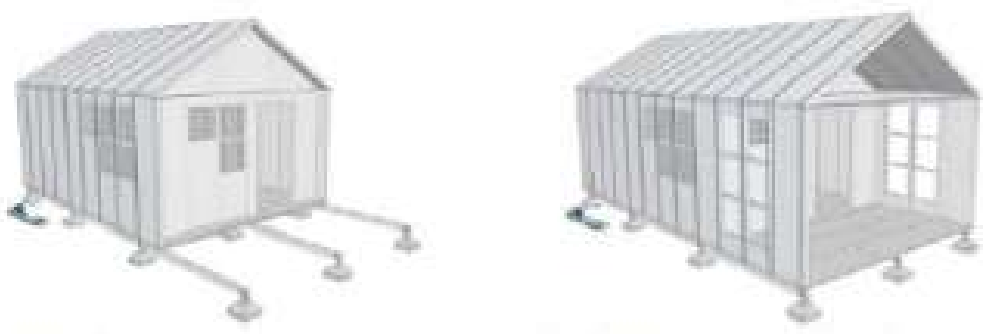

**Figure 5.9-3.** The addition of the front terrace, simply by attaching 3 additional frames. **(Meinhold, 2011)**

Adding partitions will provide semi-private spaces separated from the multi-purpose living space for (Eating, working, and living) and the internal kitchenette. the gable shaped roof allow for adding an inner loft which can be used as additional sleeping space or as a storage area.


**Figure 5.9-4.** The assembly process of the prefabricated panels and the stacked frames. **(Meinhold, 2011).**

the UNHCR standard Tarps can e used as a screening layer, that will protect the frames from UV solar radiation and rainwater which will increase the frames and the shelter durability and enhance the envelope performance as a waterproofed and shaded envelope with less heat gain.

### 5.9.2. Just add water

A conceptual sheltering proposal for refugees done by Cutwork design studio, in 2019, for arid climates, the proposed durable shelter is 6.8*3.6 m which can be self-built by two persons within a couple of days but for a very long life span of 30 years for a family size of 5 members.

**Figure 5.9-5.** Theproposed perspective of " Just add water " Humanitarian shelter. **(Wang, 2019).**

The concept is using concrete textile (concrete clothe) that can be rolled over the structural frame and ardened within 24 hours after water is added also, the proposed shelter used bendable metallic tubes that allow for easy bent by hand on-site to form the shelter sectional frames.

**Figure 5.9-6.** The use of innovative materials of both Concret textile and easy bendable metallic frames, **(Wang, 2019)**

The modular sectional frames allow for building the shelters in different lengths and also allow for future additions and expansions, however, expansion joints are required and it could be problematic technically. The internal space could be divided by partitions, and the proposal contains a private bath and kitchen.

**Figure 5.9-7.** The internal division and space of the proposed shelter. **(Wang, 2019).**

The rollable concrete textile can be formed to almost any shape, but once it hardened it cant be reshaped, so the created shell is permanent and can't be dismantled, also difficult to be transported. Due to the inefficient shape and size for transportation, however, the bent frames are reusable and easy to dismantle and reassemble.

### 5.9.3. Weaving a Home

It is a tent of folding structural fabric that is transportable and expandable, also provide shelter in a variety of weather conditions. The tent-crafting is inspired by the traditional tents of the Beduin or Al Bado as called in native Arabic that they used to live in the desert inside a traditional tent called " Beit-al-Shaar" that is made from goats hair, camel's hair, or/and sheep wool, this handcrafted and porous tapestry has been combined with innovative "collapsible structural fabric" to allow for expanding and enclose as a responsive skin performance due to the different weather conditions. **(Scene Arabia, 2020).** The project represents potential socio-cultural solutions that link the local traditional architecture with humanitarian relief and sustainable development.

**Figure 5.9-8.** perspective of the proposed "Weav your home" Tent for humanitarian sheltering**. (Scene Arabia, 2020).**

### 5.9.4. Grow your home

Nowadays Green roofs and walls are in progress of integration into architectural buildings, and for HSR, it is common to shade your shelter or external balcony with climbing plants or for shade. Even

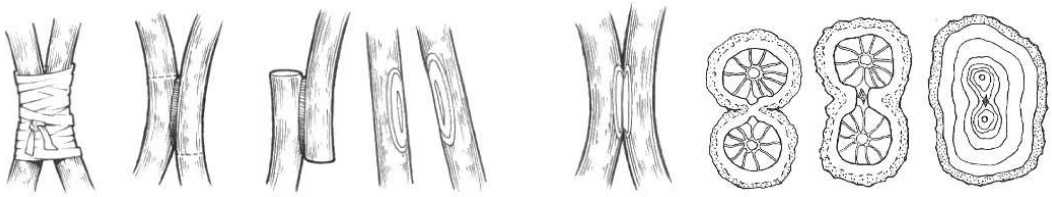

**Figure 5.9-10.** Grafting between tow young steam, adopted from **(Link, 2008).**

**Figure 5.9-9.** Examples of grafted plants, **(Link, 2008).**

though it seems to be early to consider building humanitarian shelters from growing plants, an interesting idea called Arbortecture or Botany building is still under investigation but carry a lot of potential enhancement in sheltering response. "Arbortecture" is an abbreviation of "arboreal" and "architecture." (Link, 2008).

And Botany building is a building that is created from a living structure, which is possible by bleaching or grafting plants together and manipulating plants growth to create a living form of structure.

Another useful process called "**Espalier**" is the process of using pruning and/or grafting to grow trees branches or shrubs in two-dimensional patterns against support structure, espalier has different common patterns to grow that could be architecturally beneficial, such as (Belgium fence, horizontal cordon, Fan, and Tunnel).

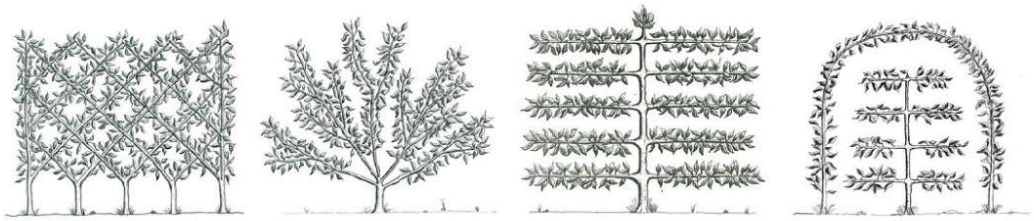

**Figure 5.9-12.** Illustrations of common espalier patterns by Beth thevelnot, **(Growables, 2014).**

**Figure 5.9-11.** Comon espalier patterns. **(Growables, 2014).**

A more simple strategy is the weaving of fast-growing plants wands together. such as willow wands to form a surface or a living structure with a leafy canopy.

**Figure 5.9-13.** The weaving process of living plants, collected from **(Stocken, 2021).**

The next photo represents a comparison the photo on the right shows a man building a wood frame for his emergency shelter in Dadaab, Kenya, 2008, similarly a living structure can be built by using woven living plant techniques presented on the left.

**Figure 5.9-14.** Woven living willow weeds for living structure. **(Stocken, 2021).**

**Figure 5.9-15.** framed woody structure for emergency shelter, in Dadaab, Kenya, 2008 **(UNHCR, 2019a).**

The time required to construct a Botani Building is highly related to the species type, rate of growth, growing conditions, and the height of the design. However it is possible to initiate a grafting and bending within an hour but removing the material that holds the grafting could be as long as 1 year, and an Arbortecture project may never be finished as long as the plants are growing until it dies. **(Link, 2008).**

So the concept presents a potential incremental project that gets bigger and stronger with time. The potential of effective implementation of this Idea required further research, investigation, development, testing and verification. An Imaginary proposal created by Terraform designers, Mitchell Joachim, Lara Greden and Javier Arbona, is called Fab Tree Hab The idea is to form the structure of the house in 5 years process then to cover the internal space with clay.

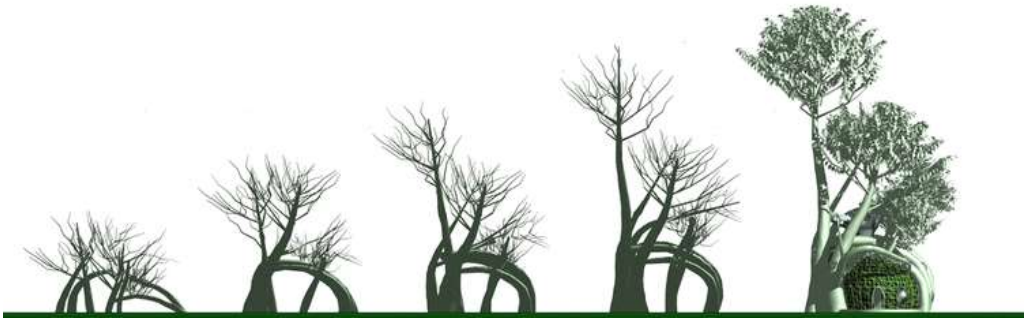

**Figure 116.** The growth Process of the " Fab Tree Hab", by **(Terreform, 2005).**

Another Provision by a group of students in Milan Polytechnic University and Swedish architectural firm VisionDivision, design growing plants to shape a dome structure. The project uses ten Japanese sherry trees that are planted in a circle in order to be guided with controlled growing by different techniques (bending, twisting, pruning, grafting, braiding, and weaving),

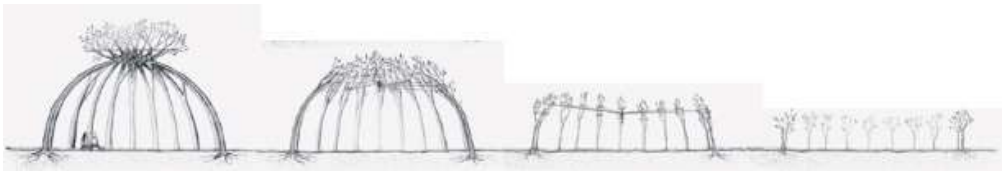

**Figure 5.9-16.** Schematic design of the dome shaped guided growing plants, **(Cilento, 2011).**

an experimental structure of utilizing living plants as a load-bearing system, carried out in 2005, by **(Ludwig and Schonle, 2005)** called The Baubotanik footbridge

**Figure 5.9-17.** The experiemental structure of baubotanik foot bridge by **(Ludwig and Schonle, 2005)**

the living bearing structure was built using willow Salix viminalis species that has god ability to generate roots, this is why a conventional foundation was not required, as the living structure was able to direct the load to the ground, additionally, the whole structure is anchored to the ground by the willow growing roots, However, some of the plants have died, so a maintenance method of regeneration via sprouting has been developed. The photo down shows how the plants grow around the steel frame handrail and create a form that fits.

**Figure 5.9-18.** Development of steel handrail connection with living trees over 5 years, **(Future Architecture, 2016).**

Also, An experimental building designed by the German architect Ferdinand Ludwig at the technical university of Munich with PHD intention called "the Baubotanic Tower" was awarded the prize of "landmark 20210".This tower tests the new possibilities of living plants construction and visualizes the potentials of Baubotanik, this eight square meter building with 9 m height with 7 layers **using the plant addition method**, where are the lowest white willow plants of 2 m height embedded into the ground while the next layers were grown into containers.

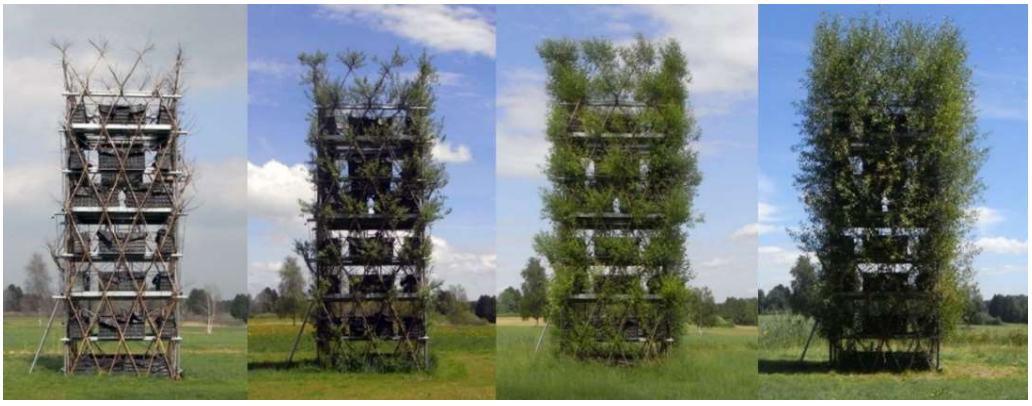

**Figure 5.9-19.** The evolution of Baubotanik tower, **(Ludwig, 2009).**

The plant addition method is the fusing of many small plants into one plant "**Hyber organism**" it is a time-effective method to build a living structure immediately in the required size that is required at the beginning of a temporary supporting structure and each plant should be watered and fertilized individually wich over time converted to self-supported and self-efficient living structure.

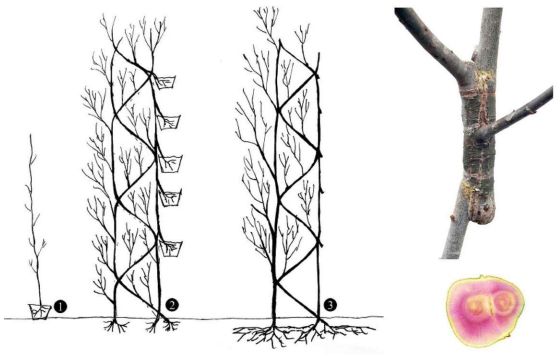


**Figure 5.9-20.** Plant addition method. **(Ludwig, 2009).**

So in this project, the whole structure was supported by a temporary structure of steel tube scaffold with intend to be removed after the plants merge together by the grafting and develop a timber-framed supporting structure that takes over the loading capacity, so the scaffold can be removed after a process of 5 to 10 years. the experiment aims to assess how long it takes the plants to intergrow with each other until the whole structure can take water and nutrition from the ground independently.

A bigger and more complex structure representing the larger Baubotanik project which won "Special prize for Innovation "for 2012, called Plane-Tree-Cube Nagold is an exhibition within the urban context that is presenting a nature space that is architecturally designed and it is presenting the Baubotanik environmental performance as the air inside is **cool due to the power of leaves evaporation process**, and with time the frame work-structure of stem increase in strength until the whole green tube becomes stable and the temporary structure will be removed. It is a potential method of structure frame upgrade that required patience, skill learning, and the contribution of the beneficiaries.

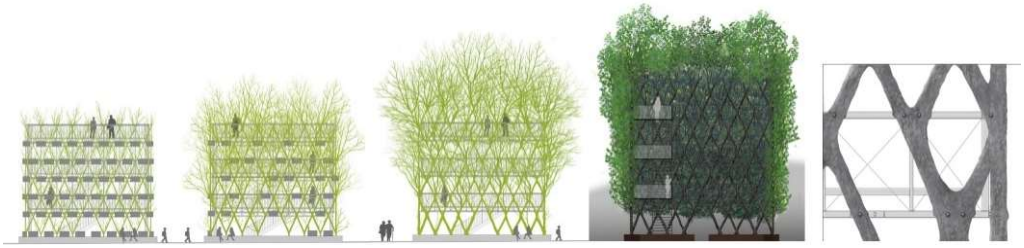

**Figure 5.9-21.** the evolving schematic of the "Plane-Tree-Cube Nagold" (Ludwig and Schonle, 2012)

However, creating an envelope for the living structure shelter is still a fresh wide field to investigate with high potential of environmental benefits. the Fab tree Hab has used clay to create an envelope from inside the living structure, and **(Vallas and Courard, 2017)** highlight that the living structure could be used in combination with traditional architecture. Additionally, the living structure naturally provides a leafy envelope, that provides some passive quality functions to the shelter envelope such as privacy, passive cooling due to leaf's evaporation process and protection from the cold wind, due to the stabilized air movement within the leafy canopy, passive shading and protecting from rainwater lashes, nevertheless, it is a breathable structure that is subject to allow for another species to live within the envelope which is good for the species diversity and environment, but comes with safety concerns for the occupants, additionally, some locations required shelters with thermal massing, therefore the combination with the traditional construction methods could provide the needed envelope function in addition to the benefits of the living envelope. Nevertheless, it is a strategy that can be used for expanding the living space such as adding part of the external space to be converted to a semi-internal space that supports daily life activity with privacy, healthy and more controlled environment Than outdoor. The photo down represents an outdoor utilized space by growing climbing plants to create an extended space of semi-internal space in al Beqaa refugee camp

**Figure 5.9-22.** Extended living space, behind a refugee tent using climbing plant and robs, in Arsaal, Albeqaa, Lebanon (2021), reference **(Altaleb, 2021).**

Or in the implementation of a double-layered structure (temporary and transitional living structure) which could provide additional comfort and pleasing-looking to the temporary structure which helps in accepting the emerging structure by both the occupants and the host communities.

For instance, a Transitional shelter called Tent shelter constructed in northern Afghanistan from the bamboo frame and tarps covering has been built as an extension and contains the existing Tent shelters.

**Figure 5.9-24.** Bamboo frame covered with plastic sheet built around the existing tents., **(UNHCR, 2016)**

**Figure 5.9-23.** living canopy, Imaginary photo by the Author.

Similar extensions can be provided by growing a living structure around a temporary shelter to provide a self-growing and sustainable envelope that add the required extended space, privacy, protection, healthy, self-supporting and environmentally friendly, with high potential of acceptance from both occupants and host communities due to its pleasing-looking which present a potential beneficial implementation in the field of humanitarian sheltering.

This time-consuming method doesn't fit the need for fast and active emergency response, however, it is a possible eco-friendly, self-maintained method for initiating early recovery by contributing the FDP in the continuous growth of their shelters transformation, upgrade, addition, and extension which is still applicable even in temporary lands. While ensuring an eco-friendly sheltering response.

Growing plants required water, soil, and solar, however settlement usually established on open areas, and required sanitation facilities, so greywater can provide the required watering needs at the same time present an ecological treatment of the greywater, which increases the fertility of the lands and offsetting the environmental Impacts.

Appropriate fast-growing plants should be selected due to the geolocation of the shelter. seeking native plants that is functional to the purpose could present a better practice. Even though it is required further research and testing the Living architecture can enable the population to build a low-cost shelter, permanent or semi-permanent structure, and avoid land tenure obstacles with reversed environmental impacts to live in harmony with nature, however living architecture should be used in combination with traditional architecture, a whole living shelter proposals is still required prototypes and further investigation. **(Vallas and Courard, 2017).**

**-The end of the Appendix.-**